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International Journal of Multimedia Art, Design and Education

Prof. Siu-Tsen Shen
Editor-in-Chief

A warm welcome to the sixth edition of the International Journal of Multimedia Art, Design and Education (MADE), an open-access resource dedicated to publishing high quality, peer-reviewed research papers in all areas of design research.

As the Ukraine war drags on, economies around the world start to focus on other pressing issues such as poverty, climate change and inflationary pressures. Later this year the latest instalment of the Conference of Parties (COP 28) will take place in the United Arab Emirates. [1]

World poverty is on the increase and this is starting to affect the so-called 1st world countries and developed economies. The result is a proliferation of food banks, job insecurity and lower disposable income.

A spike in the inflation rate, particularly in the UK earlier this year to double-digits collectively amounted to a failure of the Bank of England (BoE) to control this important metric to under the 2% target. [2]

With limited resources available to the citizens of a country, they rely on smart technology to save money by giving them the advantage of information at the speed of light to make their money go further.

Smart design of systems, software and services has a huge roll to play in these tough times. The cost of a smart phone, its running cost and the cost of fast internet services can make the difference between just surviving and thriving.

Many countries around the world are looking at upgrading these services and reducing their cost to improve productivity.

Our Editorial Board consists of leading design researchers and practitioners from all over the world, all of whom have proved willing to contribute their valuable time to the development of this new journal. To reach the widest possible audience, the journal will be published both online and in print. The online version will be open access, freely available for anyone, anywhere to download, read, distribute, and use, with proper attribution of authorship, for any non-commercial purpose. A printed version of the journal will also be available at cost.

The journal aims to provide an international forum for exchange of ideas and findings from researchers across different cultures, by encouraging research on the impact of cultural factors on design theory and practice. The journal also seeks to promote the transfer of knowledge between professionals in academia and industry. To help make our vision a reality, we invite you to submit your best work to the MADE Journal and to encourage your colleagues to do the same.

In these turbulent times, we all have a responsibility to use design tools to boost economic growth and provide opportunities to the younger generation. These are our future leaders, and together we can overcome the current challenges of post-Covid-19, recession and geo-political tensions in the world.

Acknowledgements
The fifth issue of MADE was only possible due to the hard work of the three contributors. Each of the contributors went through an extensive revision/review

process, which resulted in works of excellent quality. The reviewers in the various disciplines spent countless hours on top of their already busy schedules to ensure the works included are of the highest quality. The MADE executive committee not only had the goal of creating this journal, but also served a large role in determining the initial format and general guidelines for the journal. They had online meetings to discuss deadlines, submission, and their careful consideration helped the editorial board avoid a number of pitfalls we could have encountered with this issue. They were also charged with the difficult task of selecting the cover design from an impressive set of submissions. I also need to acknowledge the work of Assisting managing editor, Zhi-Xing Dai, who spent hours discussing policies, formatting, and any other number of other details about the journal with me.

References

[1] Conference of Parties (COP 28) (10 July 2023), United Nations Climate Change. Available from: https://unfccc.int/

[2] The Bank of England is accused of 'losing control of inflation' as households face another £2,300 hit to their finances (July 2023), Mail Online. Available from: https://www.dailymail.co.uk/news/article-12288893/The-Bank-England-accused-losing-control-inflation.html

Prof. Siu-Tsen Shen

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The Relationship Between Image and Text in Digital Media

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Abstract

Images and text both possess narrative functions, yet compared to textual messages, images are more likely to capture attention. In today's image-saturated society, the frequent occurrence of discrepancies between images and their accompanying text on modern digital platforms has prompted this study to explore the influence of text on images. The placement of textual information often leads most people to focus on the text rather than contemplating the image itself. This study explores the influence of text on images in today's image-heavy digital landscape, particularly focusing on whether text alters the viewer's critical thinking and emotional responses. It finds that while text on images significantly affects emotions, especially when there's inconsistency between text and image, it does not substantially impact reflective or critical thinking abilities. The research, using emotional assessment questionnaires, notes a marked change in participants' emotions before and after viewing text-image combinations, suggesting that the relationship between the text and image plays a key role in altering emotional responses.

Keywords **–** Critical Thinking, Reflective Ability, Text-Image Relationship, Semantic Differential Scale

Relevance to Design Practice **–** The study highlights how text accompanying images in digital media influences viewer perception and emotions, underscoring the importance of considering text-image relationships in design practices.

Introduction

Text is an integral part of our lives, forming the basis of learning from an early age. It serves as

a medium for preserving significant historical information and facilitating the rapid development and progression of human civilization. Text not only acts as a crucial bridge for communication among people and a means of expressing innermost feelings, but also plays a pivotal role in shaping societal order. Each piece of writing, created to meet human needs, holds a special purpose. The advent of writing marked a significant milestone in human civilization and its advancement. Without written records, there would be no history or civilization (Eshet, 2004).

With the rapid evolution of technology, human behavior patterns have also evolved. The convenience of modern living has accelerated the pace of life, demanding efficiency. From the transition of basic mobile phones to smartphones and the widespread use of the internet, the evolution of communication methods has shifted towards instant messaging and digital platforms. This trend towards ease and rapid access to information has led to the digitization of documents and magazines, facilitating reading via smartphones. Social media platforms have become hotspots for business opportunities, with Facebook, established in 2004 by Mark Elliot Zuckerberg and others, being particularly active. The Taiwanese public became acquainted with Facebook in 2009 through a game, which led to its widespread adoption due to its simplicity and immediate connectivity. The subsequent rise of Instagram in 2010, focusing on instant imaging and visual content, marked a shift from Facebook's text-centric approach. This change signifies a cultural shift towards visual and digital media, raising the possibility of a 'post-textual society' where multimedia technologies render traditional writing obsolete (Kirsten et al., 2017).

Images and text both serve narrative functions, but images are more attention-grabbing than text. Studies show that 90% of the information transmitted to the brain is visual, and the brain processes visual information 60,000 times faster than text. The popularity of Instagram's image and video-focused platform reflects a societal trend towards rapid and easy information consumption, shifting away from text-heavy platforms like Facebook. This study aims to explore the role and impact of text in an image-dominated culture. It questions whether adding text to an image alters the viewer's perception and whether this combination affects critical thinking and emotional responses. Additionally, the research investigates whether the integration of text with images on platforms like Instagram influences viewers' immediate reactions and emotional shifts (Khan, & Mazhar, 2017).

Listed below are the research questions

1. Does the presence of text in an image impact the viewer's perception?
2. Does text associated with an image affect the viewer's reflective and critical thinking abilities?
3. Are there differences in the emotional responses of viewers before and after viewing text with images?

Literature Review

The Evolution of Textual Media

The essence of human intellect and civilization, language and writing, have historically been key to cultural preservation and information dissemination. Prior to the advent of paper and

printing, diverse materials like pottery, bones, and silk were used for writing, each influencing the text's context and cost. With printing, textual representation underwent a transformation, yet the interaction between text and its medium remained underexplored. Traditional media, constrained by the physical properties of materials, faced challenges like resource consumption and durability issues. Electronic media, however, revolutionized this landscape. Electricity, adaptable to various energy forms, emerged as a flexible medium for text transmission, meeting diverse application needs (Ben-Chaim, 2018).

Digital technology further expanded this domain, virtually transforming every traditional medium into a digital format. This shift led to the rise of digital media as a universal medium for knowledge expression. In the digital age, the abundance of textual information is notable, accelerated by technological progress and societal modernization. Digital media eclipsed traditional linear texts, fostering interactive, multimedia, and hypertext formats, thus altering the traditional author-reader relationship into a collaborative creation process.

The Relationship Between Text and Images

The interplay between text and images has been a longstanding subject of analysis. Texts and images both function as mediums for expression and information dissemination, yet their relationship is complex and multifaceted. For instance, Lyotard in "Discourse, Figure" and Scott Lash in "Postmodern Sociology" highlighted the contrasting roles and perceptions of text and images in modern and postmodern contexts. While text attempts to transcend its temporal constraints, images strive to encapsulate time and movement, leading to a competitive and conflicting relationship (Sherman et al., 2013).

Images, often deemed more direct and impactful than text, can be subject to varied interpretations and potential misunderstandings. Text, in contrast, provides clarity and specificity, particularly effective in conveying complex and abstract concepts. In the internet era, traditional linear text has evolved into more dynamic forms like hypertext and multimedia texts, transforming the author-reader dynamic into a cooperative venture. The relationship between text and images can encompass various modes of intertextuality, including corroboration, explanation, complementarity, and contradiction (Renchen, 2007).

The digital age has positioned visual imagery as a key tool for self-expression and idea transmission, necessitating an understanding of visual literacy for efficient content interpretation. The synergy of text and images can enhance this literacy, provided there is a consistency in the conveyed message. However, discrepancies between the two can affect information processing and memory retention (Lochbuehler et al, 2017; Paivio, 1991).

In conclusion, the interconnectedness of images and text significantly influences cognition and memory. Studies indicate that images initially attract more attention than text, yet consistent messaging between the two is crucial for clear understanding. The development of text and image, especially in the context of digital technology, underscores the complexity of their relationship and its impact on information dissemination and comprehension (Lochbuehler et al, 2017; Paivio, 1991; Sherman et al.,2013).

Research Methodology

This chapter is divided into three sections. The first section outlines the research framework, hypotheses, and overall research flow. The second section details the research design and introduces the tools used in this study. The third section covers data collection and analysis, describing the sources of the study's data and the statistical analysis software used.

Research Framework and Hypotheses

The study examines the impact of viewing images and texts on subjects' feelings, reflection, and critical thinking. The framework (Figure 1) differentiates between 'unexpected' and 'expected' groups based on whether the image and text elements match. The 'unexpected' group has incongruent elements, while the 'expected' group has congruent elements.

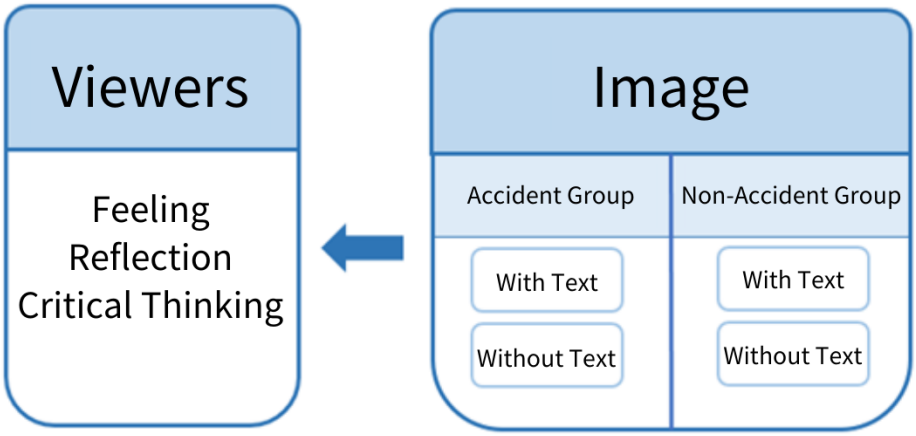

Figure 1. Research Framework Diagram.

Motivated by the shift from text-dominated social media like Facebook to image-centric platforms like Instagram, this study aims to explore how viewing images and texts affects an observer's reflective and critical thinking abilities. The hypotheses proposed are as follows:

- H1: Text on images significantly impacts viewers' feelings.

- H2: Reflective and critical thinking abilities significantly differ after viewing images with text.

- H3: Emotions significantly differ before and after viewing images with text.

- H4: There is a significant difference in feelings between the 'unexpected' and 'expected' groups.

Research Process

The research process began with preparing materials based on the Semantic Differential (SD) scale, focusing on the relationship between text and images and their impact on viewers' feelings.

Research Subjects

Subjects were recruited from high-frequency Instagram users in Taiwan. The selection process involved posting a call for participants on a business Instagram account (Figure 2 and 3) and screening responses.

Figure 2. Instagram Icon and the Commercial Account Used in This Study.

Figure 3. Job Posting.

Image Creation Tools Used: Paint Tool SAI, Corel Painter, and a Bravod first-generation Aurora drawing tablet with a battery-free stylus (Figure 4) were used to create nine images (Figure 5).

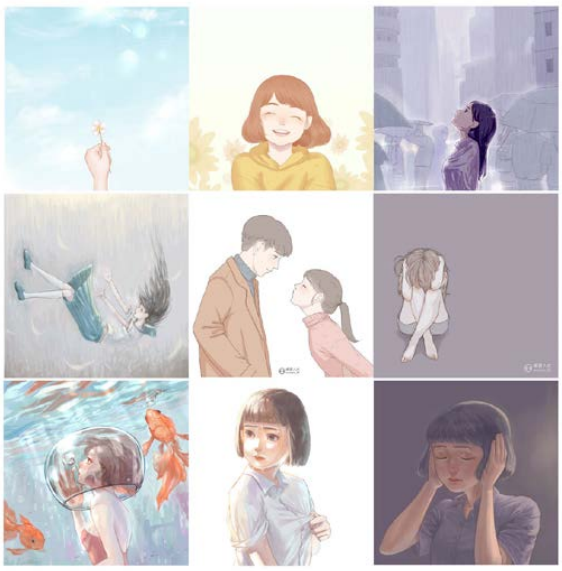

Figure 4. Nine Thumbnails Used for Experimental Study.

Figure 5. Bravod First Generation Aurora Drawing Tablet.

Research Tools

Four questionnaires were used: Critical Thinking Ability, Reflective Thinking, AEQ Learning Emotion Scale, and the SD Semantic Differential Scale. Each tool is described in detail.

(1) Critical Thinking Ability Questionnaire

This questionnaire measures critical thinking ability, which includes having systematic and analytical thinking, open-mindedness, empathy, curiosity, and a reflective attitude. Developed by Schraw, G. & Dennison, R.S. (1994), it employs a Likert five-point scale ranging from "Strongly Agree" to "Strongly Disagree" to gauge responses. This questionnaire is administered before and after the Semantic Differential (SD) scale to participants.

(2) Reflective Ability Questionnaire

Developed by Kember, Leung, Jones et al. (2000), the Questionnaire for Reflective Thinking (QRT) aims to understand the extent of students' reflective thinking. It uses a Likert five-point scale, similar to the Critical Thinking Ability Questionnaire, and is given to participants before and after the SD scale.

(3) AEQ Learning Emotion Scale

The Achievement Emotions (AEQ) Questionnaire developed by Pekrun and others is designed to assess students' learning-related emotions. According to research statistics, these emotions can predict a student's classroom performance and likelihood of dropping out early. The AEQ divides learning contexts into three categories: emotions related to the classroom, learning, and exams. These contexts can be used together or separately. The AEQ questionnaire consists of pre, mid, and post-tests, including eight emotions: Enjoyment, Hope, Pride, Disappointment, Anxiety, Shame, Hopelessness, and Boredom. This study uses the learning emotions scale from AEQ to investigate differences in participants' emotions before and after completing the experiment.

(4) SD Semantic Differential Scale

The Semantic Differential Scale, also known as the Semantic Differentiation Scale, is an attitude measurement technique developed by American psychologist Charles E. Osgood and others. It's a method for measuring the meaning of a word or concept as understood by the respondent. This technique involves designing a series of bipolar adjective scales (e.g., Good-Bad) with typically 7 to 11 intervals. Participants are asked to choose their position on the scale based on their feelings or understanding of the word or concept.

In this experiment, professionals with 12, 13, and 10 years of experience in drawing were invited to provide corresponding vocabulary based on their feelings towards nine images.

Initially, 20 sets of bipolar vocabularies were drafted, defined by the Ministry of Education's Mandarin dictionary, and then filtered to eliminate similar meanings. Finally, 10 sets of bipolar vocabularies (Table 1) were used for the Semantic Differential questionnaire.

Table 1. Semantic Differential Scale Vocabulary.

Warm	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***Cold***
Bright	1	2	3	4	5	6	7	Dark
Joyful	1	2	3	4	5	6	7	Depressed
Happy	1	2	3	4	5	6	7	Unhappy
Sweet	1	2	3	4	5	6	7	Bitter
Fearful	1	2	3	4	5	6	7	Fearless
Anxious	1	2	3	4	5	6	7	Relaxed
Lonely	1	2	3	4	5	6	7	Crowded
Stuffy	1	2	3	4	5	6	7	Cool
Free	1	2	3	4	5	6	7	Restrained

Experimental Image Groups

The study used nine images created by the researcher (Figure 3-7 to 3-15), categorized into 'unexpected' and 'expected' groups based on whether the added text matched the image. The groups and their corresponding images are outlined in Table 3-4 and 3-5.

Figure 6. Group A pictures.

Figure 7. Group B pictures.

Figure 8. Group C pictures.

Figure 9. Group D pictures.

Figure 10. Group E pictures.

Figure 11. Group F pictures.

Figure 12. Group G pictures.

Figure 13. Group H pictures.

Figure 14. Group I pictures.

Table 2. Semantic Differential Scale Vocabulary.

1	***Warm***	***Cold***
2	Bright	Dark
3	Joyful	Depressed
4	Happy	Unhappy
5	Sweet	Bitter
6	Fearful	Fearless
7	Anxious	Relaxed
8	Lonely	Crowded
9	Stuffy	Cool
10	Free	Restrained

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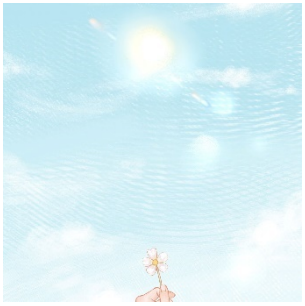
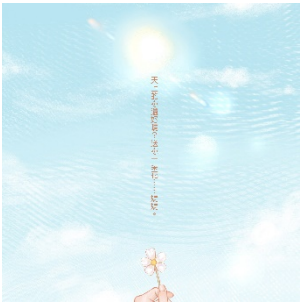
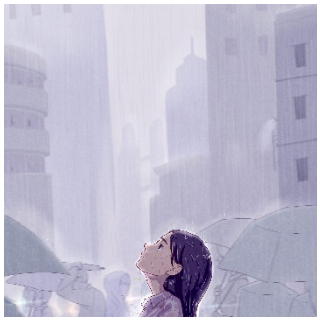
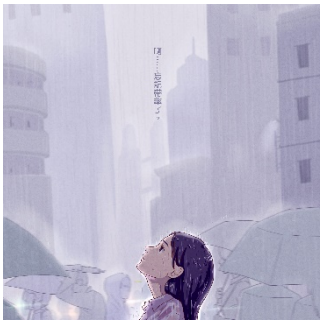
Table 3. Image Group Code Indication Table.

Accident Group		
A		
B		
C		
Non-Accident Group		
D		

E

F





G

H

I

Data Collection and Analysis

Data were collected using SurveyCake and Google Forms. Subjects were selected through Instagram and communicated via LINE@ APP. The process spanned five days, with different sets of questionnaires administered each day. IBM SPSS Statistics Subscription Trial was employed for statistical analysis, using independent sample t-tests, paired sample t-tests, and supplementary Excel analysis.

Research Results and Discussion

Questionnaire Analysis

The study conducted reliability analysis on the reflection, critical thinking, emotional scales, and semantic differential scales. While the reliability for reflection was $\alpha \leq 0.7$, it was considered credible as it was greater than 0.5. The other aspects showed $\alpha \geq 0.7$, indicating good reliability (Table 4).

Table 4. Reliability Analysis Results.

Aspect	Cronbach's α
Pre-test for Reflective Thinking	0.639
Post-test for Reflective Thinking	0.641
Pre-test for Critical Thinking	0.878
Post-test for Critical Thinking	0.895
Pre-test for Emotion Scale	0.757
Post-test for Emotion Scale	0.854
Semantic Differential Scale	0.784

Table 5. Research Hypothesis Results.

1. Is there a significant difference in viewers' feelings towards images with text?		
H1	Text on images affects viewers' feelings.	✓
2. Is there a significant difference in subjects' reflective and critical thinking abilities after viewing images with text?		
H2	Changes after viewing images with text affect reflective and critical thinking abilities.	✗
3. Is there a significant difference in subjects' emotions before and after viewing text and images?		
H3	Viewing text and images results in emotional differences.	✓

4. Is there a significant difference in feelings between the 'unexpected' and 'expected' groups of images?		
H4	There is a significant difference between unexpected and expected groups.	✓

Hypothesis 1: The presence of text on images significantly affects the viewer's perception.

This study aims to test the hypothesis: Does text on images affect the viewer's perception? To analyze this, we gathered data on "perceptions of images without text" and "perceptions of images with text." Initially, we performed a paired sample t-test. Ten pairs of antonymous words were labeled as numbers 1 to 10 (see Table 6-14), and image sets were coded from A to I in English.

After analysis, significant differences in the ten pairs of antonymous words for group A were examined according to Table 4-3. It was found that pairs 8 and 9, with t-values close to 0 and P>0.05, were not significant. Similarly, in image set D, one pair of antonymous words also had a t-value close to 0 with P>0.05, indicating insignificance. For image set A, pairs 1 to 7 and 10 were significant with P≤0.05 (see Table 6). It is inferred that pairs 8 and 9 in image set A, and one pair in image set D, have little correlation with image perception, as the subjects had minimal perception of these word pairs. Image sets A, B, C, D, E, F, G, H, and I were all analyzed using the paired sample t-test (Tables 6-14), with most showing significance at P≤0.05. Therefore, we accept Hypothesis 1: Text on images does affect the viewer's perception.

Table 6. Research Hypothesis Results

Dimension	Mean (SD)		*df*	t	*P*
	Without Text	With Text			
1	1.53 (.91)	3.11 (1.74)	217	-12.41	.000*
2	1.77 (.96)	2.61 (1.41)	217	-7.88	.000*
3	1.54 (.95)	2.36 (1.41)	217	-7.39	.000*
4	1.33 (.77)	2.53 (1.49)	217	-11.30	.000*
5	1.43 (.89)	2.50 (1.59)	217	-9.24	.000*
6	5.94 (1.26)	5.46 (1.38)	217	5.08	.000*
7	6.31 (.98)	5.71 (1.43)	217	6.01	.000*
8	4.98 (1.21)	5.04 (1.35)	217	-.637	.525
9	4.86 (1.30)	4.83 (1.34)	217	.351	.726
10	2.13 (1.26)	2.56 (1.40)	217	-3.90	.000*

Table 7. Image Set B - Pure Images and Text-Added Paired t-test (N=218).

Dimension	Mean (SD)		*df*	t	*P*
	Without Text	With Text			
1	6.36 (0.90)	4.31 (1.14)	217	21.57	.000*
2	6.67 (0.76)	4.88 (1.28)	217	18.96	.000*
3	6.85 (0.52)	5.50 (1.18)	217	16.77	.000*
4	6.49 (0.84)	5.13 (1.25)	217	14.72	.000*
5	6.47 (0.85)	5.09 (1.18)	217	16.02	.000*
6	1.18 (1.03)	3.01 (1.33)	217	-13.85	.000*
7	1.35 (0.67)	2.08 (1.26)	217	-8.56	.000*
8	1.20 (0.59)	3.21 (1.09)	217	-24.42	.000*
9	3.25 (1.56)	3.58 (1.15)	217	-3.37	.001*
10	6.14 (1.08)	4.91 (1.35)	217	11.83	.000*

Table 8. Image Set C - Pure Images and Text-Added Paired t-test (N=218).

Dimension	Mean (SD)		*df*	t	*P*
	Without Text	With Text			
1	5.80(1.12)	4.99(1.36)	217	7.19	.000*
2	6.23(.87)	4.83(1.31)	217	13.66	.000*
3	6.26(.97)	4.68(1.13)	217	15.91	.000*
4	5.84(1.12)	5.07(1.13)	217	7.88	.000*
5	5.94(1.08)	4.96(1.03)	217	10.68	.000*
6	2.10(1.34)	3.67(1.51)	217	-12.08	.000*
7	2.03(1.16)	2.99(1.46)	217	-8.05	.000*
8	1.75(1.03)	3.98(1.12)	217	-22.12	.000*
9	3.39(1.41)	3.77(1.09)	217	-4.45	.001*
10	5.67(1.21)	4.26(1.35)	217	12.79	.000*

Table 9. Image Set D - Pure Images and Text-Added Paired t-test (N=218).

Dimension	Mean (SD)		*df*	t	*P*
	Without Text	With Text			
1	1.49(.84)	1.61(.97)	217	-1.69	.091
2	1.19(.57)	2.29(1.41)	217	-12.1	.000*
3	1.70(1.03)	4.22(1.61)	217	-21.55	.000*
4	1.89(1.09)	3.81(1.56)	217	-16.13	.000*
5	2.52(1.29)	4.56(1.79)	217	-14.17	.000*

Dimension	Mean (SD)		*df*	t	*P*
	Without Text	With Text			
6	5.46(1.28)	4.72(1.24)	217	7.97	.000*
7	6.28(.93)	4.33(1.20)	217	20.88	.000*
8	3.99(1.22)	2.53(1.15)	217	14.18	.000*
9	5.60(1.49)	4.42(1.24)	217	11.07	.000*
10	1.66(1.06)	3.39(1.25)	217	-17.83	.000*

Table 10. Image Set E - Pure Images and Text-Added Paired t-test (N=218).

Dimension	Mean (SD)		*df*	t	*P*
	Without Text	With Text			
1	1.29(.69)	3.95(1.39)	217	-25.9	.000*
2	1.40(.84)	4.45(1.61)	217	-25.28	.000*
3	1.29(.73)	5.32(1.20)	217	-42.55	.000*
4	1.33(.73)	4.73(1.14)	217	-36.18	.000*
5	1.75(1.06)	5.81(1.16)	217	-36.91	.000*
6	5.64(1.32)	3.77(1.32)	217	14.4	.000*
7	6.15(1.03)	3.25(1.03)	217	27.66	.000*
8	4.72(1.18)	2.42(1.08)	217	20.75	.000*
9	5.60(1.49)	4.42(1.24)	217	11.07	.000*
10	1.66(1.06)	3.39(1.25)	217	-17.83	.000*

*Indicates statistical significance

Table 11. Image Set F - Pure Images and Text-Added Paired t-test (N=218).

Dimension	Mean (SD)		*df*	t	*P*
	Without Text	With Text			
1	6.20(.95)	4.36(1.14)	217	19.42	.000*
2	6.07(.93)	4.57(1.22)	217	15.32	.000*
3	6.30(.86)	4.96(1.20)	217	15.21	.000*
4	5.73(1.14)	5.49(1.10)	217	2.69	.008*
5	5.98(1.01)	4.95(1.03)	217	12.74	.000*
6	3.61(1.64)	4.35(1.19)	217	-6.35	.000*
7	2.88(1.25)	3.15(1.51)	217	-4.72	.000*
8	1.69(.87)	2.92(1.12)	217	-15.03	.000*

Dimension	Mean (SD)		*df*	t	*P*
	Without Text	With Text			
9	4.40(1.65)	4.66(1.44)	217	-2.82	.005*
10	4.29(1.61)	3.63(1.20)	217	5.42	.000*

Table 12. Image Set G - Pure Images and Text-Added Paired t-test (N=218).

Dimension	Mean (SD)		*df*	t	*P*
	Without Text	With Text			
1	5.37(1.33)	4.70(1.19)	217	6.62	.000*
2	5.41(1.53)	4.93(1.44)	217	4.63	.000*
3	5.66(1.33)	5.02(1.43)	217	5.68	.000*
4	5.90(1.32)	5.19(1.26)	217	7.53	.000*
5	5.40(1.31)	4.98(1.12)	217	4.84	.000*
6	2.11(1.39)	3.65(2.06)	217	-10.12	.000*
7	2.67(1.37)	3.11(1.78)	217	-3.49	.001*
8	2.19(1.20)	2.67(1.24)	217	-5.27	.000*
9	4.13(1.27)	4.35(1.16)	217	-2.9	.004*
10	4.23(1.50)	3.81(1.49)	217	3.78	.000*

*Indicates statistical significance

Table 13. Group H - Pure Images and Images with Added Text Paired t-test (N=218).

Dimension	Mean (SD)		*df*	t	*P*
	Without Text	With Text			
1	4.14 (1.57)	3.09 (1.37)	217	8.41	.000*
2	3.43 (1.73)	2.63 (1.33)	217	6.75	.000*
3	5.16 (1.27)	3.39 (1.60)	217	13.10	.000*
4	4.85 (1.13)	3.63 (1.56)	217	9.42	.000*
5	4.99 (1.11)	3.60 (1.26)	217	12.22	.000*
6	3.29 (1.37)	4.71 (1.25)	217	-12.17	.000*
7	2.48 (1.21)	4.41 (1.67)	217	-14.45	.000*
8	2.97 (1.23)	5.26 (1.54)	217	-17.10	.000*
9	2.21 (1.52)	5.24 (1.76)	217	-19.51	.000*
10	4.90 (1.31)	3.20 (1.49)	217	12.36	.000*

Table 14. Group I - Pure Images and Images with Added Text Paired t-test (N=218).

Dimension	Mean (SD)		*df*	t	*P*
	Without Text	With Text			
1	3.22 (1.65)	4.37 (1.35)	217	-0.911	.000*
2	2.27 (1.31)	3.72 (1.66)	217	-1.20	.000*
3	3.39 (1.75)	4.87 (1.40)	217	-1.22	.000*
4	3.33 (1.45)	4.61 (1.30)	217	-1.04	.000*
5	3.67 (1.42)	4.70 (1.31)	217	-0.819	.000*
6	5.24 (1.48)	4.17 (1.52)	217	1.30	.000*
7	5.18 (1.48)	3.34 (1.48)	217	2.10	.000*
8	4.05 (1.85)	3.48 (1.47)	217	0.808	.000*
9	5.84 (1.26)	4.90 (1.56)	217	1.14	.000*
10	3.50 (2.08)	5.24 (1.68)	217	-1.43	.000*

*Indicates statistical significance

Hypothesis 2: There is no significant difference in the subjects' reflective and critical thinking abilities after viewing images with added text.

(1) Analysis of Pre-test and Post-test for Critical Thinking Ability Questionnaire In this study, paired sample t-tests were conducted on the critical thinking ability questionnaires administered before and after the test. The critical thinking questionnaire items were numbered 1 to 18 for identification. The results showed that, except for pairs 12 and 18 which had t≥(df)0.05 indicating significance with a two-tailed P≤0.05, all other pairs had t<(df)0.05 with a two-tailed P>0.05 (Table 15). These results suggest that there is no significant difference in critical thinking ability before and after viewing text with images.

(2) Analysis of Pre-test and Post-test for Reflective Ability Questionnaire This study also conducted paired sample t-tests on the reflective ability measured before and after the test. The questionnaire items for reflective ability were sequentially numbered 1 to 5. The results indicated that except for pair 1, which had t≥(df)0.05 with significance (two-tailed) P≤0.05, pairs 2 to 5 all had t<(df)0.05 with significance (two-tailed) P>0.05 (Table 16). Most of the questionnaire items for critical thinking and reflective ability showed no significant difference with a two-tailed P>0.05. As multiple data points showed no significant difference in t-values and values, it can be concluded that there is no significant difference in reflective and critical thinking abilities. Therefore, Hypothesis 2 "H2: The change after viewing images with added text affects reflective and critical thinking abilities" is rejected.

Table 15. Critical Thinking Paired t-Test (N=218).

Dimension	Mean (SD)		*df*	t	*P*
	Without Text	With Text			
1	4.07 (.71)	4.09 (.67)	217	.356	.723
2	4.07 (.63)	4.16 (.64)	217	1.50	.134
3	4.22 (.67)	4.11 (.62)	217	-1.75	.080
4	4.24 (.66)	4.27 (.64)	217	.359	.720
5	4.29 (.74)	4.21 (.68)	217	-1.19	.234
6	3.54 (.85)	3.70 (.79)	217	2.03	.043*
7	4.02 (.79)	4.09 (.76)	217	.966	.335
8	4.06 (.70)	4.10 (.70)	217	.551	.582
9	3.76 (.84)	3.82 (.80)	217	.786	.433
10	3.71 (.76)	3.78 (.79)	217	.963	.337
11	3.57 (.89)	3.72 (.85)	217	1.75	.080
12	3.66 (.81)	3.82 (.82)	217	1.99	.048*
13	3.94 (.85)	3.92 (.79)	217	-.249	.803
14	3.79 (.89)	3.84 (.79)	217	.551	.582
15	3.63 (.82)	3.75 (.78)	217	1.50	.134

Dimension	Mean (SD)		*df*	t	*P*
	Without Text	With Text			
16	3.82 (.85)	3.88 (.74)	217	.810	.419
17	3.86 (.76)	3.93 (.70)	217	1.03	.303
18	3.73 (.88)	3.90 (.73)	217	2.21	.028*

Table 16. Critical Thinking Paired t-Test (N=218).

Dimension	Mean (SD)		*df*	t	*P*
	Without Text	With Text			
1	4.07 (.71)	4.09 (.67)	217	.356	.044*
2	4.07 (.63)	4.16 (.64)	217	1.50	.498
3	4.22 (.67)	4.11 (.62)	217	-1.75	.494
4	4.24 (.66)	4.27 (.64)	217	.359	.176
5	4.29 (.74)	4.21 (.68)	217	-1.19	.507

*Indicates statistical significance

Hypothesis 3: Emotional Differences Before and After Viewing Text and Images**

The study compared the collected data with a standard sample and analyzed eight emotional dimensions. Most emotions showed significant differences, except for 'Boredom' (Tables 17). Positive feedback from subjects indicated a change in emotions after viewing the text and images.

Table 17. Independent t-tests Compared with Norms (N=389) and This Study (N=218).

	Mean (SD)		*df*	t	*P*
	Without Text	With Text			
ANGER	2.61 (.44)	1.54 (.22)	12	5.69	.000*
ANXIETY	2.96 (.36)	2.27 (.64)	14	2.67	.018*
BOREDOM	2.82 (.51)	1.62 (.22)	10	6.37	.000*
ENJOYMENT	2.87 (.50)	3.97 (.11)	2	2.98	.096
HOPE	3.50 (.32)	4.00 (.25)	4	-2.11	.102
HOPELESSNESS	1.94 (.11)	1.83 (.79)	2	0.223	.843
PRIDE	3.45 (.17)	3.60 (.15)	4	-1.14	.317
SHAME	2.73 (.28)	2.73 (.69)	4	0.008	.994

*Indicates statistical significance

Hypothesis 4: Significant Difference Between Unexpected and Expected Groups**

Analysis showed significant differences in emotional responses between 'unexpected' and

'expected' image groups (Table 18). The incongruence in text and image information appeared to have a more substantial impact on the viewers, requiring more time for interpretation.

Table 18. Group I - Pure Images and Images with Added Text Paired t-test (N=218).

	Mean (SD)		*df*	t	*P*
	Without Text	With Text			
Emotion 1	4.35 (2.04)	3.65 (1.94)	2495	13.88	.000*
Emotion 2	4.50 (2.10)	3.53 (2.03)	3922	10.28	.000*
Emotion 3	4.53 (2.22)	4.27 (1.98)	2363	3.50	.000*
Emotion 4	4.40 (2.15)	4.21 (1.88)	2321	2.70	.007*
Emotion 5	4.40 (2.14)	4.41 (1.76)	2213	-0.156	.876
Emotion 6	3.61 (2.10)	4.23 (1.73)	2223	-9.215	.000*
Emotion 7	3.41 (2.24)	3.96 (1.84)	2209	-7.630	.000*
Emotion 8	3.36 (1.83)	3.24 (1.64)	2378	2.00	.045*
Emotion 9	3.94 (1.47)	4.57 (1.67)	2932	-11.97	.000*
Emotion 10	4.28 (1.96)	3.74 (1.77)	2388	8.41	.000*

Discussion of Research Results

H1: Text on Images Affects Viewers' Feelings

The statistical analysis confirmed that text on images significantly affects viewers' feelings, with certain exceptions in groups A and D. This suggests that the congruence of text and image influences emotional responses.

H2: Changes in Reflection and Critical Thinking Abilities

Despite no significant changes in critical thinking and reflection abilities, qualitative feedback suggested that subjects engaged critically and reflectively with the material.

(1) Qualitative Feedback:

Participant A: "I want to ask if adding some sentences doesn't quite match the pictures. Is it just me being a bit strange..." Participant A mentioned, "The sentences don't quite match the pictures." They expressed doubt about the correlation between the pictures and the text after the test, raising questions that indicate logical thinking. They didn't passively accept the text accompanying the pictures but actively questioned it. This process aligns with critical thinking ability. Furthermore, when they asked, "Is it just me being a bit strange?" they objectively questioned whether the issue was with themselves, demonstrating reflective thinking.

Participant B: "I rarely reflect on myself, so there might be some bias." Participant B's statement, "I rarely reflect on myself, so there might be some bias," indicates that they have reflected on their shortcomings, which is an act of reflective thinking regarding past

experiences.

(2) Organizing and Analyzing Qualitative Feedback:

The feedback provided by the two participants indicates that they acknowledged their potential issues, demonstrating a certain level of reflective thinking. It can be inferred that both participants engaged in reflection after completing the experiment, and during the experiment, they gained insights into their own shortcomings.

H3: Emotional Differences Due to Viewing Text and Images

The study found that most subjects experienced emotional changes after viewing the text and images, as indicated by both statistical analysis and qualitative feedback.

(1) Qualitative Feedback:

Participant C: "Originally, I thought it was a boring questionnaire, but unexpectedly, I started looking forward to receiving your questionnaire after only two days~" The entire sentence from Participant C indicates that there has been a change in emotion from the initial "boring" to later "looking forward to."

Participant D: "I look forward to tomorrow's questionnaire, I really like the drawings in it." Participant E: "Just wanted to let you know, I'm now really looking forward to filling out the questionnaire. The pictures are drawn very well, and with the accompanying text, I can directly feel the scenarios. It's impressive." Participant F: "Filling this out is a lot of fun~" Participants C, D, E all mentioned the word "looking forward to," and Participant F mentioned "fun." Both "looking forward to" and "fun" are positive words, indicating that participants had a positive emotional response after viewing the images and text. In their feedback messages, Participants D and E both mentioned the images, suggesting that the images had an impact on the participants' emotions.

(2) Organizing and Analyzing Qualitative Feedback:

In the feedback messages, most of the evaluations are positive, indicating that participants experienced a change in emotion during the process and that their emotions changed in response to the content. Additionally, Participants D and E both mentioned the images, suggesting that the images had an influence on the participants' emotions.

H4: Significant Differences Between Unexpected and Expected Groups

Inconsistent messages between text and images significantly affected viewers, as supported by the analysis and literature review. This incongruence can impact the processing of visual and textual information and overall memory retention（Lochbuehler et al, 2017）.

Conclusions and Discussions

According to the statistical analysis, this study found that when subjects view images, they receive messages conveyed by the images and react with corresponding feelings. These feelings are primarily based on the messages conveyed by the images. However, when text is added, feelings change due to the text. It was also found that feelings associated with words unrelated to the images showed no difference. Thus, it's believed that when images are paired with related textual messages, they have a significant impact on feelings. Furthermore, the study compared 'unexpected' and 'expected'

groups of text and images, finding that when the image and text messages don't correspond, the difference in feelings is more pronounced. In the design of text and images, the complexity of "intertextuality" was considered, drawing on Chen Yi Zheng's paper, which divides intertextuality into 'mutual exclusion,' 'complementarity,' 'mutual confirmation,' and 'mutual release.' Most commonly observed in the text-image relationship is the 'mutual confirmation,' where the degree of confirmation increases with the amount of textual message displayed by the image. In the 'expected' group of text and images, which mostly follow the 'mutual confirmation' mode, there is less discrepancy with one's thoughts, unlike the 'unexpected' group that often uses 'mutual release' and 'mutual exclusion.' Hence, 'mutual release' and 'mutual exclusion' are more challenging to understand initially, labeling them as the 'unexpected' group. Images are mainstream in this era and are helpful in cognition. This study believes that conveying feelings is also aided by images, and textual messages can convey messages more clearly. After the experiment, it was found that subjects' feelings easily changed due to text, signifying the significant impact of words in conveying feelings. A combination of both can more completely convey the message of feelings.

This study analyzed critical thinking and reflective ability questionnaires with paired t-tests and found no significant difference in these abilities before and after viewing text and images. Therefore, it's believed that enhancing these abilities might require creating an interactive space for discussion, which was lacking in this experiment due to its non-physical nature. According to the statistical analysis, subjects experienced emotional differences due to viewing text and images. The study also compared data with the AEQ Learning Emotion Scale norm and found differences in ANGER, ANXIETY, and BOREDOM, with lower averages in these negative emotions among the study's subjects. This suggests that the text and images designed for this study were likely more relaxed and fun for the subjects. Since images attract more attention and the brain processes them faster than text, the feelings experienced while viewing are more intense. Thus, the use of images can attract more viewers and make the presentation richer.

Regarding the overall experiment, this study acknowledges the impact of text on images in terms of feelings. Measuring both text and images together may show a stronger difference in feelings than measuring them separately. Future research could compare these aspects. For emotions, subjects were limited in expressing emotions due to the single administration of the emotional scale, which might not accurately analyze the emotions. If an experimental and control group were used, two emotional scales could be administered, though this might lessen the intensity of feelings towards the text and images. Future research should consider this balance and further refine image designs, such as comparing different styles or using more life-like photos. More relatable images could evoke stronger connections and empathy in viewers due to their relevance to personal experiences.

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Developing a Software Program to Improve English Pronunciation: A CALL (Computer-Assisted Language Learning) Analysis

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Abstract

This study aimed to construct a speech recognition-based, English vocabulary-learning software with editable teaching materials for instructors, as well as examine the use of the software interface. The speech engine was based on the Microsoft Speech Platform SDK11 and offered text-to-speech and speech recognition libraries. Two modes of English vocabulary learning were designed for novice English language learners in elementary schools. Therefore, we recruited English instructors at elementary schools to test the software. During semi-structured interviews, they provided opinions and suggestions regarding the editable course interface and assisted learning functions, and these opinions and suggestions were used in revising the system. After two rounds of user testing and revisions, the operating interface was more closely adapted to the users' habits and needs; at that point, the users indicated that the editing process was uncomplicated and easy to learn. The speech recognition function was suitable for one-on-one conversations in environments that were not too noisy; because background noise decreased the recognition rate. The instructors felt that the software could be used as an after-class learning aid or for self-study at home. The system's editable functions allowed the instructors adjust the difficulty and content of the lessons based on each student's progress and made it more flexible than educational software with fixed content.

Keywords **-** Automatic Speech Recognition, Computer-Assisted, Teaching Software, English Vocabulary Learning, Software Design.

Relevance to Design Practice – Software development to improve English pronunciation.

Background and motivations

Rapid advancements in technology have transformed how instructors teach and students learn in the classroom. Computers are often used to assist in instruction. Many computer-assisted, learning-related software applications have been developed and have generated positive educational outcomes.

English is the most important global language. It is taught in elementary schools in Taiwan, and some parents have even allowed their children to learn the language in kindergarten. This highlights the salience of language. The foundation of a language is its vocabulary. The extent of an individual's vocabulary influences their reading comprehension skills and mastery of the language as a whole (Meara, 1995). Therefore, building one's vocabulary is an important aspect of language learning. Numerous computer-assisted language learning (CALL) applications for studying the English language are available. Speech recognition technologies have been widely used in computing in recent years due to their growing maturity. Many software applications used in language learning utilize speech technologies to replace in-person instruction or supply interaction in language learning. According to the statistics provided by Taiwan's Ministry of Education in its "White Paper on Information Education for Elementary and Middle Schools," internet access was available in all schools in 15 counties at the end of 2007, and the computer classrooms in schools in 17 counties had been upgraded, resulting in a nationwide upgrade rate of 90%. Despite the availability of physical information technology (IT) infrastructure in schools, some instructors are still unaccustomed to or restrict their use of computers in teaching. Instructors' information competency influences their willingness to use technology. Those who feel that operating complex software exceeds their capabilities often prefer using traditional rather than computer-assisted instruction (CAI). Moreover, many software developers do not design their products from the instructor's perspective. Due to commercial considerations, most manufacturers do not modify the contents of their educational software after release, and users must purchase newer versions if they wish to access fresh content. Learners become bored with stale content, which has a significant negative effect on their learning outcomes, and instructors are often unwilling to use educational software that cannot be adjusted to accommodate a learner's progress. This study

operated from the instructor's standpoint in designing an English vocabulary-learning software with editable teaching materials for instructors. The teaching materials that we created can be edited and substituted easily through a simple and intuitive interface. Instructors can make adjustments according to each learner's progress without using complex programming languages and settings.

Purposes

In this study, we developed a speech recognition-based, English vocabulary-learning software application that offers two modes of learning. In addition, in response to educational software that is mostly non-scalable and non-substitutable, we designed a user-friendly and intelligible curriculum editing interface that allows instructors to edit content easily. The key purposes of this study were

1. to develop a speech recognition-based, English-vocabulary-learning software with editable functions for instructors;
2. to examine the operation of the software interface;
3. to assess users' opinions about and suggestions for the use of the software in teaching.

Literature review

This study focused on the key issues in instructor-centered analytics software. This chapter consists of three sections. The first section introduces CAI and its challenges and covers the literature on computer-assisted learning. The second section covers speech recognition technologies, including descriptions on speech recognition and the Microsoft Speech Platform software development kit (SDK). The third section covers topics relating to the user interface, including user-centered design and the principles of interface design.

Computer-assisted instruction

This section covers the literature on CAI in two sections, the first being an introduction to CAI and the second being the challenges of using CAI.

Introduction to CAI

CAI (Tan & Hsu, 2018) is a learning approach in which teaching materials are presented through computer systems, and learners acquire knowledge by interacting and communicating with the computers to achieve their learning targets (Huang, 2003; Tan, 2013). Through vivid feedback, CAI attracts learners and increases their motivation to learn. Research has shown that the inclusion of digital technologies and the

use of sounds, imagery, and interactive components can enhance learners' attention and strengthen learning outcomes (Wu et al., 2010). Other studies have found that CAI boosts motivation for learning among low achievers and students with a fear of failure (Meskill & Swan, 1996; Tan, 2015; Tan, 2019).

Five learning approaches are used in CAI software: tutorial, drill and practice, simulation, game-based, and test-based (Alessi & Tropllip, 1991; Tan, 2015; Tan & Hsu, 2017a, 2017b; Tan, 2019). Thanks to technological advancements, the majority of current CAI software applications include multiple approaches. For example, the English electronic textbooks published by Kang Hsuan Educational Publishing Group in 2011 (Figure 2-1) incorporate all five learning approaches. Tutorials teach key points and explain big words much as an instructor would. In the drill and practice sessions, the speech recognition functions of the system identify and evaluate users' pronunciation. In the simulations, students can choose a role to play and converse with the system much as they would with a real-life respondent. The built-in games and tests enable them to learn in a relaxed manner and verify their learning outcomes.

The challenges of using CAI

According to the 'White Paper on Information Education for Elementary and Middle Schools' (2008) published by Taiwan's Ministry of Education, all elementary and middle schools in 25 counties and cities were connected to the Taiwan Academic Network (TANet) from 1999 onwards. At the end of 2007, Internet access was available in all schools in 15 counties, and the computer classrooms in schools in 17 counties had been upgraded, resulting in a nationwide upgrade rate of 90%. Therefore, elementary and middle schools in Taiwan have Internet access and computer infrastructure that can meet the educational needs of students and instructors. The report also mentioned that instructors should possess IT competency, which is a compulsory component in instructor education in South Korea. In Canada, too, instructors must attain certain minimum IT competency requirements to obtain their teaching certificate. However, the elementary and middle school instructor preparation programs in Taiwan have yet to make IT competency compulsory.

While young instructors have aligned themselves with the digital era and have a high acceptance of technology, older instructors must develop digital literacy from scratch (Tan & Hsu, 2018b; Tan, 2019). In Davis' (1989) technology acceptance model, perceived ease of use is the degree of accepting a new technology. A user

would reject using a new technology if they perceived learning to use it to be a barrier. Therefore, even if the physical infrastructure for learning is improved, instructors have a low willingness to use digital technology if they do not possess the ability to do so without difficulty (Tan & Hsu, 2018b; Tan, 2019). However, the deans of academic affairs in elementary and middle schools surveyed by the Ministry of Education (2008) reported that high software costs were the main barrier to the use of educational software. For commercial reasons, software developers often design each course to stand alone, and purchases are required to expand the application's functions. Because the use of educational software requires scalability, developers who do not expand their software disrupt the teaching process and decrease instructors' willingness to use their programs. To examine the technology-use needs of instructors, Chen (2013) conducted onsite interviews in learning environments. The instructors Chen interviewed had three requirements for educational software: 1) that the teaching materials could be reorganized, 2) that the teaching contents could be added or deleted, and 3) that the tools for editing teaching materials cater to the IT competency of instructors and are user-friendly, intelligible, and accessible to lessen the instructors' workload.

These studies suggest that little attention has been directed to the level of acceptance of educational software among instructors despite the rapid development of digital teaching materials. Some instructors do not have the computer literacy required to use digital approaches to enhance their teaching outcomes and prefer to offer traditional instruction. The software designed in this study offers simple editing functions so that instructors can easily modify the contents of their teaching materials.

Speech recognition technologies

This section covers the literature on speech recognition technologies in two sections. The first introduces speech recognition, and the second introduces the Microsoft Speech Platform SDK.

Introduction to speech recognition

Speech recognition technology, also known as automatic speech recognition (ASR), is a human-machine interactive technology that has been developed in recent years. Developments in speech recognition technology have not only brought convenience to our lives but also provided flexible learning approaches that cater to different types of learners with different levels of achievement. For instance, by combining databases with speech recognition technology and recording and analyzing learners'

conversations, more suitable materials can be selected from the databases and presented to learners. There are currently three types of speech recognition technologies (Precision Machinery Research and Development Center, 2008); they are aimed at different intended users.

1. Speaker-Dependent System

Speaker-dependent systems are designed specifically for certain users and must be trained by those users. They are designed to recognize speech from the designated users and do not guarantee an acceptable recognition rate for other users.

2. Speaker-Independent System

Speaker-independent systems do not have to be trained by users and are designed for general users. However, their speech recognition rates are poorer than those of speaker-dependent systems because it is harder to collect the voice recordings for training. Their recognition rates can be improved by building command word databases.

3. Speaker Adaptive System

Speaker-adaptive systems require little training to achieve a recognition rate similar to those of speaker-dependent systems. Users follow the system requirements when they first use the system and record an audio segment. The segment undergoes signal analysis in the system to calculate the adaptive parameters for the users and build files. When a user returns to the system, it continues to adapt to their voice to enhance the recognition rate. Since the aim of this study was to design a multiuser learning application, a speaker-independent system was used alongside the Microsoft Speech Platform SDK to develop the software.

Introduction to the Microsoft Speech Platform SDK

The Microsoft Speech Platform SDK is a comprehensive engine for speech recognition and speech synthesis. By embedding speech recognition and speech synthesis functions in developed software, users can replace certain keyboard and mouse gestures with voice commands. The speech recognition in this engine is restricted to only preset strings, and strings that are not preset will not be recognized at all. The Microsoft Speech Platform SDK is based on the .NET windowing operating system. Its lower-layer protocols, in the form of .NET components, are completely independent of the application software layer so that software developers can avoid the need to use complex speech recognition technologies. The engine's latest version is 11.0. Its workflow diagram is presented in Figure 2-2 and its working principles are described as follows:

1. Initialize the speech recognition object engine.
2. Define the speech interface components such as language identification, recognition event callback function, string data, and input sources. After completing this process, set the speech engine in work mode.
3. Input voice commands through a microphone.
4. Once the set strings have been detected, start the recognition event callback function to analyze the detection. The information generated includes the detected strings and recognition rate. This procedure is reiterated until the speech recognition task ends.

User interface

This section covers the literature on the user interface in two sections. The first addresses user-centered design, and the second treats the principles of interface design.

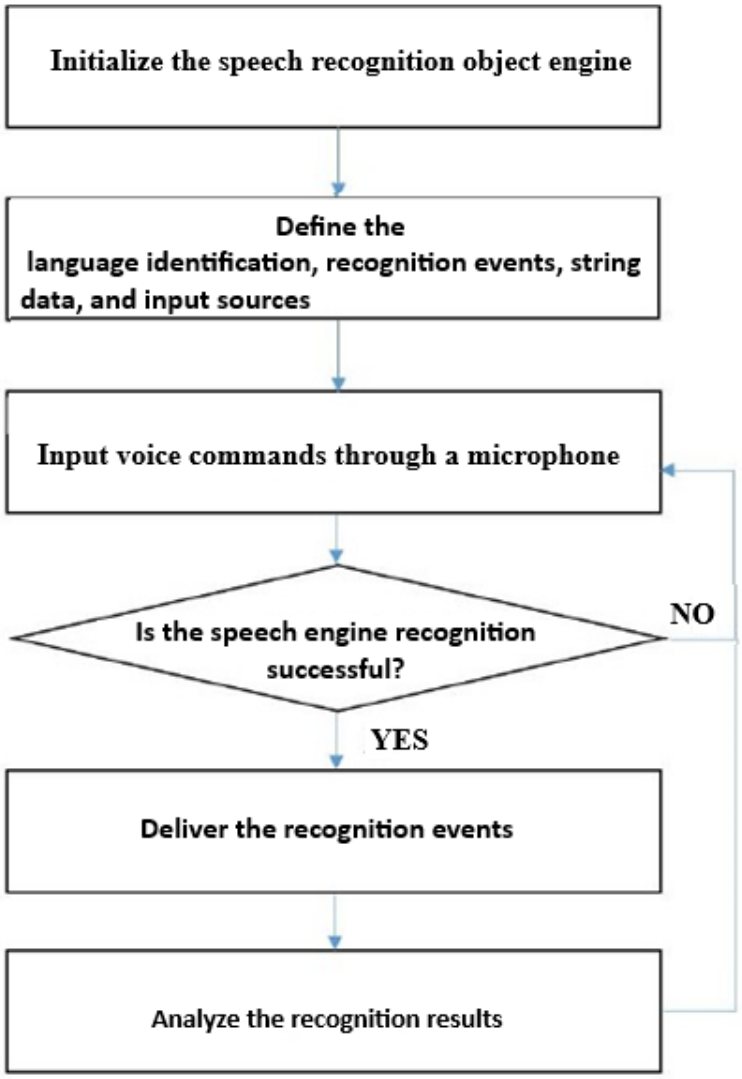

Figure 1. Microsoft Speech Platform workflow diagram.

User-centered design

Winograd and Woods (1997) stressed that a system developer must be able to create a user experience-centered integrated system, rather than focusing on the basic system functions. Otherwise, the system may be impractical and limited.

Tory and Moller (2004) pointed out that creating a user-centered design requires the use of a cycle of processes that include task analysis, design, prototype implementation, and testing (see Figure 2-3). The entire process of system design is a cycle that incorporates product testing,

revision, and redesign. This process is also known as user-centered design (Tan & Hsu, 2017a; 2017b).

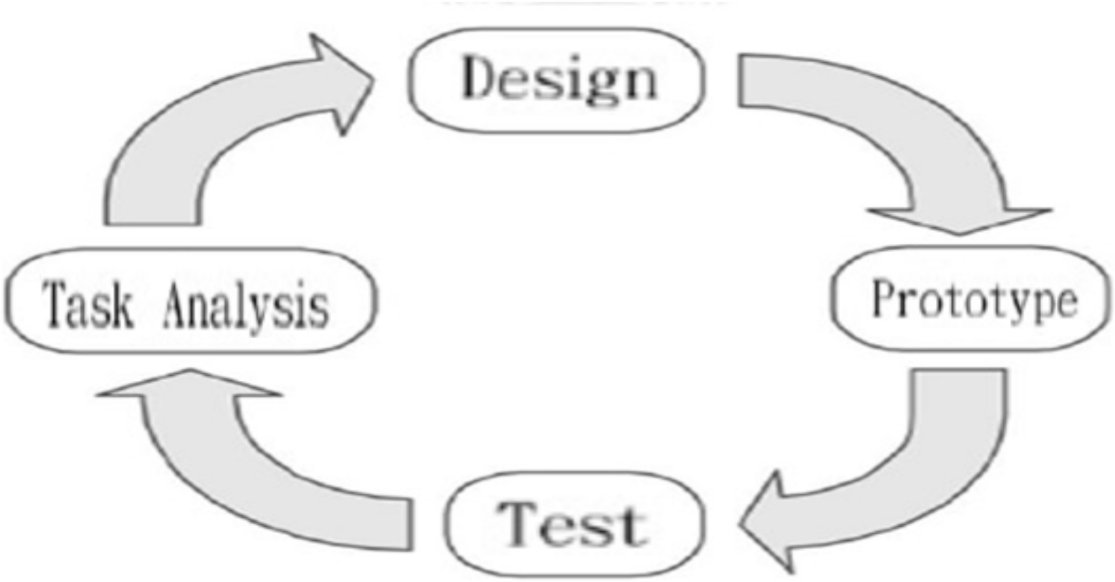

Figure 2. The user-centered design cycle (adapted from Tory and Moller, 2004).

Users should be engaged in each phase of the design process as much as possible. This ensures that the functional orientation of the product is based on their needs and that users can identify with and accept the end product. However, this design model has drawbacks. Collecting information from users requires a considerable amount of time, as does considering the different scenarios in which users employ the system. Therefore, the trade-off between meeting user expectations and controlling costs is an important consideration in product design (Abras et al., 2004).

Principles of interface design

A user-friendly application must have a well-designed user interface. Based on years of observations and experience, Shneiderman and Plaisant (2010) identified the eight principles of interface design necessary for the creation of an excellent user experience. These principles are listed below.

1. Strive for consistency

The prompts, menus, and information screens should have a consistent color, size, and font. Exceptions are permitted (e.g., requiring users to confirm whether they sent a delete command) but must be limited in number.

2. Cater to universal usability

The interface design should be flexible to meet the needs of different users. For example, providing extra information for beginners or adding shortcuts or special commands for experienced users enhances system quality and usage efficiency.

3. Offer informative feedback

Users should receive feedback from an application after using it. Important actions and changes need to be clearly and visually presented along with enriched responses to guide the user. For example, visual feedback should accompany volume adjustments and progress tracking.

4. Design dialogs to yield closure

Appropriate feedback should be provided to the user at each phase in a group of actions (start, middle, and end) so that the user fully understands the process. For example, e-commerce websites guide users from product selection to checkout and present a confirmation screen when a transaction has been completed.

5. Prevent errors

The user interface should be designed to minimize user errors. If the user errs, the operating system should be able to detect the mistake and provide clear and simple instructions for recovery.

6. Permit easy reversal of actions

Actions should be as reversible as possible so that the user can recover from an error. For example, many software applications include “Undo” or “Cancel” commands to reduce user anxiety.

7. Support internal locus of control

Experienced users are extremely mindful of their control over the user interface and wish to know how it responds to their actions. Therefore, these users do not desire drastic changes to the user interface with which they are familiar.

8. Reduce short-term memory load

Because humans have limited information processing capacity in short-term memory, the interface should be designed to prevent users from having to source information from other interfaces. For example, cell phones should not require rekeying phone numbers, and multiple web pages should be merged.

As the guidelines above suggest, a good software interface should be attentive to detail and have a consistent visual presentation and mode of operation. Therefore, the style, appearance, and color tone of images in every interface should be consistent so that information will be conveyed

clearly to users. The design of the application developed in this study followed the user-centered design approach proposed by Tory and Moller. Unsuitable components were identified through repeated testing to produce an application that attends closely to user needs (Tan & Hsu, 2018a, 2018b).

Methods

This section describes the methodology in four sections. The first covers the study framework, the second describes the study participants, the third outlines the software design concepts, and the fourth details the study tools.

Study framework

The main elements of the study framework, as shown in Figure 3-1, were proposing the design principles, developing the software, having it evaluated by users, and revising the software. These elements are detailed below.

Proposing the design principles

Based on the literature, we identified the challenges that the use of computer-assisted learning software presented. We learned that instructors desired digital educational tools with editable teaching materials. This study utilized the speech recognition function of the Microsoft Speech SDK to develop a speech recognition-based, vocabulary-learning software with editable teaching material functionality for instructors (Tan et al., 2019).

Software development

The experimental software application developed in this study using Shneiderman and Plaisant's (2010) eight principles of interface design consisted of two classes of components: 1) speech processing programs that analyzed the user's voice patterns and converted the words into speech composites generated through computer speech, and 2) user control programs, which integrated the game and course editing interfaces, processed user actions, and provided feedback.

User evaluation and software revision

To allow the software to serve the user's needs more closely and eliminate deficiencies in its design, once the design was completed, the first round of user evaluation took place and the interview outline was designed. After the evaluation, interviews were conducted to identify, summarize, and rectify errors. The revised version that was based on the user evaluation was still considered the first version. After evaluating the revised version, we summarized the experimental results and considered directions for improvement and future developments.

Participants

The editable English vocabulary-learning software developed in this study offers instructors an interface for editing teaching materials, is integrated with speech recognition, and has two modes for English vocabulary learning. We interviewed English language instructors after they used the software to obtain their opinions and suggestions about the software interface and the practical utility of the program, as well as to identify correctable issues. The learning modes and games cater to elementary school students who are novice English learners. Thus, the users in this study were English language instructors at elementary schools.

Due to workforce, time, and locational considerations, we selected English language instructors at an elementary school in Tucheng District, New Taipei City as participants.

Because the speech recognition engine only works on a Windows operating system, we ran the software on a Windows 7 computer with a 1280*720 screen resolution. The experimental location was the teachers' room at the school. After the software was installed, each user used the software and engaged in an interview to provide their suggestions for revisions.

Design concepts

This section describes the system design concepts in three sections. The first introduces the application of the software in student learning, the second its application in teaching, and the third its application in the design of educational materials.

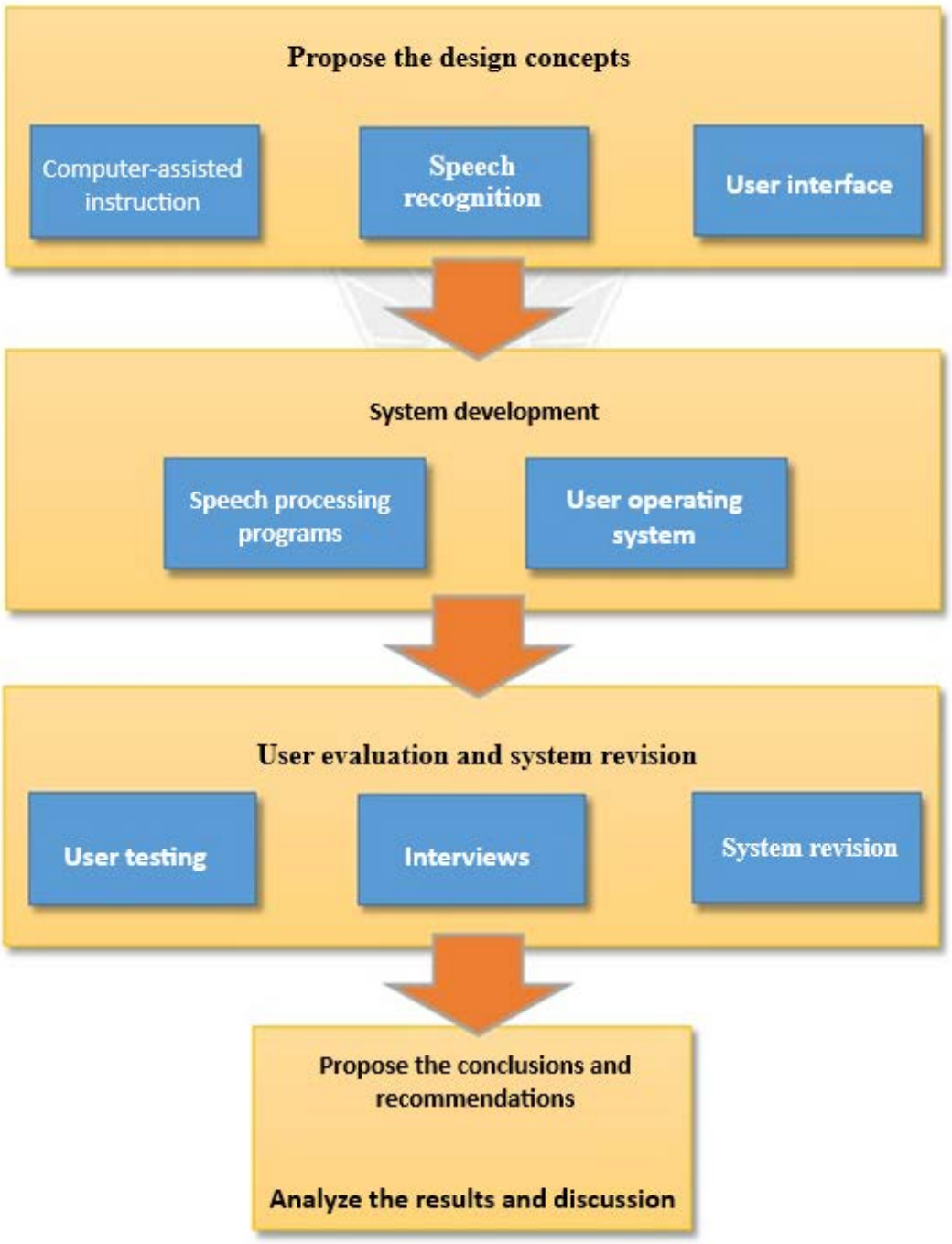

Figure 3. Study Framework using the Speech Interface.

Using speech recognition technology, the system listens to student pronunciations and scores them on accuracy. A text-to-speech program provides the correct pronunciations through a computer. This allows the students to practice repeatedly,

correct their pronunciations, and strengthen their vocabulary.

The primary goal of developing the learning software in this study was to introduce various English words to students so that they could build their vocabulary. The software includes a training mode and a game mode. In the training mode, images and English terms of objects are presented alongside their pronunciations. When students attempt to pronounce the words, the system scores them on the accuracy of their pronunciation. This training mode allows them to learn at their leisure so they do not become anxious when they enter the game mode. In the game mode, objects fall continually from the top of the screen over a specific time interval, and the students must pronounce the names of the objects correctly. If they reach a certain score for correct pronunciations, the objects disappear and the scoring begins; if they do not reach the scoring threshold, the objects do not disappear. Objects disappear once they reach the bottom of the screen but are excluded from the scoring.

Application in teaching

Most CALL software applications are developed for commercial purposes. The teaching materials such applications offer are often limited; they are only suitable for certain units, and the teaching materials cannot be edited. For this study, we designed an interface that allowed instructors to edit the teaching materials, which were replaceable and easy to edit. The instructors did not need to learn complex software settings or programming languages and could edit new teaching materials simply by clicking, which allowed them to make adjustments based on their teaching progress.

Application in the design of educational materials

The learning software developed in this study is primarily geared toward teaching English vocabulary and encouraging correct pronunciation through a game-based approach. The games were designed to teach students to correctly pronounce the names of the objects shown, and therefore the images of the objects were designed to be clearly recognizable to avoid confusion. For example, if the image chosen to represent the word “beautiful” is a girl, the students may mistake the word as “girl”. Therefore, ambiguous words had to be avoided in the design of the software.

To allow the teachers to edit the teaching materials, the software has a completed term base with a search function that allows them to identify words effortlessly. The words in the term base consist of the basic 1,200 English words specified in the Ministry of Education’s

(2008) curricular guidelines for English education in elementary and junior high schools (Grades 1 to 9).

Study tools

The study tools consisted of the software development tools and an interview outline.

System development tools

We used the Unity game engine to develop our software. Unity has an interactive and uncomplicated graphical interface. Some of its functions, such as the text-to-speech and speech recognition libraries, are built on the Microsoft Speech Platform SDK 11. However, Unity does not directly support the Speech SDK, so another program designed specifically for speech recognition processing (such as the .NET Socket framework) must be used to connect the two programs. Both programs are developed using the C# Script programming language. We used Visual Studio 2012 to write and develop the programs and Adobe Photo shop CS6 to design the system interface. The system development tools are presented in Table 3-1.

Table 1. The list of system development tools.

Type	Product
Programming language	C# Script
Program editing tool	Visual Studio 2012
Software development tool	Unity 4.3.0
Inter-process communication mechanism	.NET Socket
Speech recognition engine	Microsoft Speech Platform SDK 11
Interface design tool	Adobe Photoshop CS6

Interview outline - After the system was developed, an interview outline was designed based on the system functions and interface design. Interviews were conducted to collect the users' experience to serve as a basis for system development and function revisions. Seven instructors were invited to test the system and provide their opinions regarding the revisions to the system functions and user interface as well as future developments. The interview outline is shown in Table 2.

Table 2. Interview outline.

Interview questions	Description
Have you ever used editable teaching materials and speech recognition-based English learning software?	To understand the interviewees' experiences in using editable speech recognition-based English vocabulary-learning software to facilitate subsequent questioning.
Is the course editing interface intelligible and user-friendly, and is its layout appropriate?	To understand whether the operation, displays, and feedback elements of the course editing interface were appropriate (to provide a basis for further revisions).
Are the layouts of the two interactive games in the learning function and the feedback they provide appropriate?	To understand whether the layout of the interface and the feedback offered in the two interactive games in the learning function were appropriate (to provide a basis for further revisions).
What are your thoughts on and suggestions for the editable teaching materials? What are their strengths and weaknesses?	To understand the potential of integrating the editable teaching materials and interactive games, assess what added value they might offer, and how they influence developments in teaching.
Do you have other additional thoughts and suggestions on applying this system in teaching?	To understand what the users think about using the software in teaching and obtain their suggestions for further revisions and developments.

Conclusions and recommendations

The primary goal of this study was to construct a speech recognition-based, English vocabulary-learning software application that allows instructors to edit the teaching materials. The study findings are summarized in the first part of this section, under "Conclusions," and the recommendations for future research are presented in the second part.

Conclusions

The editable English vocabulary-learning software developed in this study employs speech recognition and speech synthesis technologies to help learners build vocabulary, while the editable course interface allows instructors to edit course materials based on their needs. After the software was developed, it was tested by English teachers in elementary schools, who were then interviewed. They provided recommendations and opinions on the editable course interface and learning assistance functions; their recommendations and opinions provided a basis for system revisions.

After experimenting with the system twice, users who were not computer-savvy felt that more direct information or comprehensible and meaningful icons should be added to the system so that users could learn how to use the system more easily. However, they indicated that the editing process was easy and uncomplicated.

In assessing the educational aspects of the software, most instructors focused on the feedback to students. They felt that the use of rich imagery or sound effects would be more effective in attracting students' attention. Some instructors indicated that the games were useful for learning as they improved the students' motivation to learn.

The participants also addressed the practical applications of the software in teaching. They indicated that the speech recognition function was suitable for one-on-one conversations in less noisy environments; noisy environments decreased the recognition rate. They felt that the software could be used as an after-class learning aid or for self-study at home. The editable functions in the system allowed the instructors to make suitable adjustments to accommodate each student's progress. The program was more flexible than educational software applications that offer fixed teaching contents.

Recommendations

The system in this study was an experimental framework that could be considered a complete educational system because of its editing components and educational functions. However, there were too few editable items, and only users

could edit them. Many users expressed a desire to add their own terms to the term base instead of choosing from the existing content. For aesthetic reasons, the system was designed in a way that requires the users to memorize the images (which most of them would not). Therefore, a built-in term base is required so that the software itself provided the images for teaching. The interface design should be improved as well as the use of some of the interfaces was not intuitive. For example, the buttons may not seem clickable to first-time users. The aesthetic quality of the images should also be improved.

The suggestions and ideas for further development of the software were based on the interviews with the seven instructors. The instructors felt that a member management function could be added to the system so that they could edit their courses or share them with other teachers. Statistical analysis functions could also be included to give the instructors a better understanding of the students' learning progress. Providing more game options could enhance learners' motivation to use the system. A final observation relates to the operating platform. The Windows speech engine can only be used with Windows operating systems. However, as the penetration rate of mobile devices increases, users may favor software applications that allow cross-platform implementation. While these problems could be resolved online, they were not ameliorated during the study due to time restrictions.

To summarize, we recommend adding the following features to the software:

1. Social networking capacity
2. More diverse games
3. Cross-platform functionality
4. More editable items
5. A score management interface

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