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Exploring University Students' Preferences for AI-Assisted Learning Environment: A Drawing Analysis with Activity Theory Framework

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ABSTRACT: This study employed drawing and co-word analysis techniques to explore students' preferences for AI-assisted learning environments. A total of 64 teacher education students from a university in Taiwan participated in the study. The participants were asked to describe their perceptions of AI-assisted learning in the form of drawings and text descriptions. In order to analyze the content of the students' drawings, a coding scheme was developed based on the activity theory framework. Based on the results of the analysis, it was found that students placed more importance on personalized guidance and appropriate learning content provision. In addition, students acknowledged that AI technology can be used flexibly in different fields and situations. Interestingly, more than half of the students agreed that robots play important roles in AI-assisted learning. This indicates that the students expected a social AI learning companion. However, it was found that students' expectations of an AI learning environment were less connected to the real environment and did not reveal learning activities with higher order thinking. In addition to the need for accurate and fast AI computing, this result indicated that professional instructional guidance is also an expectation that students have of AI education.

Keyword: Preference of learning environment, AI education, Co-word analysis, Drawing analysis, Activity theory framework

1. Introduction

In recent years, many studies have identified the importance of learner perspectives for their learning performance (Deci & Ryan, 2000; Tapingkae et al., 2020). Researchers have attempted to infer and predict students' learning performance by analyzing their different perspectives (Davies et al., 2013). Among them, learners' environmental preference is a commonly explored learner perspective in technology-assisted learning contexts (Dokmecioglu et al., 2020; Yang & Tsai, 2008). This is because, compared to the conventional learning model, learning in technology-assisted learning environments is rich in instructional media and complicated in human-computer interaction (Krishnan et al., 2019; McGrew et al., 2018). Therefore, if learners' learning environmental preferences are taken into consideration during the software and hardware development stage, it will help to ensure effective learning environment design (Tsai et al., 2012).

On the other hand, scholars have pointed out that school administrators and teachers need to face the challenge of using technology for instruction in the school environment (Morrison et al., 2009). Since emerging technologies are new to most teachers, it is often the case that technology interventions do not improve teaching effectiveness (Webster & Son, 2015; Yeh & Tao, 2013). The reason for this is the lack of professional development for school administrators and teachers in technology-assisted instructional design (Hennessy et al., 2015). If educators do not understand the characteristics of technology before teaching and its practical use in learning activities, the curriculum will not be effective even with the technology intervention (Geertshuis & Liu, 2020). Therefore, it is important to understand the expectations and preferences of the participants for technology-assisted learning before engaging in activities (Chen et al., 2018; Osman et al., 2011).

In particular, artificial intelligence (AI) has gradually gained importance in education (Garcia et al., 2007). Researchers have developed a number of tools with AI computing mechanisms (Yang et al., 2021), for instance, a dynamic taxonomic system to guide students in learning about ecosystems and biological chains (Abbas et al., 2021), or a fuzzy expert system for supporting students to learn mathematics (Hwang, Sung, et al., 2020). They all agree that AI can change the future of learning. However, learners' knowledge of AI is currently limited; the studies generally investigated learners' acceptance of AI, whereas the practical use of AI in the classroom has rarely been discussed (Zawacki-Richter et al., 2019). To meet students' learning environmental preferences, in this study, students were asked to use their imaginations to visualize an AI-support classroom. By asking students to draw images, they can draw the picture in detail without it needing to be transcribed by the researcher (Nuora et al., 2019). By doing so, students' preferences for AI-assisted learning can be investigated.

2. Literature review

2.1. Role of environmental preference in students' learning

The learning environment is defined as the physical environment, the people (usually teachers and students), the learning objectives, the teaching methods, the materials, and the tasks the learners have to complete (de Kock et al., 2004). A discussion of students' preferences for the learning environment can begin with Fraser's (1998) study. He developed a questionnaire to assess students' perceptions of the psychosocial environment of the classroom: the Constructivist Learning Environment Survey (CLES). This questionnaire was used to help researchers and teachers assess the extent to which a particular classroom environment is aligned with a constructivist epistemology, and to help teachers reflect on the design of their instructional activities.

In a technology-based environment, learners' learning preferences in e-learning environments, mobile learning environments, and so forth, are situations worthy of researchers' exploration (Pletz & Zinn, 2020; Rejón-Guardia et al., 2020). For researchers, further differentiating different types of technology-enabled learning environments helps describe the core values of the technology and how to shape the environment embedded in the technology (Shernoff et al., 2017; Wolf & Fraser, 2008). For instance, Chuang and Tsai (2005) explored and found the students' environmental preferences that need to be considered in Internet-based learning environments, that is student negotiation, inquiry learning, reflective thinking, relevance, ease of use, and challenge. Further, Tsai et al. (2012) explored students' learning preferences in a mobile learning environment. They found that providing students with authentic and relevant information enhanced student negotiation and inquiry learning.

When investigating the interaction among learners, tools, and activities, researchers have acknowledged that activity theory is a suitable evaluation framework (Jonassen & Rohrer-Murphy, 1999). Activity theory describes actions through six related elements: objective, subject, context, tools, division of labor, and rules (Engeström, 1987). It considers an entire activity system, accounting for the environment, history of the person, culture, role of the artifact, motivations, and complexity of the real-life activity. Many researchers have used this framework to examine the integrity of activities and environments (Blayone, 2021; Galvis et al., 2021). For instance, Longhurst et al. (2021) employed activity theory to evaluate the effectiveness of social and cultural factors on the teachers' application of strategies in teaching.

Accordingly, researchers have frequently discussed learners' environmental preferences when introducing new technology into the classroom (Lung-Guang, 2019; Martin et al., 2020). Among different evaluating frameworks, activity theory is one that considers the overall interaction among humans, computers, and environments. However, as far as we know, few studies have explored learners' environmental preference in the AI-support learning context, especially through the lens of activity theory.

2.2. AI in education

Researchers consider artificial intelligence (AI) as a channel for providing precision education (Garcia et al., 2007; Tsai et al., 2020). Generally, researchers define AI in education as using AI techniques (e.g., Neural Networks, deep learning, or rule-based inferencing) for supporting teaching or learning (Colchester et al., 2017). Due to effective computing and data storage, AI has been rapidly applied in various educational settings (Macgilchrist et al., 2020). Many studies have aimed to develop efficient AI systems for supporting students' learning, while also investigating learners' perspectives on the use AI in education (Chocarro et al., 2021; Segal et al., 2019).

Researchers not only pay more attention to optimizing embedded and responsible AI, but they also care about learners' and teachers' perspectives on AI (Yang et al., 2021). For instance, Chocarro et al. (2021) examined the teachers' acceptance of AI chatbots. Their result revealed that ease of use and usefulness played important roles in the acceptance of AI. In addition, teachers preferred AI robots as a formal assistant rather than for social assistance. Tai and Chen (2020) investigated the effectiveness of intelligent personal assistants (IPAs) on learners' willingness to communicate. The EFL students who participated in the research enhanced their confidence in communicating. Also, they enjoyed talking with the virtual assistant which decreased their speaking anxiety.

Therefore, it is known that users' perceptions of AI need to be considered from various aspects. Researchers usually adopt surveys or interviews to learn users' perceptions. However, learners' environmental preferences include personal perceptions as well as their spatial needs and social interactions (Mason et al., 2010). These are more difficult to obtain through surveys or interviews. Researchers have recommended that drawing is another way to directly obtain interviewers' perspectives (Guillemin, 2006; Nuora et al., 2019), as drawings are rich visual illustrations that represent the interviewee's imagination of the environment or social interactions (Ehrlén, 2009).

2.3. Drawing analysis technique

Drawing is an expressive method that uses a combination of visual and textual expressions to compensate for content that is missed when expressed purely in words (Ehrlén et al., 2009; Selwyn et al., 2009). The method whereby researchers invite participants to draw pictures and then analyze the results of their drawings is called drawing analysis. This method has been used not only to assess college students' thoughts on specific issues (Xu et al., 2020), but also those of high school and even elementary school students (Wang & Tsai, 2012; Yeh et al., 2019). By collecting participants' opinions in this way, the participants are able to share their ideas in a less stressful manner (Brown & Wang, 2013; Hsieh & Tsai, 2018), while researchers are able to obtain the information in the most convenient way and within a valid time period. Many studies have also shown that drawing can be used as a research method to reveal the complexity and importance of participants' ideas (Dikmenli, 2020; Lamminpää et al., 2020).

Hsieh and Tsai (2018) used a drawing analysis technique to explore the learning concepts of 1,067 elementary school students. They found that most of the students' drawings depicted conventional teacher-centered classroom learning activities. Students were usually passive listeners during learning activities. Yeh et al. (2019) also used drawing analysis to investigate high school students' perceptions of technology-assisted science learning. Based on the results of the analysis, they found that there was a significant difference between students' actual and ideal concepts of technology-assisted science learning; that is, there was a gap between students' expectations of technology and their current reality.

In recent educational research, drawing has been recognized as a phenomenological research method that is effective in terms of guiding learners to share their personal thoughts (Hsieh & Tsai, 2017). At the same time, many studies have demonstrated that the results of drawing analysis are a useful way to support learning (Chang, 2018; Chiang et al., 2020); researchers can use drawing analysis to reveal and understand learners' perceptions of learning. In other words, in educational research, analyzing students' drawings can be a useful tool for understanding their engagement in learning, their expectations of technology, and their learning preferences.

2.4. The purpose of this study

With the rapid development of AI in recent years, the application of AI in education has received increasing attention from educational researchers (Luckin & Cukurova, 2019). However, it remains a challenge for most researchers and practitioners (Kay, 2012). The main reason for this is that AI is a field that is highly dependent on technology and interdisciplinary integration (Breines & Gallagher, 2020). Teachers and educators who do not understand the role of AI in education and how these AI technologies can help teaching and learning are likely to find it difficult to make AI work in the classroom (Fryer et al., 2017).

Much of the research emphasizes the importance of understanding learner perceptions before new technologies or environments are introduced (Geertshuis & Liu, 2020). However, at this stage of education, the introduction of AI in teaching and learning is still more sophisticated than other technologies (e.g., web-based learning, mobile learning). Therefore, through interviews and questionnaires, it is difficult to portray students' preferences for AI learning environments (Chatterjee & Bhattacharjee, 2020; Hsieh & Tsai, 2018). Using drawing, the researcher can draw a snapshot of students' ideas and expectations of the AI environment from their drawings, and it can be used as a vehicle to convey information that is difficult to convey in words (Chiang et al., 2020; Yeh et al., 2013). Therefore, this study intended to use the drawing technique to collect students' perceptions of AI-based learning, and to analyze the information in students' drawings in order to understand the students' preferences for AI learning environments. The research questions of this study are:

- Into what categories can students' environmental preferences for AI-assisted learning be classified?
- What are the students' tool needs (tools, objectives, rules) in the AI-assisted learning environment?
- What are the students' contextual needs (context, subject, division of labor) in the AI-assisted learning environment?

- What are the most frequently mentioned keywords in the students' AI-assisted learning drawings? Is there any relationship between the keywords?

3. Method

3.1. Participants and the data collection procedure

For this study, the researcher conducted a survey at a university in northern Taiwan. To help AI developers understand the need of the teaching and learning field, this study selected two classes of students who had attended teacher training courses. They had a basic understanding of the current teaching environment in Taiwan's elementary schools, but none had any expertise in IT-related fields. Therefore, we were able to elicit the students' needs for AI from the users' standpoint rather than from that of the developers. In these two courses, the instructor taught the current state of technology-based learning, and assigned students to design relevant technology-based learning activities. Therefore, students have certain concepts of technology-integrated learning and teaching.

Before inviting the students to create their drawings, the instructor gave a 2-hour lecture on the application of AI in education to ensure that the students had a preliminary understanding of AI. Meanwhile, teachers shared several education-related AI apps to let students understand the current development of AI in education. In addition, students were invited to share with their peers the tools and examples of AI applications in education.

Afterwards, the instructor arranged students to draw what they perceived to be their own AI learning and to describe the content of the drawings with the aid of text. Each student was given a piece of A4 paper with two prompts: "Please draw what you think of AI education" and "Please briefly summarize the contents of your drawing." In this study, students were free to choose whether or not to draw their drawings and submit their work. The activity was anonymous; the researcher did not know which student the drawing was from. After 1 hour of drawing, a total of 64 drawings were collected for this study.

3.2. Data analysis

3.2.1. Development of the coding scheme

This study first adopted the Activity Theory framework to examine students' preferences for the learning environment from multiple perspectives (Jonassen & Rohrer-Murphy, 1999). The dimensions of this framework are tool, objective, subject, division of labor, context, and rules. Next, the study referred to Haney et al. (2004) and Wang and Tsai (2012) to develop the codes for each dimension. Based on this past literature, this study first developed a coding list that included: learning topic, participants, learning places, activities, electronic technologies and objects, as shown in Figure 1. The learning topic refers to the subject of study that is mentioned in the students' drawings. Participants and learning places refer to the people and places that students draw. The types of activities are based on the learning activities depicted in the drawings. Electronic Technology refers to the electronic products that students draw, such as computers, screens, and earphones. Finally, the term objects refers to objects other than electronic technologies that students draw, such as desks, books, and so on.

To precisely analyze students' imaginations of AI-assisted learning, this study referred to Hwang, Xie's et al. (2020) definition of AI features and developed two categories: software or services, and AI functions. Software or services refers to the software or services mentioned in the student's drawing, such as Google or Facebook, whereas functions represent the functions that the AI needs in order to carry out the learning activity, such as providing learning diagnostics, uploading data, and so on. More details of the coding scheme are shown in Appendix Table 1.

The researchers invited two coders with educational psychology backgrounds to help with the coding. Before the two coders coded, the researchers explained the coding method and the coding scheme. During the process, the researcher selected one drawing at random and coded it with the coders to ensure that both of them understood the coding scheme. The two coders then coded each of the 64 drawings; they recorded the codes in an Excel file, and the researcher verified the consistency of the codes. The researchers then held a discussion meeting to discuss the inconsistent codes until the two coders confirmed that all the codes were consistent. An example of a coded student's drawing is shown in Figure 2.

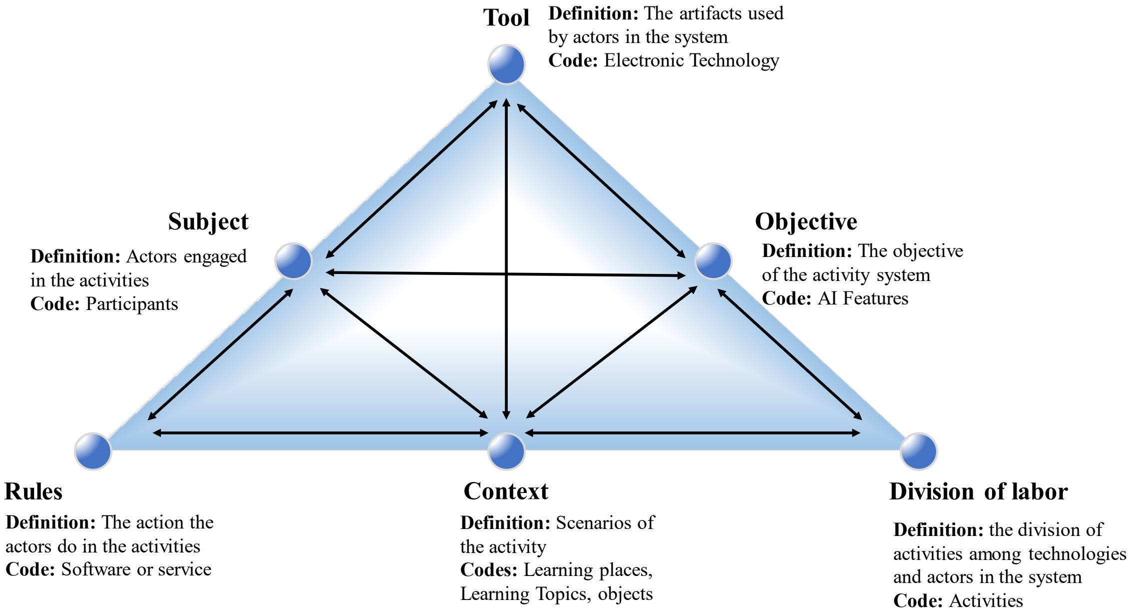

Figure 1. The framework of activity theory for AI-assisted learning

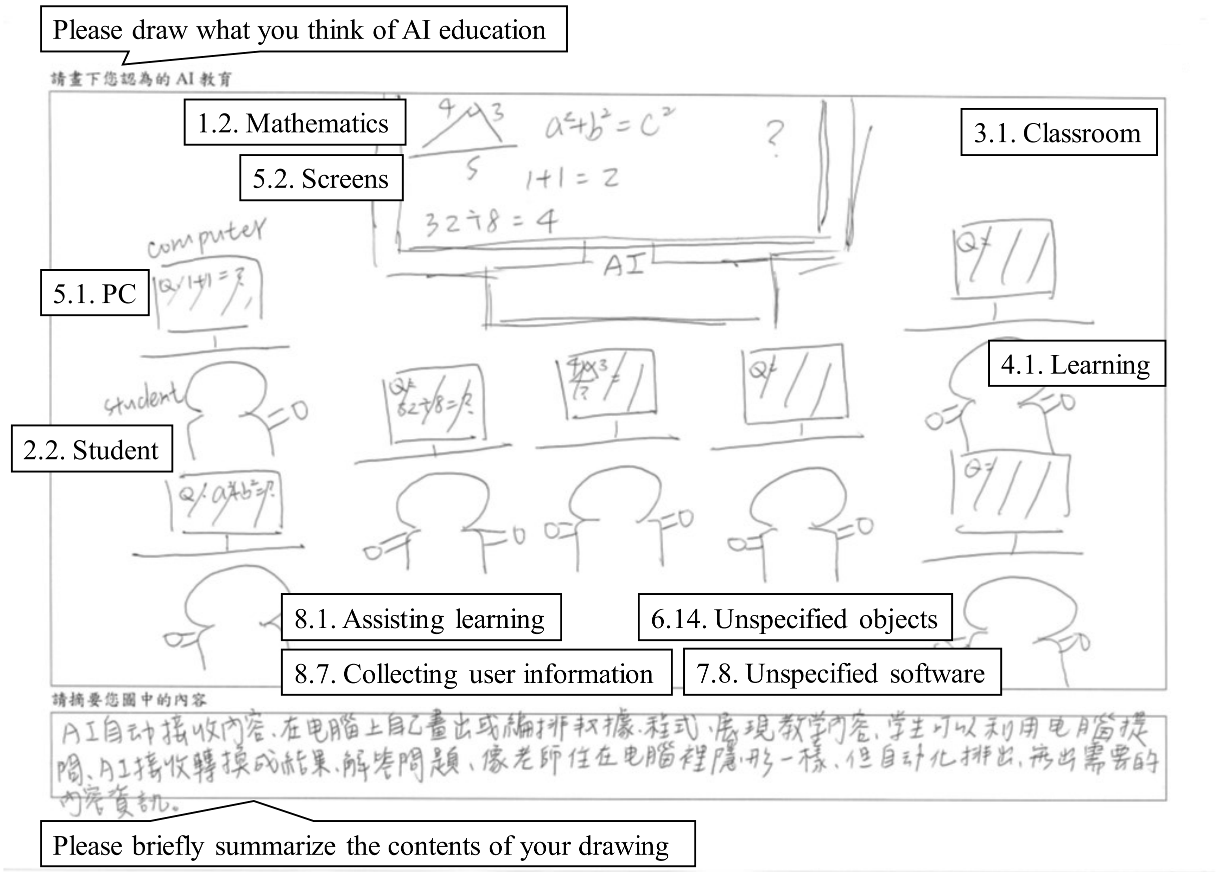

Figure 2. An example of a coded student’s drawing

3.2.2. Data analysis procedure

For the coding results, the researchers first used descriptive statistics to show the number and frequency of occurrences of each category of indicators. To understand students’ needs for AI-assisted learning, this study cross-compared AI features and activity types to try to understand what functions students expected AI to provide in different activities.

On the other hand, this study also analyzed the textual content of the students' descriptions. For this purpose, this study used a software package that can perform co-word analysis, VOSViewer, which is concerned with the use of word patterns as a tool to explain the structure of ideas, questions, and so on. The researcher can use the co-word analysis to analyze the content of the students' descriptions. Researchers can use the results of the co-word analysis to analyze themes in a specific field. The analysis tool can extract the most frequent words from all sentences, analyze the associations between the occurrence of different words to find clusters, and finally present the results using a visual network (Tibana-Herrera et al., 2018; Yilmaz et al., 2020). Through this analysis, the researcher can find out what issues are important to students in AI-assisted learning.

4. Results

4.1. Coding scheme results

Students' drawings were analyzed according to the coding scheme in Table 1. Table 1 shows the frequency and percentage of what students drew for the learning topics. The majority of students did not specify the learning topic in their drawings (91%). This means that the content of learning was not the focus of learning when students were thinking about AI-assisted learning. Students may draw a picture of what AI learning looks like in terms of learning approach or AI functions. Still, some students linked AI technology to the subjects they were learning, such as language (3%), mathematics (3%), science (3%), physical education (2%), programming (2%), and music (2%). The data indicate that language, mathematics and science were the most important learning topics for students compared to other subject areas.

Table 1. Distribution of learning topics in the students' drawing content

	Language	Mathematics	Science	Physical education	Programming	Music	Unspecified
Frequency	2	2	2	1	1	1	58
Percentages	3%	3%	3%	2%	2%	2%	91%

With regard to the participants category (as in Table 2), the students code had the highest percentage of presence in the drawings (55%). Secondly, 52% of the drawings mentioned robots. This means that AI is an abstract concept and students want a concrete image to represent it. On the other hand, it also means that robots may play an important role in the learning process in the future. This was followed by 27% of the drawings that did not mention any characters, indicating that these students may have wanted to convey the characteristics of technology through their drawings. The fourth highest category was teachers. This means that in AI learning activities, as in most learning environments, a significant proportion of students and robots are present. There were two drawings, each with a different character. One picture includes a baby, which inferred that the student is linking AI-assisted learning with babies and childcare. The other drawing showed a teacher for robots, which indicated that robots learn knowledge from a teacher. It means that the student had the concept of human-provided knowledge for robots.

Table 2. Distribution of participants in the students' drawing content

	Teacher	Student	Robot	Baby	Others	No participant
Frequency	8	35	33	1	1	17
Percentages	13%	55%	52%	2%	2%	27%

The majority of the students did not mention the place of study in the learning places category (as in Table 3). This also means that they perceived that AI learning is not limited by time and space, but is possible in any situation. Second, the classroom accounted for 23%, which means that students also expected AI-assisted learning to take place in the classroom. Finally, 5% of the drawings depicted AI for learning at home and 2% depicted AI for learning outdoors.

Table 3. Distribution of learning places in the students' drawing content

	Classroom	Home	Outdoor	Unspecified
Frequency	15	3	1	53
Percentages	23%	5%	2%	83%

For the activities category (as in Table 4), learning was mentioned in 31% of the drawings. Secondly, instruction was mentioned in 27%. Interestingly, students seldom indicated a clear place of learning; however, they expected learning to take place through AI. Again, this suggests that learning, especially learning with AI, is not limited by time and space. Of the drawings, 34% did not specify how the activity would be carried out using AI; this may indicate that students may place more emphasis on describing AI functions. Finally, 17%, 2%, 2%, and 2% of the drawings depicted human/robot interaction, information justification, chess-playing, and nursing, respectively.

Table 4. Distribution of activities in the students' drawing content

	Learning	Instruction	Human / Robot Interaction	Information justification	Chess-playing	Nursing	Unspecified
Frequency	28	17	11	1	1	1	22
Percentages	44%	27%	17%	2%	2%	2%	34%

In the electronic technologies category (as in Table 5), 38% of the drawings did not indicate what technology was used. This is where students have the concept that AI is not a specific symbol. That said, 25% of the drawings mentioned computers, 22% mentioned screens, and 22% mentioned mobile devices. This means that students need to use some kind of technology to compute and read the content. On the other hand, touch screens (3%), smartwatches (2%), mice (5%), calculators (2%), earphones (3%), and VR glasses (5%) were also mentioned in some of the drawings.

Apart from mentioning electronic technologies, the students also drew non-technology-related objects such as desks and chairs, stationery, and so on. According to the results of the analysis, 67% of the students did not mention other objects. However, there were still a few students who drew non-technology objects such as desks and chairs (9%) and stationery (3%), as shown in Table 6. This means that AI technology can be built into the existing learning environment. On the other hand, some of the drawings mentioned objects that occur in daily life, such as glasses (2%), chess (2%), natural objects (e.g., the sun, clouds) (3%), transportation (3%), and so forth. This means that AI can help students learn outdoors and try to connect with their learning in daily life.
In the statistics for software or services (as in Table 7), 80% of the drawings did not mention either software or services. This may mean that the students are still unclear about the types of services AI can provide. Nevertheless, 8% of the drawings referred to databases and 4% to teacher management systems; in other words, they thought AI could help teachers organize their teaching resources and help databases perform better calculations.

Table 5. Distribution of electronic technologies in the students' drawing content

	PC	Screens	Mobile devices	Touchscreen	Smartwatches
Frequency	16	14	14	2	1
Percentages	25%	22%	22%	3%	2%
	Mouse	Calculator	Earphone	VR glasses	Unspecified
Frequency	3	1	2	3	24
Percentages	5%	2%	3%	5%	38%

Table 6. Distribution of objects in the students' drawing content

	Desk and chair	Stationery	Blackboard	Books	Mannequin	Projector	Wi-Fi
Frequency	6	2	2	1	1	1	2
Percentages	9%	3%	3%	2%	2%	2%	3%
	Brainscope	Eyeglasses	Chess game	Natural objects	Transportation	House	Unspecified
Frequency	1	1	2	2	2	1	43
Percentages	2%	2%	3%	3%	3%	2%	67%

Table 7. Distribution of software or services in the students' drawing content

	Database	Teaching Management System	Google	IoT	VR content	YouTube	Facebook	Unspecified
Frequency	5	4	1	1	1	1	1	51
Percentages	8%	6%	2%	2%	2%	2%	2%	80%

Finally, this study discusses the features that students expected AI to provide, as shown in Table 8. Two of the most important features were assisting learning (47%) and supporting instruction (28%). Next, students believed that AI could help in collecting user information (27%) and conducting data analysis and diagnosis (23%). In addition, some students think that AI can be used for communicating with students (17%), connecting with human communication (3%), playing chess (3%) and soothing a child (2%). Despite this, 25% of drawings did not depict AI's capabilities.

Table 8. Distribution of AI features in the students' drawing content

	Frequency	Percentages
Assisting learning	30	47%
Supporting instruction	18	28%
Connected human communication	2	3%
Talking to students	11	17%
Data analysis and diagnosis	15	23%
Collecting user information	17	27%
Playing chess	2	3%
Soothing a child	1	2%
Unspecified	16	25%

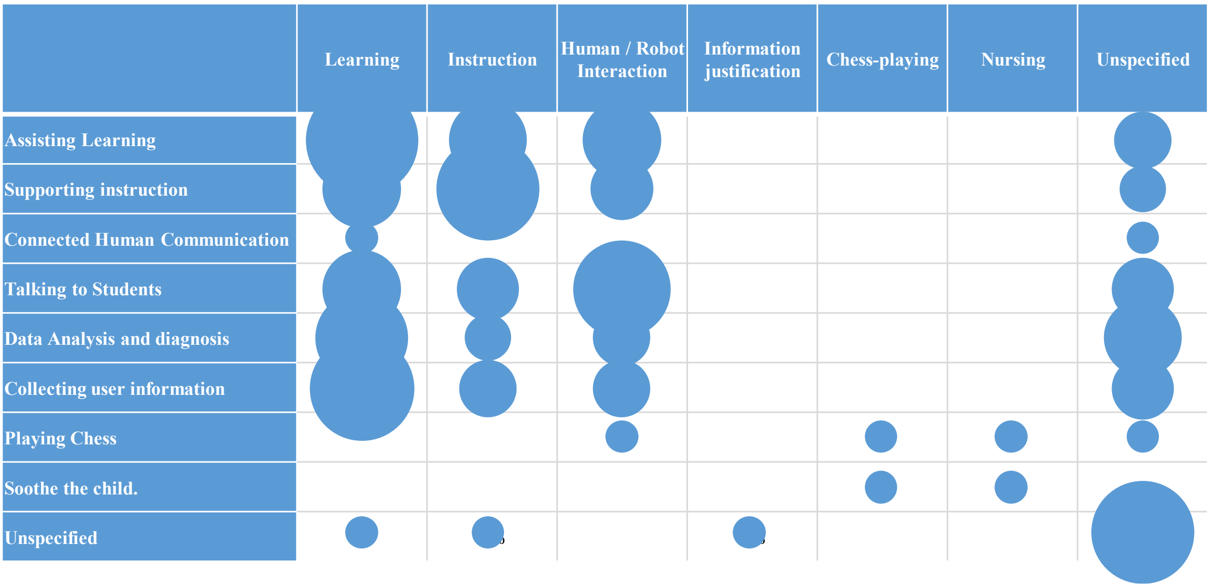

Figure 3. Cross analysis of AI features and activities in the students' drawing content

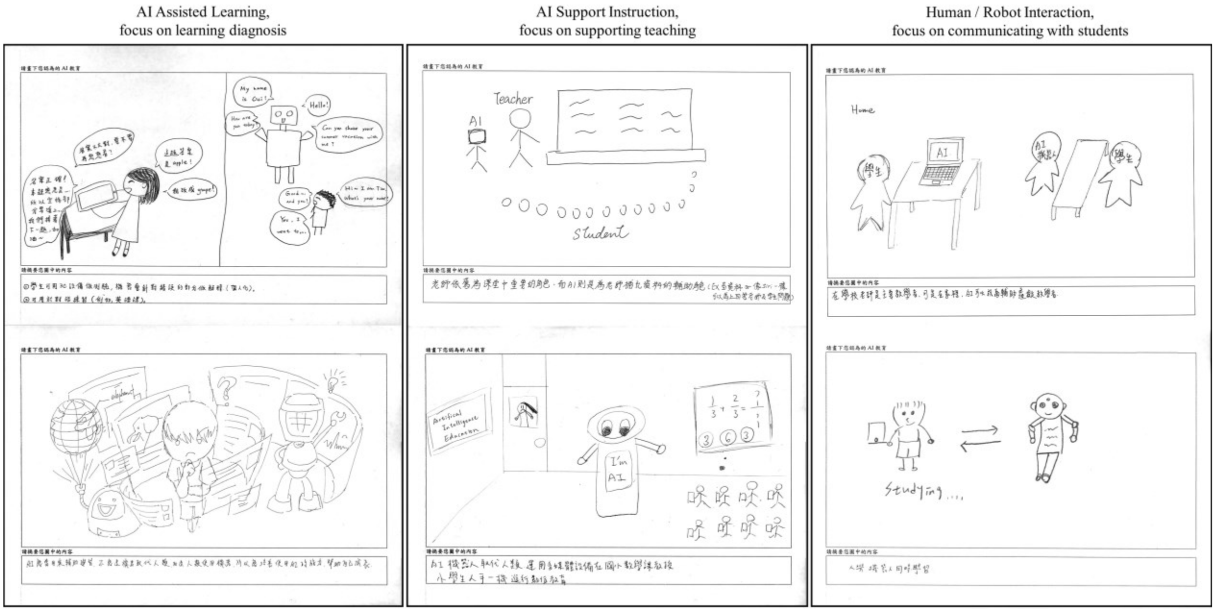

Figure 4. Examples of AI-assisted learning and support instruction

To discuss the role that AI technology can play in different learning activities, this study cross-analyzed the features of AI and the activities (as Figure 3). The results show that the students expected AI to assist with individual learning, collect user information, and perform data analysis and diagnosis. This also means that students consider analyzing learner profiles and providing diagnoses as important functions of AI to support personalized learning (as Figure 4). On the other hand, in instruction, students expect AI to assist teachers in teaching, to support students' classroom studying, and to collect user information. In other words, AI technology needs to help teachers understand students' needs and classroom operations during the instructional process. Next, in human-computer interaction, students emphasize the ability of AI to communicate with students; this also means that students expect speech recognition and semantic interpretation to be incorporated into AI-assisted learning.

4.2. Results of the word co-occurrence network analysis

To explore the most used words by students when describing the content of their drawings, this study used VOSviewer to analyze the students' words. The minimum number of occurrences of each term is 2, meaning that 34 terms could be selected. Their relationships are shown in Figure 4.

Figure 5 shows four clusters, and the words student ($f = 18$), teacher ($f = 15$), robots ($f = 9$), and AI education ($f = 8$) are the most used. The results showed that the students valued every role that was present in their learning activities, including teachers and robots.

The line between teacher and student is the thickest, which means that the students often mentioned "students" when they said "teacher." Sometimes "robots" are discussed as well. On the other hand, when students talk about "AI education," they sometimes mentioned the word "future." From this, we can see that the essential roles in learning are teachers, students, and robots. However, students' perceptions of AI education are still more future-oriented rather than being oriented towards current learning activities.

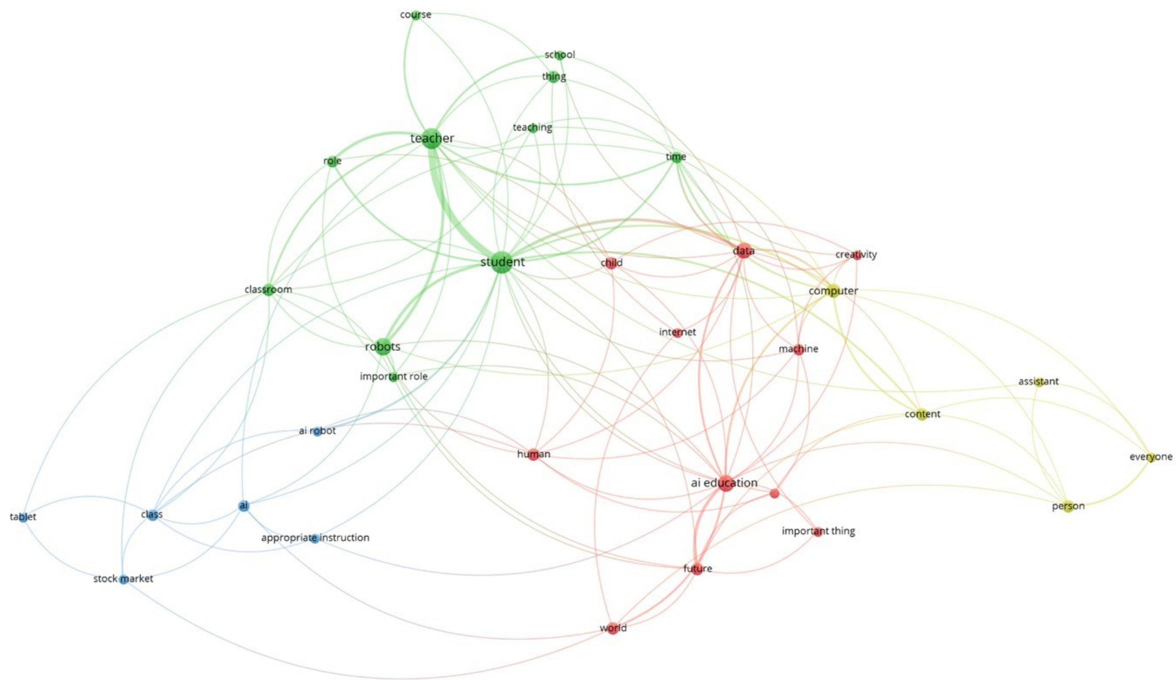

Figure 5. The most used words in the textual descriptions of the drawings

On the other hand, the distance between words indicates the correlation between the two. For example, the proximity of "learning" to "things" and of "robots" to the "important roles" indicates that students perceived these things to be highly relevant. In other words, students need the assistance of some virtual or real objects in the learning process, and robots are essential players in the learning process. It is also interesting to note that the proximity of the computer to creativity, albeit in a different group, shows that students know that it is vital to use computers to create the learning process.

Last, the cluster analysis revealed four issues that were important to the students (as in Table 9). The first cluster is the importance of AI to the future of education, with words such as AI education, data, child, future, and human appearing in the first cluster. The second cluster is the teaching context of AI, with frequent words such as student, teacher, robots, classroom, and thing. The third cluster is the carriers of AI, with frequent words such as AI, class, and AI robot; and finally, the fourth cluster is the functions of AI, such as computer, content, person, and assistant.

Table 9. The co-words in each cluster

Cluster 1		Cluster 2		Cluster 3		Cluster 4	
Label	Weight	Label	Weight	Label	Weight	Label	Weight
AI education	20	Student	37	Class	8	Computer	17
Data	19	Teacher	29	AI	7	Content	9
Future	10	Time	14	AI robot	4	Person	7
Human	9	Classroom	12	Appropriate instruction	4	Everyone	5
Machine	8	Robots	12	Tablet	3	Assistant	3
Child	7	Role	8				
World	7	Important role	6				
Creativity	6	School	5				
Ability	5	Teaching	5				
Important thing	3	Thing	5				
Internet	3	Course	4				

The results of this study are summarized in Table 10. It was found that the students preferred AI as a tool to assist their learning. Robots may be effective agents to achieve the students' expectations of AI. The students want AI-intelligent robots to provide appropriate learning support according to their learning needs. They also believe that AI may not be limited to any hardware, but should be everywhere. However, the study also found that the students did not explicitly request learning topics, learning places, objects, and software or services. It is suspected that these items are not a priority for students. For them, an AI-intelligent learning partner was what they needed.

Table 10. Summary of findings

Categories	Highlight
(1) learning topics	Not specified
(2) participants	Student and robot
(3) learning places	Not specified
(4) activities	Learning
(5) electronic technologies	PC, screen, mobile devices, but not limited
(6) objects	Not specified
(7) software or service	Not specified
(8) AI features	Assisted learning and instruction, collect information and data analysis and diagnosis

5. Discussion and conclusion

5.1. New technology and on-demand analysis are needed

From a technology perspective, computers, screens, and mobile devices are still playing an important role in students' expectations of the AI learning environment. These tools are seen by students as important for receiving AI information. However, this study also found that students have not clearly defined their needs in terms of technology or in terms of software or services. In other words, students had difficulties articulating their needs for AI technology and services from current life examples. It also means that students place more emphasis on hardware than on software or services. Therefore, a concrete tool, which may be a smart learning partner, is more important to students (Hwang et al., 2020).

Based on the results of the analysis of learning places, participants, and AI features, this study found that the students were not restricted to their learning places, which means that they need technology that can help them acquire knowledge anytime and anywhere. Interestingly, the category of participants found that robots played an important role in the students' learning process; in other words, the students recognized the role of robots in AI education. Therefore, robots that are highly portable and knowledgeable about learning would meet the needs of students (Chen et al., 2020). In terms of analytics support, students expected AI to provide the learning content they needed through data collection and data analysis. With current AI technology, decision trees, expert systems, or other computational methods that can provide needs based on students' different learning performance and contexts may be able to meet students' needs (Chen & Lian, 2020; Patterson, 2020).

5.2. Convenient, flexible and adaptable content and feedback

In terms of content, from students' expectations of AI features and learning activities, it was found that students expected the AI learning environment to provide them with easy access to the learning information they needed. In particular, students appreciated AI's capability to provide personalized learning at any time and any place. Next, students expected AI to collect their learning profiles and provide appropriate diagnostic results in real time.

From these results, we found that there was no obvious difference between students' content needs for online learning, mobile learning, or AI learning environments (Tsai et al., 2012; Yang & Tsai, 2008). They all expected the learning environment to provide appropriate, real-time, and diverse learning content. However, in an AI environment, students are more concerned about the differences in learning content for learners and the interaction between AI technology and learners. Therefore, AI development requires not only stronger computing techniques and logical reasoning abilities, but also the professional knowledge of educators to assemble learning packages that meet the needs of different learners (Fryer et al., 2017).

The findings of this study were different from those of Chocarro et al. (2021) who explored teachers' perceptions of AI. In their study, teachers expected AI to provide formal teaching assistance. However, in this study, the students wanted AI to assist their learning, but without being limited to specific subjects and contexts; in other words, the students wanted a socially oriented AI aid. This result reflects that teachers' expectations of AI's functions may be incompatible with those of students; future researchers or system developers may have to design AI systems with different algorithmic mechanisms or logic for different roles. Moreover, students' needs may not be limited to the learning content itself; they may expect anthropomorphic AI, as Gartner (2021) reports for emerging technology forecasts.

5.3. Learning that focuses on individual needs

Finally, from the object analysis, we know that students rarely mention objects outside the classroom. For example, they had not yet considered that AI could assist them in inquiry learning, ecological observation, or solving practical life problems. They often considered that AI features are mostly used to assist with personalized learning or teaching. Similar findings have been found in previous studies, where the majority of students' perceptions of learning time were in the form of listening to the teacher in the classroom or studying individually (Hsieh & Tsai, 2018). Rarely were there classroom interactions or learning activities that were connected to real-life situations.

Nevertheless, AI-assisted learning should be more than just personalized learning. With appropriate materials, and with its powerful computational, reasoning, and diagnostic abilities, AI education should be developed toward more fluid, interactive modes and a wider range of learning activities (Zawacki-Richter et al., 2019). According to students' expectations, robots with AI knowledge may become important learning companions in the future; the participation of such companions should not only provide smooth interaction and appropriate learning content, but should also guide learners to go outdoors to learn and create.

Based on the findings, this study concluded that students emphasized the importance of personalized learning modes in AI learning environments. At the same time, the students expected a robot or social learning companion to join the learning context. However, the AI learning environment that students expected was less clearly related to real contextual learning or higher level thinking. This result is also important to educators, as students' perceptions of learning patterns have not changed significantly. Therefore, it is suggested that future researchers need to consider appropriate instructional guidance (not only course content but also teaching materials and life applications) when designing AI-assisted learning activities (Zawacki-Richter et al., 2019). At the same time, students should be provided with more opportunities to interact with AI to enhance their imagination of AI-assisted learning.

6. Research limitations

Although this study uses both graphical and textual analysis to analyze the students' needs in an AI-supported learning environment, the actual needs of students were not taken into account. Moreover, individual students' academic background and their abilities of presentation could be different. This implies that collecting students' needs from diverse aspects could be needed. Therefore, it is suggested that researchers collect and analyze both qualitative and quantitative data in the future.

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Appendix

Table 1. Coding scheme for coding the students' drawings

Categories	Indicators	Indicators
(1) learning topics	1.1. Language	1.5. Programming
	1.2. Mathematics	1.6. Music
	1.3. Science	1.7. Unspecified
	1.4. Physical education	
(2) participants	2.1. Teacher	2.4. Baby
	2.2. Student	2.5. Other
	2.3. Robot	2.6. No participant
(3) learning places	3.1. Classroom	3.3. Outdoor
	3.2. Home	2.4. Unspecified
(4) activities	4.1. Learning	4.5. Chess-playing
	4.2. Instruction	4.6. Nursing
	4.3. Human/robot interaction	4.7. Unspecified
	4.4. Information justification	
(5) electronic technologies	5.1. PC	5.6. Mouse
	5.2. Screens	5.7. Calculator
	5.3. Mobile devices	5.8. Earphone
	5.4. Touch screen	5.9. VR glasses
	5.5. Smartwatches	5.10. Unspecified
(6) objects	6.1. Desk and chair	6.8. Brainscope
	6.2. Stationary	6.9. Eyeglasses
	6.3. Blackboard	6.10. Chess game
	6.4. Books	6.11. Natural objects (Cloud, sun)
	6.5. Mannequin	6.12. Transportation
	6.6. Projector	6.13. House
	6.7. Wi-Fi	6.14. Unspecified
(7) software or service	7.1. Database	7.5. VR Content
	7.2. Teaching management system	7.6. YouTube
	7.3. Google	7.7. Facebook
	7.4. IoT	7.8. Unspecified
(8) AI features	8.1. Assisting learning	8.6. Collecting user information
	8.2. Supporting instruction	8.7. Playing chess
	8.3. Connected human communication	8.8. Soothe the child
	8.4. Talking to students	8.9. Unspecified
	8.5. Data analysis and diagnosis	