Investigating the User Experience of Mind Map Software: A Comparative Study based on Eye Tracking

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***Abstract*—Software for creating mind maps is currently prevalent, and it should have strong usability and create a good user experience. Usability testing can help to uncover flaws in software's usability and support its optimization. This paper took the mind map software "Xmind" and "MindMaster" as study cases and conducted comparative research on three aspects: effectiveness, efficiency, and satisfaction. The research investigated 20 participants' interactions with the two software. Task completion rate, number of errors, and number of requests for help were collected to evaluate the effectiveness. Eye tracking data and task completion time are collected to evaluate efficiency. System usability, interface quality, and emotional dimensions were collected with subjective scales to assess the software's user satisfaction. The data together led to a conclusion: each software has a few usability issues. The use of jargon to explain functions was costly to learn and quickly undermined users' confidence in using the software; the interface's simplicity impacted satisfaction, although users tended to evaluate utility tools in terms of their ease of use and ease of learning. These findings could be used to optimize utility software.**

***Keywords*—Usability; mind map software; comparative research; eye tracking; user experience**

I. Introduction

The Mind Map was created in the twentieth century in England. Tony Buzan discovered a prototype of a form of representation concerning the radioactive mind and its images (i.e., mind map) while studying the neurophysiological science of the brain[1]. As a practical tool to visualize the thinking process, it has been widely used in teaching, business, personal, and team information management and is still penetrating other areas. Because of the continuous development of mobile network technology and application devices, software for drawing mind maps increased gradually and variously. Current research primarily focuses on applying mind map software in specific fields, with little concern about usability and user experience. As a utility tool, mind map software requires good usability and user experience to help users draw mind maps much simpler and increase efficiency and pleasure. In-depth usability research in this paper can help software designers understand better how the interaction logic, information quality, and interface layout influence the user experience together.

This study examines the usability of mind map software from three aspects: effectiveness, efficiency, and satisfaction. 20 subjects were invited to complete the given tasks with mind map software, and data were collected through eye tracking, user interview, and usability questionnaire. The usability problems in the interaction and visual aspects of the mind map software were explored.

The paper is organized as follows. The literature review is explained in Section II. Next, the methods adopted for this research is described in Section III, followed by the experimental tasks and procedure in Section IV, and evaluation metrics in Section V. The research results of usability and user experience are analyzed in Section VI. And the discussion in Section VII. Finally, the conclusion and future works are given in Section VIII.

II. Literature Review

For mind map software, good usability helps users to record and disperse their thoughts efficiently. User experience assessment can identify software problems regarding effectiveness, efficiency, and user satisfaction.

A. Implementation of Mind Map Software

Mind mapping is the process of constructing concepts graphically[2]. The core concept acts as the center, and related and subordinate concepts are grouped into various branches. A new concept is derived from an additional point of an existing concept, forming a tree structure in the diameter direction[3]. With eye-catching colors, simple graphics, and logical and precise lines, mind maps help increase learning and job productivity by making words and theories systematic and neatly structured[4].

In recent years, mind maps have become increasingly significant in education and teaching reform at all levels, from elementary school to university. Many studies use mind mapping to improve teaching and learning. For example, Fung D[5] investigated the effectiveness of mind maps in in Hong Kong Primary Science Classrooms; YANG A et al.[6] used mind maps in the teaching practice of elementary school composition; WEI C et al. [7] used mind maps in the teaching practice of human parasitology. These studies show how visual tools can improve teaching and learning and promote more profound knowledge. Olga Maksimenkova et al. [8] created an automatic grader for educational mind maps (AGEMM) based on the quantitative properties (node count, associations count, image count, and branching levels), which acts like a teacher's assistant.

In several other fields, including Finance [9], Medicine [10], Marketing [11], Economics [12], Engineering [13], Management [14], Computer [15], Fine Art and Design [16], Advertising [17] and Public Relations [18], etc., mind maps are also used to facilitate the collaboration in the workplace. Mind mapping contributes to collaborative work, especially during the COVID-19 pandemic today. Dilshod Kuryazov et al. [19] introduced the tool CMCM (Collaborative Mind-and Concept-Mapping) to demonstrate the viability of tool cooperation made possible by model differencing used for the collaborative modeling of Mind Maps.

However, little research has been done on drawing mind maps. According to Joeran Beel et al.[20], users generally construct "typical" mind maps that are relatively short, usually only a few hundred branches, seldom use annotations, linkages, and other features, and are typically modified repeatedly within a day or two. This indicates that people care more about mind maps' timeliness than the amount of information, which implies that more attention should be paid to the software's efficiency and efficacy while drawing.

However, being efficient and effective does not equate to a positive User Experience (UX). Many scholars have done a significant amount of usability research on digital libraries, online advertising, and systems engineering. Sudatta Chowdhury et al. [21] divided the concept of usability into two main lines (library intelligence and human-computer interaction). Hansen P [22] considered that usability in human-computer interaction systems refers to a particular interface's effectiveness, efficiency, and satisfaction. Usability is defined by the International Organization for Standardization (ISO) as the “extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use” [23]. The specific interpretations are as follows:

- Effectiveness: the user's precision and completeness in achieving the specified goal.
- Efficiency: the resources consumed by the user to precisely achieve the goal.
- Satisfaction: the user's comfort and acceptability of use.

However, ISO 9241 focuses too much on established tasks and goals, emphasizes efficiency and effectiveness, and ignores what is challenging to grasp in user experience. Furthermore, it does not apply to all scenarios, and satisfaction is also unsuitable as a usability indicator in many cases[24]. Even though ISO 9241 has been criticized for being inadequate as a criterion for evaluating usability, it is still extensively used.

Usability is a highly abstract term difficult to quantify and cannot be precisely tested. Many researchers have decided to build an assessment index system based on each index to assess the system's overall usability. According to Nielsen[25], usability can be divided into "efficiency of use," "ease of learning," "memory retention," "use reliability," and "user satisfaction." "response time," "learning time," "long retention time," "user error rate," and "subjective satisfaction" were chosen by Schneiderman[26] as indicators of user interface usability. Preece et al.[27] chose "throughput," "ease of learning," and "attitude" to measure the usability of HCI systems; Shackel[28] combined "effectiveness (speed)," "ease of learning (learning time)," "ease of learning (memory retention)," "effectiveness (error rate)," and "attitude" to define as usability evaluation index systems. In addition, content metrics and user-centered metrics can be categorized under the usability metrics system [29].

Current research has clarified the metrics for usability evaluation and established many theoretical foundations. However, there are specific variances between different genres, and the mind map software evaluation system should be updated to consider the peculiarities of mind mapping and user habits. This study employs a user-centered approach to usability evaluation, accounting for the efficacy, efficiency, learnability, and usability of mind-mapping software, user interface, and user sentiment metrics.

B. Usability Methods based on Eye Tracking

Typical usability assessment techniques include questionnaires, heuristic evaluation, focus groups, think-aloud, and card sorting[30]. However, the main limitations in implementation, particularly in user interface evaluation, are as follows[31]:

- The host will unavoidably affect the subjects and their behavior during the test through words, deeds, expressions, and expectations. This is especially true when there are several staff members.
- The test result’s objectivity is not very good. The test mainly gathers qualitative information about individuals' preferences and inclinations.
- The experimental control is not strict enough during the test, and the reproducibility of the test results is low[32].
- The internal processing of the user is complicated for the test data to reflect directly, and the interpretation of the phenomenon is based chiefly on the tester's knowledge and experience, which is subjective.
- The test is costly, the sample size is limited, and there are issues with the statistical significance and representativeness of the test results.

Eye movement is crucial for visual processing information when using a computer interface. Eye tracking was initially recognized in reading studies in the late 19th century, and the first eye tracking apparatus was created in the early 20th century. As eye tracking technology advances, experts and academicians gradually discover the relationship between eye movements and human cognitive processes. Paul[33] and his colleagues were the earliest researchers who employed eye tracking in user experience research in 1947. This method was not frequently used until the late twentieth and early twenty-first centuries. According to Aga Bojko [34], objective data gained from eye tracking aids in better understanding how different designs affect user experience and the demands, preferences, motivations, and processes of consumers or potential product users. According to Ivory and Hearst, visual recordings can be used for usability testing[35].

Eye tracking is a technology that records an individual's eye movements and can be used for usability assessment, especially for assessing visual user interfaces. This could be achieved by analyzing the data generated using this technology[35], including Fixation, Saccade, Behavior metrics, and data related to areas of interest (AOI) that dominate the data presented here. Data can also be visualized as gaze maps, scan paths, gaze videos, swarm maps, heat maps, focus maps, etc. According to Sandra Milena et al.[36], the aspects of usability evaluation that can be performed in digital information environments by eye tracking metrics primarily include search efficiency, interface quality, information visibility, and expectation flow.

Few studies have used eye tracking technology to evaluate dynamic processes and overall usability, while data from eye-tracking devices alone cannot shed additional light on user experience. This study attempts to assess mind map software's effectiveness, efficiency, and user satisfaction by combining subjective scale scoring and objective eye-movement data. The eye movement heat map was used to investigate the factors influencing the software's overall usability. We also combine interviews, and user behavior observations to more thoroughly argue the deeper reasons for user behavior. As a result, more reliable usability conclusions can be reached.

III. METHODOLOGY

The technique for the experiment's usability testing is described in the following section. The source of the sample software is discussed, along with how the task was created so that the participants could understand how to use the software and incorporate eye tracking into the experiment.

A. *Study Design*

An assessment test and a comparison test were both employed in this experiment. As much as possible, we gathered qualitative tendency data and quantitative operational data using simulated tasks, interviews, observations, and eye tracking [37]. We can evaluate which alternative is easier to use and learn by contrasting the various design possibilities of two software examples. Additionally, it aids in our comprehension of the advantages and disadvantages of multiple designs.

Due to variances in the mind-mapping process among the individuals, the functions and time spent generating distinct graphs varied. The task scenario was set to "You need to use the software which we offered to draw a mind map for work reporting as shown in the case diagrams" to control the variables. The individuals were instructed to execute the tasks using the sample software, and we gathered usability-related data.

B. *Sample Software*

A web-based questionnaire was used to conduct a study on the use of vector drawing software before the start of the experiment. Ninety-four valid questionnaires were collected, with 64 people (68.09%) having previous vector image drawing experience. Mind maps were drawn by 82.81% of those with vector drawing experience in the sample. Xmind was chosen by 38 people, accounting for 71.7% of those who used related software. Visio (11 people, accounting for 20.8%), EDraw (8 people, accounting for 15.1%), MindMaster (6 people, accounting for 11.3%), and ProcessOn (6 people, accounting for 11.3%) were the others in that order. MindMaster is more focused on mind mapping because EDraw and MindMaster are owned by the same company and have similar product designs. According to market share, this study chooses Xmind and MindMaster as the study cases.

In the beginning, the similarities between Xmind and MindMaster as mind map software are primarily centered on the functional level, as both are designed to suit the needs of a daily mind map. Both provide a range of templates when producing a new drawing; the basic features of the drawing are essentially the same. Both provide labels, pictures, and other elements, and both may export standard image formats after the drawing is completed.

In addition to the preceding similarities, the two software differ significantly in information hierarchy, page layout, and visual style. MindMaster externalizes more information than Xmind in terms of information hierarchy, stacking as many functions as possible on the top toolbar. In contrast, Xmind hides more functions in the secondary directory, which must often be retrieved via the top menu bar or right-click. Table I displays the exact differences.

TABLE I. DIFFERENCES IN DESIGN BETWEEN THE TWO SOFTWARE

Differences	***Xmind***	***MindMaster***
Top Toolbar	Other functions in the first level of the menu bar drop-down menu are only for frequently used parts in the form of text with icons in the second level.	Using tabbed management, huge categories beneath the text and icons to indicate specific available options, and the default state to display the most often used tools.
Free Themes	Different levels from "Topics" and "Subtopics" are placed at the top of the page under "Insert."	In the top toolbar category, "Topics" and "Subtopics" are on the same level.
Side Format Panel	Default Hidden	Default Expand
Presentation of Auxiliary Functions	Preference for textual descriptions.	Pure icons are preferred, with text descriptions loading after the mouse hovers over.
Visual Style	The Minimalist style is dominated by grey and white tones.	Simple yet not excessively energetic green as the theme color
Online Features	None	Cloud files, online sharing, etc.

C. *Participants*

Five people can discover around 77%-85% of the detection system's usability difficulties, according to Nielsen's fitted regression curve $n=N\ 1-(1-L)^{n}$ [38] where n is the number of users, N is the total number of usability problems in the design and L is the proportion of usability problems discovered while testing a single user. However, because substantial variations between participant groups from a smaller number of participants are difficult to uncover, Spyridakis [39] stated that

10-12 people would better properly investigate the product's usability concerns.

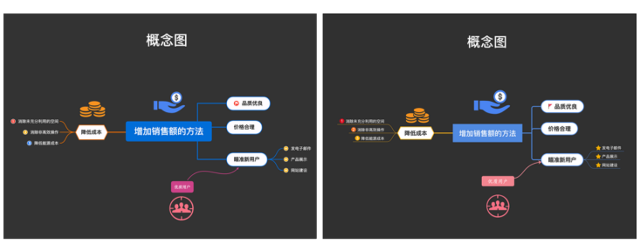
Based on their familiarity with the software, time spent using it, and frequency of use, inexperienced and experienced participants were purposefully picked for the experiment. Twenty participants were chosen from a Chinese university with various specialties. They were split into two groups, A and B; each group had five novice participants and five veterans.

D. *Materials*

1) Experimental equipment: The eye movement data were recorded by the Tobii-Glasses2 RU-type oculomotor, and the data were analyzed using the Tobii Pro Lab software. With a weight of only 45 grams, this eye-tracking head module model provides an ultra-lightweight and sturdy non-intrusive head-tracking module that ensures the interviewee's comfort and freedom of movement. Lenses for vision correction are also appropriate for a wider variety of people (independent of age, gender, or myopia)[40].

Under Windows 10, Xmind version 11.2.2 and MindMaster version 9.0.9 were used, as they were the newest versions available in China at the time of the experiment. For post-test interviewing, EV recording software was utilized to record during the task. All software is available in Chinese.

2) Test sample images: According to Beel J's[20] research and pre-test interviews with the participants, users strive to complete the mind map in a timely and efficient manner by adding topics, changing styles, and finally completing the drawing and exporting the required file format. In contrast, mind map software features such as annotations and hyperlinks are used less frequently. A standard tiny mind map is defined as the target, which involves using high-frequency functionalities such as topics, subtopics, floating topics, relationship lines, branches, and styles. When users completed the drawing work under the usage scenario, the collected data was used to examine the usability issues. Fig. 1 shows an example of each software provided to participants as reference.



(a) Xmind Test Sample Images (b) MindMaster Test Sample Images

Fig. 1. Test Sample Images (Chinese Version).

IV. EXPERIMENTAL TASKS AND PROCEDURE

By having the participants create an identical mind map using each software, the experiment aims to compare the many interaction forms of the two kinds of software in-depth and assess the usability of the entire system. The drawing process is divided into ten key operations (see Table II) to collect the critical nodes in the software more effectively and identify the essential components affecting the user experience. The entire task is finished once all ten tasks have been completed.

TABLE II. EXPERIMENTAL TASKS

Task Number	Task content	Key Operation
Task 1	Launch the software to start a new [mind map].	Find the New entry.
Task 2	Enter [Central Topic] and add [Main Topic].	Find the add Topic entry and its interaction.
Task 3	Add [Subtopic].	Find the add Subtopic entry and its interaction.
Task 4	Add [Floating Topic] and [Relationship].	Free Topic entry and insertion of a Relationship form.
Task 5	Modify the style of [Central Topic], [Main Topic], [Subtopic] and [Branch].	Efficiency and degree of comprehension of the style adjustment area.
Task 6	Add [Mark].	Find the Mark entry.
Task 7	Add [Clipart] from the materials folder.	Clipart add form.
Task 8	Modify [Background Color].	Find the Background Color entry.
Task 9	Modify [Text] size, style, color.	Text adjustment area positioning and understanding efficiency.
Task 10	[Save] file to desktop/personal cloud and [Export] PNG.	Save and Export entry.

Within-subjects design was used in this experiment. The mind maps were created by each participant in the experiment using Xmind and MindMaster, respectively. To prevent the learning effect brought on by order of use. Group A was assigned to use Xmind first, then MindMaster, and group B vice versa.

Fig. 2 depicts the experimental procedure. The participants were briefed on the purpose and details of the experiment before it began. They were also asked to sign an experimental consent form. Pre-test interviews were done to assuage any potential uneasiness in the participants and to learn how they think about the mind map software and how it was used in their ordinary work. Then, the participants were assisted in donning the apparatus, and the machine was calibrated to guarantee the validity of the results. Following the commencement of the experiment, the participants utilized the first software and finished tasks 1 through 10 concerning the example. The participants were not required to speak aloud during the procedure to guarantee the correctness of the task completion time. The subject completed the subjective questionnaires and scales when the task was finished. Then repeat the process above using the second software after a five-minute break and recording every action on screen. After completing all tasks with the two software, participants watched the recorded video while giving a retrospective oral report to help them remember particular usability difficulties. Post-test interviews were conducted afterward to delve deeper into the underlying causes of the users' behavior.

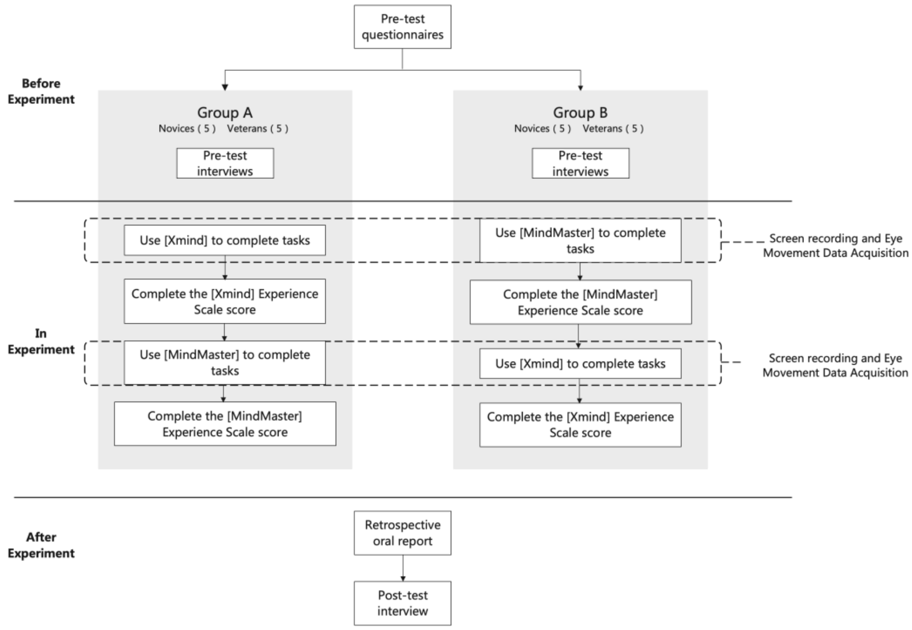


Fig. 2. Experimental.

V. Evaluation Metrics

This study divides the usability index of mind mapping software into three categories based on the ISO definition: effectiveness, efficiency, and satisfaction. Data were gathered by eye tracking and subjective scales corresponding to the subdivided indicators for each category after it had been divided into smaller sub-dimensions. Table III can provide more information. Throughout the test, user behavior and interviews are recorded.

A. *Effectiveness*

By counting the task completion rate of 20 participants, the software's effectiveness in attaining the stated objectives can be evaluated. However, the quantity of errors reflects how accurate it is. Additionally, we allowed the participants to seek assistance during the experiment and record the results to make the test procedure more thorough. “Task completion rate,” “Number of errors,” and “Number of requests for help” together provide for a more comprehensive assessment of the software's effectiveness.

B. *Efficiency*

Time is an essential resource for achieving goals while using mind map software. The efficiency of both software can be measured by comparing the “Task Length.” Eye movement analysis can be used to measure efficiency in addition to task completion time. The heat distribution before entering the AOI and the time spent before entering the AOI can infer the area where participants are used to finding the target and can reflect the target visibility. Scan routes can be used to compare user interfaces. The search behavior is less effective the more extended the scan path[31]. The duration of the first glance at the AOI and the number of visits can be used to assess the participant's comprehension of the specific area of interest and the ease of operation.

TABLE III. Metrics for Evaluating Usability and Data-Gathering Techniques

	Evaluation Metrics	**Date gathering techniques**	
Effectiveness	Task completion rate	Percentage of completers	Experimental records
	Number of errors	Overall errors	
	Number of requests for help	Overall requests for help	
Efficiency	Task Length	Timing	
	Target Visibility	Heat Map	Eye-movement data
		Time to first fixation in AOI	
	Target identifiability	Scan Path Map	
		Duration of first look at AOI	
		Number of AOI visits	
Satisfaction	System Usability	Ease of use	SUS Scale
		Easy to learn	
	Interface Quality	Interface comfort	Subjective Likert scale
		Preference for the interface	
		Richness of interface functions	
		Simplicity of interface	
		Attractiveness of the interface	
	Perceptual Emotional Experience	Level of comfort	
		Level of enjoyment	
		Level of excitement	
		Level of clumsiness (inverse)	
		Level of frustration (inverse)	

C. Satisfaction

In this study, satisfaction was primarily measured using the SUS system usability scale[41], and Bangor[42] determined its reliability coefficient as 0.91 based on a significant sample of trials. The interface quality and user-perceived emotional experience were two additional variables that this experiment added to the user experience[43]. A total of 20 items on a 7-point Likert scale made up the questionnaire, which vehemently opposed is "1," whereas firmly in favor is "7."

D. Credibility Analysis

Measures of scale assessment include validity and reliability. The term "reliability" refers to the consistency and dependability of the results; if these characteristics are weak, the results are unstable and subject to the effects of place and time. The capacity to measure accurately is implied by validity or accuracy. The dependability quality level of the 20 question items in this experiment was measured using Cronbach's α[44]. The result of Cronbach's α was 0.919, which suggests good internal consistency and high-scale reliability. The sample size was appropriate, the KMO values for the three satisfaction-related features were 0.855, 0.739, and 0.635, all of which were higher than 0.6, and Bartlett's sphericity test, $p=0 < 0.05$, was compatible with the sphericity test.

VI. Research Results

A. Effectiveness

As shown in Fig. 3 and Fig. 4, the fact that MindMaster outperforms Xmind in task completion and has much fewer errors and help requests per task indicates that it is more efficient. It can be noticed that each software has some challenges for inexperienced users by contrasting the two categories of users. Task V had the most mistakes made by the participants, with 72 made using Xmind and 26 using MindMaster. The task also included the majority of requests for assistance. This suggests that there are issues with both software when it comes to changing the drawing style, which is a crucial factor in the software's effectiveness.

B. Efficiency

The difference in efficiency between the two software can be ascertained by contrasting the two software's total and individual task lengths. Table IV shows that the overall task time of MindMaster is lower than Xmind and that this difference is significant, demonstrating that MindMaster is much more efficient than Xmind. The tasks that revealed notable variations were tasks 2, 5, and 10. For tasks 2 and 5, MindMaster performs better than Xmind. Xmind spends less time on task 10. Eye movement data for the three tasks mentioned above was examined to investigate the apparent disparities.

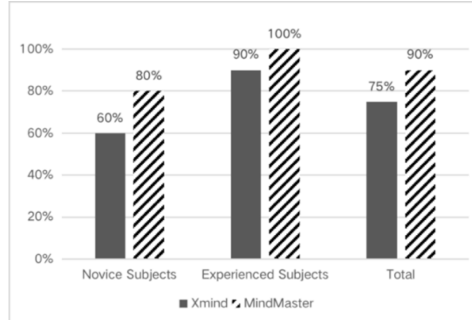


Fig. 3. Task Completion Rate of the Two Software.

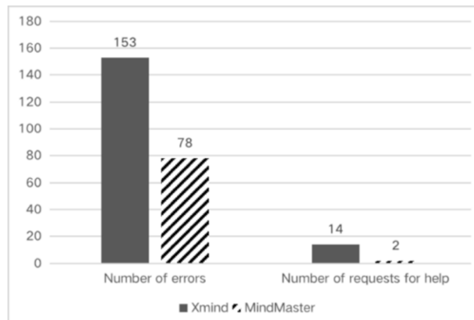


Fig. 4. The Number of Errors and Helps of the Two Software.

TABLE IV. Task Length and the Result of Paired t-test

Items	Paired(M±SD)		Mean difference	t	Sig.
	Xmind(s)	MindMaster(s)			
Task 1	12.20±5.79	14.10±8.10	-1.89	-0.778	0.450
Task 2	112.19±37.41	88.66±45.11	23.53	2.425	0.029*
Task 3	119.87±34.12	110.15±51.27	9.71	1.000	0.334
Task 4	56.34±23.47	69.26±58.34	-12.92	-0.844	0.413
Task 5	591.76±247.08	246.51±110.79	345.25	5.902	0.000**
Task 6	68.80±36.81	55.75±21.29	13.05	1.333	0.204
Task 7	111.06±60.01	92.11±60.83	18.95	0.761	0.459
Task 8	74.24±35.22	90.45±54.71	-16.20	-1.026	0.322
Task 9	65.79±34.83	94.58±32.95	-28.79	-1.975	0.068
Task 10	59.35±20.11	94.38±31.38	-35.03	-3.700	0.002**
Total Task Length	1271.60±325.95	955.94±301.47	315.66	3.866	0.002**

*Sig.<0.05 **Sig.<0.01

1) Task 2 – add [main topic]: According to the Heat Map in Fig. 5, the participants could concentrate on the "Add Main Topic /Subtopic" choice quite well. And the majority of users also add subjects by selecting “Subtopic." As for the time to the first fixation in " Main Topic, "using Xmind takes more time than using MindMaster (according to Table V). However, it takes 14.316 s to view the "Subtopic" for the first time using MindMaster, compared to 2.283 s while using Xmind. Consequently, in this work, the target visibility of the two programs is quite close.

TABLE V. TIME TO THE FIRST FIXATION IN AOI OF TASK2

	Software	Mean	Std. Dev.	Sig.
Time to first fixation in " Main Topic "	Xmind	18.534	9.781	0.013*
	MindMaster	10.050	9.239	0.018*
Time to first fixation in " Subtopic "	Xmind	2.283	1.890	0.172
	MindMaster	14.316	6.394	0.000**

*Sig.<0.05 **Sig.<0.01

The Scan Path Maps show a few users’ saccades when looking at the menu bar at the top of MindMaster and the "Adjust Style" toolbar on the right side. Although this happened just a few times, it made it harder for the subject to find the target and decreased the effectiveness of use.

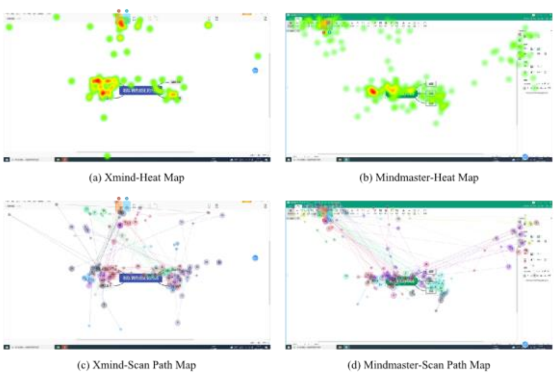


Fig. 5. Heat Map and Scan Path Map of Task2.

The "Subtopic" of Xmind was organized in the top-center toolbar, where there were fewer function options, and participants could locate the desired option more quickly. During this exercise, it was seen that the more skilled participants used shortcut keys more frequently, and these shortcut keys were consistent across both software. As a result, there wasn't much difference between how the experienced participants used the two kinds of software in this assignment. And when it comes to installing the "Subtopic," novice users typically find Xmind to be more user-friendly.

2) Task 5 – modify the style: Task 5 measures how well the two software performs regarding branching, adjusting graphics, and other features. According to Table VI, MindMaster performs better in target visibility since it takes less time for its first fixation in the AOI than Xmind. However, when using MindMaster to complete Task 5, the first stare at AOI is too long. Presumably, participants had trouble identifying "shapes" and "branches." Division and literal description of function play a significant role. MindMaster uses only icons—no text—that are both small and strikingly identical in appearance, making it more challenging for participants to locate and recognize the target icon.

TABLE VI. TIME TO THE FIRST FIXATION IN AOI OF TASK5

	Software	Mean	Std. Dev.	Sig.
Time to first fixation in "shape"	Xmind	47.298	76.678	0.191
	MindMaster	14.476	31.291	0.121
Time to first fixation in "branch"	Xmind	21.597	29.904	0.023*
	MindMaster	18.003	13.279	0.021*
Duration of the first gaze at "shape."	Xmind	7.540	5.203	0.016*
	MindMaster	13.959	13.146	0.002**
Duration of the first gaze at "branch"	Xmind	7.910	7.633	0.034*
	MindMaster	18.366	13.107	0.000**
Number of visits to "Shape"	Xmind	10.333	6.501	0.011*
	MindMaster	14.462	15.967	0.007**
Number of "branch" visits	Xmind	20.286	16.226	0.000**
	MindMaster	9.857	8.153	0.019*

*Sig.<0.05 **Sig.<0.01

The fact that the side formatting panel was default hidden and had to be opened by selecting the "Panel" button in the top right corner was one of the primary causes of the increased time spent on Xmind. Some participants (mostly the less skilled ones) complained that they could not comprehend what the "panel" meant and that the placement of the alternatives did not correspond to their cognitive tendencies, making them challenging to identify the target.

The Heat Map (Fig. 6) also demonstrates that the participants' perspectives were primarily dispersed in the panel editing area and the right toolbar region when completing task 5 using MindMaster. However, when using Xmind, its viewpoints increasingly straddle other sections. The main challenge is finding the operation target. The mind map's branches are not free by default; you have to check the "Branch Free Layout" box in "Layout," and the user has to move the top tabs in the style panel to discover the "Layout." Users can more easily locate what to do with MindMaster because its control options are more consistent.

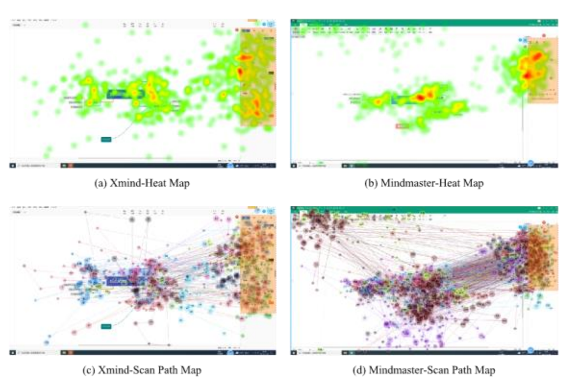


Fig. 6. Heat Map & Scan Path Map of Task5.

While MindMaster's Scan Path Map makes it clear that users will also focus on the menu bar region in the upper left corner of the interface during work, in addition to the right toolbar and the primary drawing interface, Xmind's Scan Path Map is disorganized and erratic. We attempted to analyze a specific topic to investigate the causes of this. According to the findings, novice and skilled users differ significantly, as illustrated in Fig. 7 As you can see, new users of MindMaster are accustomed to looking for functions in the menu bar area in the top left corner of the screen.

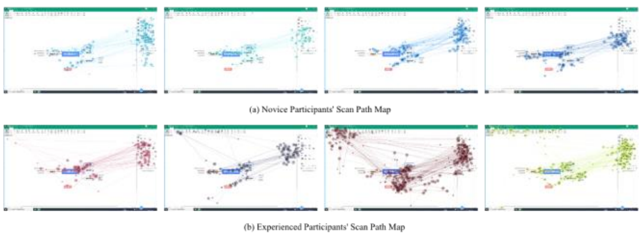


Fig. 7. Novice & Experienced Participants Scan Path Map.

3) Task 10 – [save] and [export]: Although Xmind's interface has a wide distribution of hotspots, as seen in Fig. 8, but users use Xmind to do Task 10 significantly more quickly than MindMaster. Combined with the post-test interview, it can be found the save & export feature in Xmind uses a conventional drop-down menu is consistent with participants' habits. But it lacks innovation and does not offer features like sharing and cloud storage. In contrast, MindMaster is far more feature-rich and provides greater ease by permitting the export of files in various formats and cloud storage. However, the full-page switching format in MindMaster is pretty abrupt.

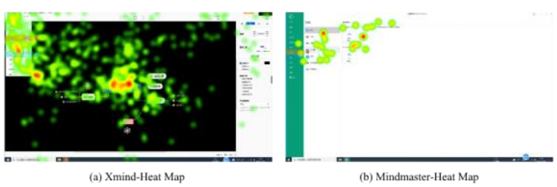


Fig. 8. Task10 Heat Map Comparison.

According to the post-test interview, some participants expressed shock at seeing this switching format, and they initially believed they had done it by accident. Efficiency decreases since more storage alternatives lengthen the user's time to find the target.

C. Satisfaction

The ease of learning and usability scores were multiplied by 12.5 and 3.125, respectively, to match them with the SUS composite score (0～100)[41]. The amount was then multiplied by 20/7 to convert the metrics measuring user affective experience and interface satisfaction results to percentages. The computer analyses of the data from the usability scale produced the statistical findings in Table VII. As can be observed, the two software is significantly different in terms of user satisfaction. In this essay, "S" stands for the overall score, and "M" for the mean value.

TABLE VII. COMPARISON OF USER SATISFACTION DIFFERENCES

	Variables	Xmind (n=20)	MindMaster (n=20)	t	Sig.
Usability	A1 Intention to use	3.40	3.85	-1.303	0.202
	A2 Complexity	3.55	4.40	-2.628	0.012*
	A3 Ease of operation	3.35	4.30	-2.832	0.007**
	A5 Degree of integration	3.25	4.15	-2.764	0.009**
	A6 Consistency	3.35	3.90	-1.297	0.203
	A7 Universality	3.00	3.95	-2.084	0.044*
	A8 Friendliness	3.25	4.10	-1.732	0.091
	A9 Confidence	3.35	4.60	-2.549	0.015*
	Total Usability	57.81	78.91	-2.457	0.019*
Learnability	A4 Information Support	3.50	4.40	-2.538	0.015*
	A10 Learning Cost	3.60	4.55	-1.736	0.091*
	Total ease of learning	63.75	86.88	-2.324	0.026*
Interface Quality	B1 Interface comfort	4.65	6.05	-2.278	0.028*
	B2 Preference of interface	4.35	6.00	-2.675	0.011*
	B3 Functional richness of the interface	4.45	5.85	-2.004	0.052
	B4 Simplicity of interface	5.65	5.90	-0.373	0.711
	B5 Interface Attractiveness	4.25	5.25	-1.287	0.206
	Total interface quality	66.71	83.00	-1.827	0.076
Emotional Dimensions	C1 Comfort level	4.35	6.25	-2.462	0.018*
	C2 Enjoyment level	4.05	5.95	-2.289	0.028*
	C3 Excitement level	3.80	5.20	-1.544	0.131
	C4 Clumsiness (inverse)	4.40	3.75	0.6	0.552
	C5 Frustration level (inverse)	3.00	3.25	-0.22	0.827
	Total perceived emotional experience	53.71	69.71	-3.762	0.001**
Total user satisfaction		59.81	77.74	-2.761	0.009**

*Sig.<0.05 **Sig.<0.01

The overall satisfaction rating data for the two software revealed a 0.01 level of significance (t=-2.761, Sig.=0.009), and the participants' overall satisfaction with MindMaster was considerably higher than Xmind (S_M=77.74>S_X=59.81). Less experienced participants gave MindMaster higher ratings. Some participants claimed that MindMaster's operating logic and page structure are more similar to Office, which is more recognizable and user-friendly. Moreover, MindMaster has more features that users value most, such as more drawing flexibility and support for online storage. Thus, MindMaster scores higher in these categories.

MindMaster outperformed Xmind in every category of usability, scoring significantly higher than Xmind in A2 complexity, A3 Ease of operation, A5 Degree of integration, A7 Universality, A9 Confidence, and overall usability. All participants stated that both products satisfied their usage requirements and that their willingness to use increased after becoming familiar with the product. However, MindMaster received a higher total score for usability.

The participants evaluate MindMaster's information support and learning costs over Xmind for novice users because the function’s descriptions are simpler to understand. The design is similar to traditional office software, making learning easier and less expensive. Participant 18 stated, "MindMaster is simple to use, and the toolbar is identical to the standard Office software," for example.

The evaluation of the two software's interface quality also showed substantial variances. Many participants in post-test interviews praised Xmind's straightforward and consistent visual style. However, it also means that more function entries have been hidden deeper, which makes user difficult to find them. Another group of users was dissatisfied with Xmind's pages because they were too "basic." Even though the green theme color of MindMaster is visually arresting and vibrant, the 13th participant claimed that "the green appearance of the interface has an effect on the user's choice of color when drawing and makes people unconsciously want to choose a color close to the theme color of the software interface." The layout of the functional area's icons and buttons also gives MindMaster a more complicated appearance. The same results were also supported by user ratings, with MindMaster significantly outperforming Xmind in every category except for interface simplicity (M_{XB4}=5.90>M_{MB4}=5.65).

Users gave MindMaster's overall emotional experience a modest edge over Xmind in terms of perceived emotional intensity ($S_{X\text{-}sense}$=53.71<$S_{M\text{-}sense}$=69.71). The participants experienced greater comfort and enthusiasm after using MindMaster. On the other hand, Xmind made people feel even more awkward and frustrated. For instance, the 3rd participant commented, "Using Xmind was challenging, and I got frustrated." The 12th participant said, "Xmind is not very free, and the experience is not very nice."

VII. DISCUSSION

The study discovered that MindMaster performed better than Xmind in efficacy, efficiency, and satisfaction. The result is based on satisfaction questionnaires, eye-tracking data, and usability testing. This section will detail the causes and provide guidelines for software designers to adhere to.

Effectiveness-wise, a function's cognitive difficulty and location in the user interface determine whether a task can be completed successfully. The inability to modify the branch-free layout under the default "Balanced Layout" is the leading cause of task failure using Xmind. However, the "free-form" and "unconstrained structure" of mind mapping itself are its benefits[45]. This advantage is undermined by how Xmind is designed, which reduces its validity. In MindMaster, the participants can freely drag the branches to change their places, and at the same time, the branches can be intelligently adhered to the next nearest trunk. Intelligent features like this will become a trend. Simultaneously, the panel's entrance is generally difficult to discover. Thus, participants asked for help for a few times. There are two main causes for this. Firstly, the button was difficult for novices to notice in the full-screen mode because it was in the top-right corner of the screen. Second, it was challenging to understand the button's meaning due to ambiguous symbol semantic expressions and overly professional text descriptions. It suggests that designers should carefully take into account both the clear depiction of icons and the visibility of function buttons in the interface layout.

In terms of efficiency, MindMaster performs better. The interface of Xmind is simpler and conceals more functional entrances. Users' search processes become more time-consuming and ineffective due to the low visibility of functional entries. On the contrary, MindMaster directly displays some commonly used functions by default. It reduces the interaction steps for users and improves efficiency. Therefore, designers should consider the usage scenario when software is designed. And optimize the interaction design of the software’s fundamental functions to match the user’s behavior. The interviews and eye-tracking data show that participants are more drawn to graphical design objects than textual objects. Consumers generally are unwilling to read lengthy passages of text; therefore, using the appropriate graphic elements in the user interface can help users get the content rapidly while keeping their interest. However, it also should be carefully exercised to prevent confusing users with similar icon shapes and layouts. For instance, the MindMaster right toolbar’s icons are small and neat. The branch and theme adjustments have similar layouts, identical icons, and repeating issues. As a result, the operation takes longer than it should because users have to take the time to examine the hover text descriptions. However, icons on MindMaster’s top-right toolbar have auxiliary textual information and are arranged according to function. They help users to understand and use easier. So, designers can combine the relevance of functions and the level of information for interface design. And suitable auxiliary information is also important.

In terms of user satisfaction. A product's usability and learnability depend on how well it fits into the user's routines and how helpful and amiable it is to them. Xmind's entry position, iconography, and text are inconsistent with users' cognitive habits. And this is why users have low usability ratings for Xmind. On the other hand, MindMaster's top and right sides, which have a multi-entry format and take into account the preferences of many users, are more inclusive. It makes Mindmaster's usability and learnability scores higher. Adding a multi-entry to functions does improve usability to some extent. At the same time, designers should be careful to use this method to avoid interface quality degradation. For mind map software, users choose designs that are specific and present functions in interface quality. Emotional dimensions are mainly related to the fluency of the operation process. Therefore, the designers must be mindful of the interaction logic's jumps to prevent user operations interruptions.

VIII. Conclusion and Future Works

The objective of this paper is to explore the usability and user experience of the existing mind map software. Comparative usability research is conducted to determine the key influential elements. A total of 20 participants participated in the study. According to the experiment results, the interactive logic, level of information, and interface design of mind map software all affect their effectiveness, efficiency, and user satisfaction. The study also suggests that designers must base their decisions on user needs, scenarios, and habits to create a better user experience for users of the mind map software. When evaluating the usability of their design solutions, both software design teams can benefit from the assessment techniques described in this paper.

The limitations of this paper are that the drawing examples used in the tests were slightly more complex and required using multiple functions to complete. It is somewhat different from the actual drawing scenarios of the users. This could be amended by testing as many functions of the software as possible. The future work will expand the number of experiment samples, focus on providing answers and optimize the design by merging the enumerated usability issues, followed by experiments to confirm the optimization's effects.

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