Experimentation of BIM and AI software to support Adaptive Learning System in interior design course

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ABSTRACT

Current undergraduate students, particularly Generation Z, are digital natives who have grown up with digital technology and exhibit unique learning characteristics that necessitate new approaches in higher education. An Adaptive Learning System in education involves leveraging technology to accommodate individual students' unique needs and preferences. This research aims to enhance learning effectiveness and design processes in interior design courses, with the case study Interior Design II course at Telkom University, Indonesia. The course currently offers limited software options for interior layout design, which may hinder students' abilities and preferences. This study compares three software tools—Autodesk AutoCAD, Building Information Modeling (BIM) software Autodesk Revit, and Artificial Intelligence (AI)-based plugin PlanFinder—to determine which is most effective in improving students' understanding and simplifying the design process. The research methodology employs a mixed-method approach, integrating qualitative methods such as literature reviews and Focus Group Discussions (FGDs) with quantitative methods like experimentation workshops and pre-test and post-test questionnaires analyzed using SPSS software. The results demonstrate that Autodesk Revit, a BIM software, notably enhances the design process's effectiveness, particularly within the Interior Design II course context. Consequently, the study recommends the implementation of Adaptive Learning Systems that allow students to select software based on their capabilities and preferences. The three software tools/plugins examined in this study can be considered for integration into interior design courses. Furthermore, future research should seek to broaden the sample size and evaluate additional AI tools in interior design courses for comparative analysis.

1. Introduction

Current undergraduate students, mainly Generation Z or Gen Z, were born between 1995 and 2010. Gen Z is known for its affinity with and reliance on technology. As digital natives who have grown up surrounded by digital technology, they have never known a world without the internet, social media, smartphones, the Internet of Things, and more [1]. For example, university students, in general, cannot be separated from the use of Canva. This web-based graphic design platform makes it easy to support their various assignments, ranging from conceptualizing to presenting ideas [2]. Nowadays, students also discuss with their friends and lecturers online through social media and email. Online discussion platforms offer increased student participation, better engagement with course material, and improved academic performance [3]. This unique relationship with technology shapes their learning characteristics, necessitating new approaches in higher education [4]. Therefore, technology in the academic world has an essential role in supporting the advancement of Gen Z in an adept and productive direction [5]. Each student has a distinct learning style, so learning systems must offer

varied suggestions and instructions to optimize students' learning process and monitor and adjust learning methods [6]. Research on student preferences in software usage reveals diverse factors influencing their choices. In software engineering projects, students select based on perceived difficulty or subject appeal, valuing enhanced learning experiences and user benefits [7]. Interface preferences vary, with graphical user interfaces offering a different approach than traditional command-line interfaces [8]. In team projects, student preferences for evaluation methods are influenced by year of study, familiarity with teammates, and overall team experience satisfaction [9]. This phenomenon has led to more research into integrating learning styles and Adaptive Learning Systems [10]. Adaptive Learning System allows students to flexibly respond to tasks, change, initiate, and take control of their learning [11], [12]. Technology is one of the most developed aspects supporting Adaptive Learning Systems [13], [14]. Artificial intelligence (AI) technology, which can collect, analyze, and process massive data quickly, provides great potential to support education [15]. Artificial intelligence (AI) enables personalized learning tailored to the individual needs of lecturers or students, including emotional ones [16]. An Adaptive Learning System is the development of learning to adjust the preferences of lecturers or students, and the use of AI will allow automation and customization based on user capabilities and preferences. Thus, AI must be optimized for use without violating academic ethics to support learning effectiveness. Technology in architecture and interiors continues to evolve along with the times. In addition to AI, BIM, or Building Information Modeling, is one of the emerging technologies in the construction world, including in architecture and interiors. BIM is a set of technologies whose entire process runs in an integrated manner in a digital model, which is then translated as a three-dimensional image, which can predict and minimize errors in the construction field [17], [18]. BIM is a revolutionary technology that allows visualization, collaboration, and stakeholder integration [19]. BIM, especially software integrated with AI systems, must be considered in the learning process to support the Adaptive Learning System.

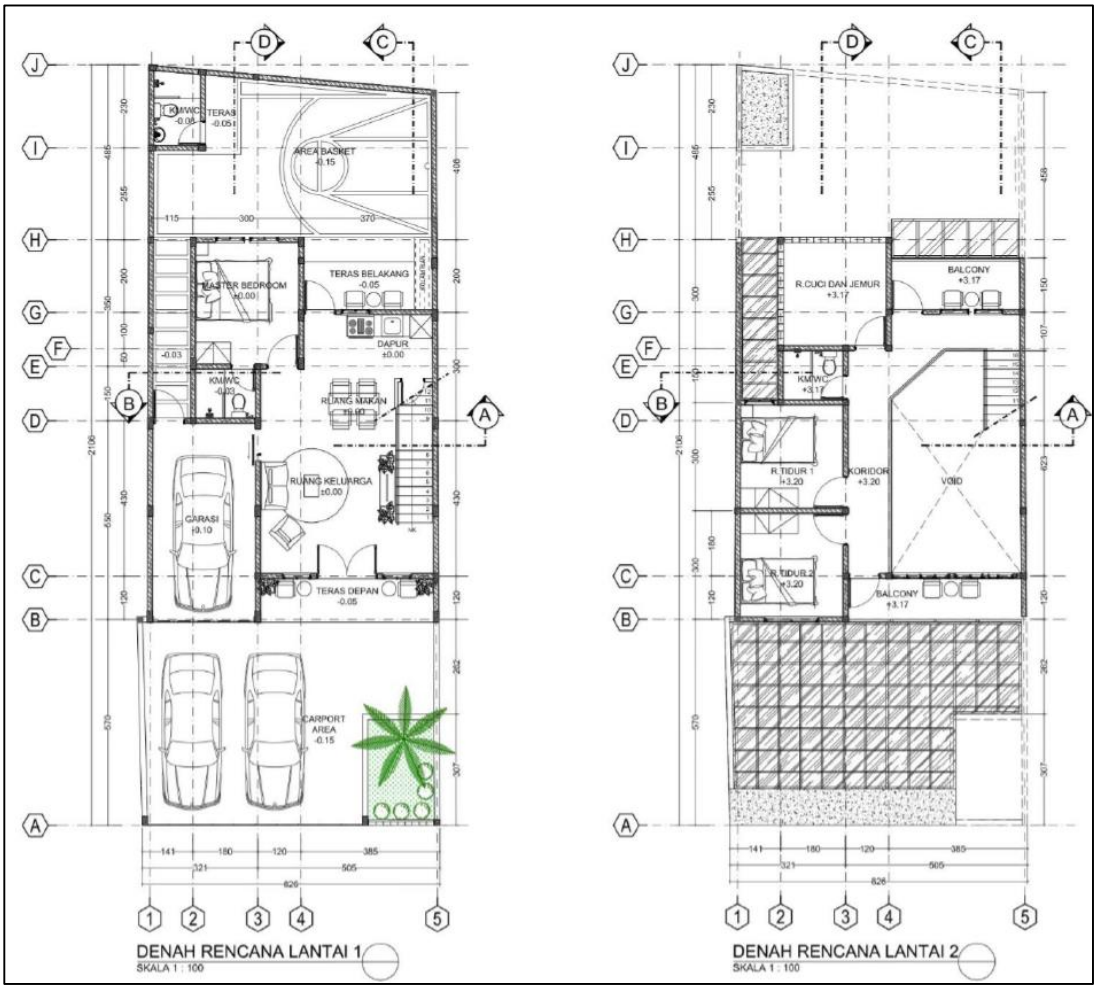

Fig. 1. Example of an interior layout plan with Autodesk AutoCAD.

This research uses a case study of the Interior Design II course, a compulsory course for the Bachelor of Interior Design Study Program, School of Creative Industry, Telkom University, Bandung, Indonesia, in semester 4, level 2. This course is an advanced studio course that applies students' knowledge and abilities to solve problems related to residential design. The residential house designed is a simple building consisting of 2 floors, with a design area of 100 - 120 m^2. In this course, students are required to achieve the ability to explain and describe their design visually, orally, and in writing. The design starts with user programming and designing the interior layout (Fig. 1), which is then developed into elevations, sections, 3D perspectives, and interior details. Generally, the Interior Design II course output is produced digitally and manually. Digital designs typically only use Autodesk AutoCAD software to produce 2D drawings (Fig. 1) and Trimble SketchUp to produce 3D drawings. The two software are not integrated into one system but can be synchronized by exporting or converting files to each other. The limited choice of software tends to inhibit students' abilities and preferences in learning, even though the abilities and preferences of each student tend to be varied. In Indonesia itself, interior design software that is commonly used is general software such as AutoCAD, SketchUp, and Enscape software [20]–[23]. BIM software is yet to be common and is still too complex to use [24], especially AI tools, which are generally still in the research and testing stage.

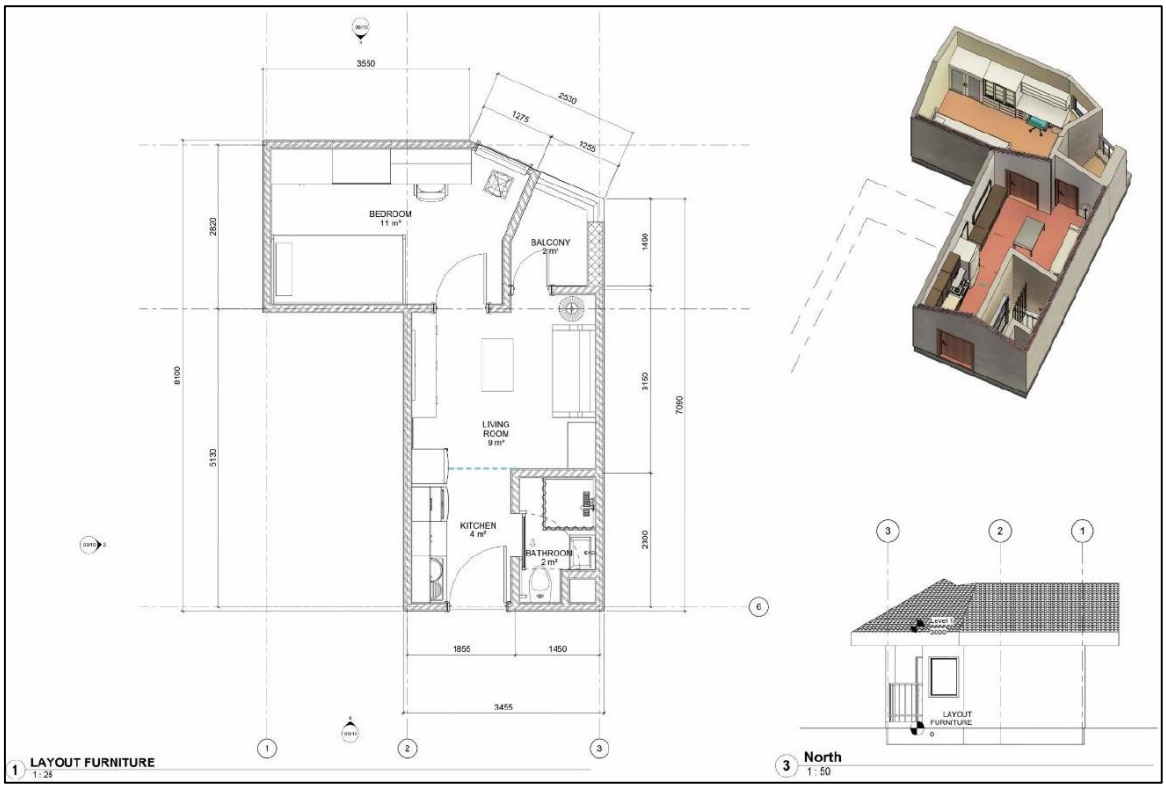

Fig. 2. Example of an interior layout plan integrated with elevation and 3D perspective in Autodesk Revit.

Autodesk Revit is one of the BIM software that has the advantage of visualizing buildings in an integrated manner regarding art, design, structural logic, financing, and project management [25]. Revit also allows workflow integration and sustainable design practices [26]. The software integrates 2D and 3D drawings in one software and allows users to design layout plans, elevations, sections, and perspectives simultaneously (Fig. 2). There is also an AI-based plugin called PlanFinder that can be connected to Rhino and Revit software. PlanFinder can optimize the efficiency of the design process by generating interior designs, architectural facades, and building plans, which will be further reviewed by its AI system in terms of drawings, blueprints, and structural databases [27]. PlanFinder can suggest alternative layouts from layouts designed by users, helping users analyze several potential layouts concurrently (Fig. 3).

Fig. 3. Example of generating process for alternative interior layout plans with PlanFinder.

Using appropriate BIM software and AI tools can potentially escalate the effectiveness of the learning and design process, especially in the Interior Design II course. This research will focus on comparing three software programs, namely Autodesk AutoCAD, Autodesk Revit, and PlanFinder, to design the interior layout of the Interior Design II course. Students' experiences using the three software will then be studied, analyzed, and compared to find the most effective software to improve students' understanding and make it easier to design interior plans and layouts. This research aims to raise the potential effectiveness of learning and designing layouts in interior design learning, especially with the case study of the Interior Design II course. It compares the use of AI-based plugins, BIM software, and the common software used by students to improve students' understanding of building integration in 2D and 3D and provide alternative suggestions for student design. This research aims to raise the potential effectiveness of learning and designing layouts in interior design learning, especially with the case study of the Interior Design II course. It compares the use of AI-based plugins, BIM software, and the common software used by students to improve students' understanding of building integration in 2D and 3D and provide alternative suggestions for student design. The objectives of this research are as follows; (1) Finding software that is effective in improving students' understanding of the process of designing interior layouts; (2) Finding software that effectively simplifies and accelerates students in designing interior layouts; (3) Producing recommendations using BIM and AI software to support the Adaptive Learning System in interior design learning.

2. Method

This research was conducted using a mixed method, qualitative and quantitative. The qualitative method was carried out by a literature review related to Adaptive Learning Systems, AI and BIM in interior learning, interior design layout process by students using three software (Autodesk AutoCAD, Autodesk Revit, and PlanFinder), and also conducting Focus Group Discussions (FGDs) to find out the experience of students in using the three software in depth. The quantitative method was carried out by testing three software and filling out pre-test and post-test questionnaires by sample students as the object of research. The test and questionnaire results were analyzed to find the effect of the software's effectiveness on the design results and the student learning process using SPSS software with the paired samples t-test analysis method. The paired samples t-test is a statistical method used to compare the means of two related groups or a single group measured at different times [28]. The test assumes that the difference scores are symmetrically distributed and that no significant outliers exist [29], [30].

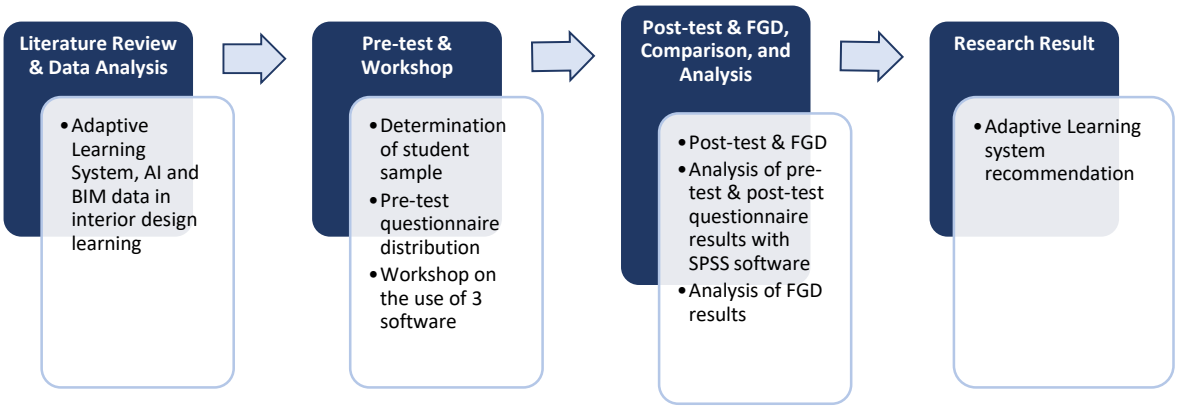

Fig. 4. Research flow.

The research proceeded in the following steps (Fig.4); (1) Literature review related to Adaptive Learning Systems, AI and BIM in interior learning; (2) Determination of student samples, distribution of pre-test questionnaires, and workshops on using three (3) software; (3) The process of designing interior plans and layouts by students using three (3) software (Autodesk AutoCAD, Autodesk Revit, and PlanFinder); (4) Post-test questionnaires distribution and FGD activities with a sample of students regarding their experience using three (3) software programs; (5) Analyzing the results of the pre-test and post-test questionnaire with SPSS software, analyzing the results of the FGD with analytical rubrication. The subjects involved in this study were three research lecturers and one reviewer lecturer from the research grant program. The research objects in this study are eight students of the Interior Design II course from two (2) different classes. They are all Indonesians, have the same basic skills, come from the same cohort, have passed the same type of course, have equal ability to use AutoCAD software for one year, and have never used Revit or PlanFinder before. In the research process, they learned to use three software: Autodesk AutoCAD, Autodesk Revit, and PlanFinder. At the end of the research, they collected the layouts they produced with different software; two (2) people used Autodesk AutoCAD, two (2) used Autodesk Revit, two (2) used Revit and AutoCAD, and two (2) used AutoCAD and PlanFinder. The comparison of three software in the form of 2D, BIM, and AI software is a new comparison method in research, especially in interior design education, so this research is expected to provide recommendations for the use of software to support the effectiveness of learning and interior design. Several prior studies supporting this research are as follows:

- Adaptive Learning System. Adaptive Learning System is an educational and technological innovation in higher education based on mastery, immediate feedback, and interactive learning [13], [31]. Adaptive Learning System aims to produce automated, interactive, and flexible content [13], [32]. Adaptive learning is an automatic process that can adjust the content based on students' understanding, their responses, or learner preferences [13]. In order to optimize an Adaptive Learning System in interior design, BIM and AI technology need to be considered, tested, and utilized.
- AI in education. The use of AI can induce a positive contribution to improving learning effectiveness and student engagement, enabling learning personalization and learning satisfaction [33]–[35]. However, AI can also be misused in academic offenses such as plagiarism, cheating, and other academic misconduct, which is still a significant problem [33]. Therefore, AI should be used ethically in academia, especially in higher education. AI should be a tool to support the learning process and not replace lecturers as facilitators nor replace students' deep understanding, creativity, and critical thinking [33]. Adaptive Learning System is the development of learning to adjust the preferences of lecturers or students, and AI will allow automation and customization based on user capabilities and preferences. Thus, AI must be optimized for use without violating ethics in the learning process, supporting learning effectiveness.
- BIM in interior learning. Autodesk Revit is one of the BIM software that has the advantage of visualizing buildings in an integrated manner regarding art, design, structural logic, financing, and project management [25]. The software integrates 2D and 3D images in one software and allows users to design layout plans and views, pieces, and perspectives simultaneously. There

is also an AI-based plugin called PlanFinder that can be connected to Rhino and Revit software. Additionally, PlanFinder can improve the efficiency of the design process by generating interior designs, architectural facades, and building plans, which will be further reviewed by its AI system in terms of drawings, blueprints, and structural databases [27]. PlanFinder has the potential to make the design process effective and efficient because it can provide alternative layout suggestions based on user-designed layouts, helping users analyze the potential of multiple layouts simultaneously.

- The importance of layouts in interior design. Layout is a plan or initial picture of the top view equipped with the building's environmental conditions, circulation, and elements [36], [37]. The layout design in the interior plays a vital role in design, facility utilization, circulation, systems, and furniture. Plans and layouts have a great complexity of most of the problems that exist in the interior, and decisions regarding the layout of the plan are complex and critical because each placement has significant consequences on global performance [38]. The residential layout in interior design is crucial for creating comfortable and functional spaces that affect the occupants' productivity and well-being [39]. A well-designed layout can also enhance balance and increase productivity and quality control in commercial space [40]. Interior design or architecture education tends to favor visual accentuation in the final presentation over the design process itself, especially in project evaluation. It suggests that pleasing images tend to dominate the core solution in the project [41]. In fact, the core solution of interior design is the interior layout. Therefore, this research limits the intervention to the layout stage, an essential stage in interior design.

The importance of interior layout design is expected to be supported by the potential of BIM software and AI tools to help simplify the layout design process, produce multiple layout evaluations at once, and streamline the layout design process, especially residential layouts. An interactive furniture layout system based on interior design guidelines can also improve the quality of the furniture layout [42]. The use of BIM and AI software in learning has the potential to increase student understanding and streamline the design process. Therefore, the researcher hypothesized that "Autodesk Revit and PlanFinder will provide effectiveness in working on interior layouts, as well as increase Interior Design II course students' understanding of the interior design process so that their use can be considered in learning other interior design courses."

3. Results and Discussion

3.1. Pre-test and Post-test Questionnaire Results

Table 1 is data compare the results of the pre-test and post-test questionnaires filled in by all sample students. Based on the data in Table 1, it was found that there was a significant escalation in Autodesk Revit software experience after respondents attended the software workshop; it raised 71.7%. There was also an increase in PlanFinder software/plugin experience after respondents attended the software workshop, with an average increase of 31.7%, while there was a slight reduction in Autodesk AutoCAD software experience by 2.5%. The reduction in Autodesk AutoCAD software experience was related to the difficulty level in learning Autodesk AutoCAD software after respondents compared the use of Autodesk Revit and PlanFinder software.

Table 1. Pre-test and post-test results of software usage experience

Topic Variable	Question	Precentage of Respondent Agreement	
		Pre-test	***Post-test***
Autodesk AutoCAD software experience	Have you ever used Autodesk AutoCAD software?	100%	100%
	What is the level of difficulty in learning Autodesk AutoCAD software?	95%	92,5%
	How long did it take you to learn the Autodesk AutoCAD software?	77,5%	72,5%
	Average Percentage Value Respondents' experience of Autodesk AutoCAD software	**90,8%**	**88,3%**
Autodesk Revit software experience	Have you ever used Autodesk Revit software?	0%	100%

Topic Variable	Question	Precentage of Respondent Agreement	
		Pre-test	***Post-test***
	What is the level of difficulty in learning Autodesk Revit software?	0%	62,5%
	How long did it take you to learn the Autodesk Revit software?	0%	52,5%
	Average Percentage Value Respondents' experience of Autodesk Revit software	**0%**	**71,7%**
PlanFinder software/plugin experience	Have you ever used PlanFinder software/plugin?	0%	37,5%
	What is the level of difficulty in learning PlanFinder software/plugin?	0%	30%
	How long did it take you to learn the PlanFinder software/plugin?	0%	27,5%
	Average Percentage Value Respondents' experience of PlanFinder software/plugin	**0%**	**31,7%**

Based on the data in Table 2, the results show an escalation of the layout design process with three software. The use of Autodesk AutoCAD software rose by 2.8%, Autodesk Revit by 43%, and PlanFinder by 22%. Software effectiveness for Autodesk Revit increased by 37%, 3.1% for PlanFinder, and a significant decrease of 40.2% for Autodesk AutoCAD. There was an improvement in software preference for Autodesk Revit by 12%, stagnant for Autodesk AutoCAD, and a decline of 13% for PlanFinder. It can be seen that according to respondents, in designing interior layouts, the most effective software in improving understanding is Autodesk AutoCAD at 87.5%, the most effective software in facilitating the design process is Autodesk Revit with a percentage of 75%, the most effective software for accelerating the design process is Autodesk Revit at 62.5%. Autodesk Revit is the most effective software for simultaneously designing layouts and elevations/sections at 62.5%. Thus, Autodesk Revit software, which is BIM software, dominates the effectiveness of use in interior design.

Table 2. Pre-test and post-test results of the interior layout design process

Topic Variable	Question	Precentage of Respondent Agreement					
		Pre-test			***Post-test***		
Layout Design Process	What software do you usually use to design an interior layout?	100%	0%	0%	100%	37,5%	12,5%
	What software do you usually use to project an interior layout drawing into an elevation/section view?	100%	0%	0%	100%	25%	0%
	How long does it take to design a complete digital interior layout? (completed with notations, room names, dimensions, column lines)	67,5%	0%	0%	76,3%	66,3%	53,8%
	Total average value percentage of respondents	**89,2%**	**0%**	**0%**	**92%**	**43%**	**22%**
Software Effectiveness	Between Autodesk AutoCAD, Autodesk Revit, and PlanFinder, which software is the most effective in improving your understanding of interior layout design?	87,5%	12,5%	0%	87,5%	12,5%	0%
	Between Autodesk AutoCAD, Autodesk Revit, and PlanFinder, which software is the most effective in facilitating the process of designing interior layouts?	100%	0%	0%	25%	75%	0%
	Between Autodesk AutoCAD, Autodesk Revit, and PlanFinder, which software is most effective in speeding up the process of designing interior layouts?	75%	25%	0%	25%	62,5%	12,5%

	Between Autodesk AutoCAD, Autodesk Revit, and PlanFinder, which software is most effective when simultaneously designing layouts and elevations/sections?	75%	25%	0%	37,5%	62,5%	0%
	Total Average Score Percentage of Respondents	**84%**	**16%**	**0%**	**43,8%**	**53,1%**	**3,1%**
Software Preference	Without considering the cost and memory size of the software, which of Autodesk AutoCAD, Autodesk Revit, and PlanFinder is suitable for you?	75%	12,5%	12,5%	75%	25%	0%
	Without considering the cost and memory size of the software, between Autodesk AutoCAD, Autodesk Revit, and PlanFinder, which software will you continue to use?	75%	12,5%	12,5%	75%	25%	0%
	Total average value percentage of respondents	**75%**	**13%**	**13%**	**75%**	**25%**	**0%**

Table 3 compared three software applications using SPSS statistical software and a paired sample T-test analysis. Based on the results from Table 3, the significance value (2-tailed) for the Revit Paired Sample T-test is 0.000 < 0.05. According to decision-making theory, there is a significant influence if the significance value is less than 0.05 or (2-tailed) 0.05, and there is no significance if the significance value is more than 0.05 [43]. Therefore, Autodesk Revit software significantly influences the effectiveness of using the software in design. So the research hypothesis: "Autodesk Revit and PlanFinder will provide effectiveness in working on interior layouts, as well as increase Interior Design II course students' understanding of the interior design process so that their use can be considered in learning other interior design courses." unacceptable because only Autodesk Revit has significant value. PlanFinder does not have a significant impact with a significance value (2-tailed) of 0.063, so PlanFinder does not significantly influence the effectiveness of using software in design. This result happened due to the limitations of PlanFinder's AI, which is more effective for rectangular, single-story plans, and the majority of PlanFinder's library comes from European countries and does not yet support interior layout in Indonesia, where the case study was conducted. In addition, a more extensive sample study regarding Adaptive Learning Systems using BIM and AI software is recommended because, based on previous research conducted [44], experiments with larger samples with similar partial results can show lower expected significance. It is also recommended that other AI software/tools be tested during the layout design process to compare with PlanFinder

Table 3. Results of pre-test and post-test questionnaire analysis with SPSS software

		Paired Differences							
		Mean	***Std. Deviation***	***Std. Error Mean***	***95% Confidence Interval of the Difference***		***t***	***df***	***Sig. (2-tailed)***
					Lower	***Upper***			
Pair 1	AutoCAD Pre-test Score - AutoCAD Post-test Score	13.433	26.067	7.525	-3.129	29.996	1.785	11	.102
Pair 2	Revit Pre-test Score - Revit Post-test Score	-43.233	29.248	8.443	-61.817	-24.650	-5.120	11	.000
Pair 3	PlanFinder Pre-test Score - PlanFinder Post-test Score	-12.400	20.751	5.990	-25.585	.785	-2.070	11	.063

3.2. Focus Group Discussion Result

The research involved conducting pre-test and post-test assessments and a Focus Group Discussion (FGD) with a sample of students. The FGD aimed to thoroughly understand the students' experiences with three different software programs. This method was also used to gather data on the strengths and

weaknesses of each software in the interior layout design process. Table 4 presents the FGD analysis results about the advantages of Autodesk AutoCAD, Autodesk Revit, and PlanFinder software based on the factors influencing the layout design process. According to the findings in Table 4, Autodesk Revit is favored by students due to its numerous advantages, such as the ability to scale setting, design alternatives, space scale or anthropometrics, symbolization, line thickness, standardization of construction drawings, construction creation, space planning or development, file conversion, speed, and neatness. The advantages of Revit are due to the software's fully automated and integrated setting capabilities between 2D working drawings and 3D perspective visual images. On the other hand, Autodesk AutoCAD excels in creating design alternatives, furniture depiction, space planning, and file conversion because its settings are more manageable and simpler than Revit and PlanFinder. PlanFinder, in comparison, offers the least advantages, primarily in its AI tools for creating alternative designs and automatically setting line thickness.

Table 4. Analytical rubrication regarding software advantages resulting from Focus Group Discussion

Component	**Tested Software**		
	Autodesk AutoCAD	***Autodesk Revit***	***PlanFinder***
Scale		The furniture scale automatically follows the room-scale; the scale can be set automatically.	
Design Alternatives	AutoCAD is more accessible and simpler for 2D drawing.	Automatic with the dimensions and materials, it can immediately see the results of the design in 3D visuals.	Users will get guidance in determining the room's function, size, and furniture arrangement.
Space scale/Anthropo metrics		Revit makes it easier for students to feel space (scale, distance, and atmosphere) and circulation between furniture because every object (space and furniture) created can be seen directly in 3D visualization.	
Furniture Depiction	Designating furniture as a 2D drawing using AutoCAD is more manageable because the settings are simple.		
Symbolization		Automatic settings make it easier and faster.	
Line Thickness		Automatic settings make it easier and faster.	Automatic settings make it easier and faster.
Standardization of Construction Drawings		Automatic settings already follow the standard and make it easier and faster.	
Construction		Integrated construction settings make it easier to create construction drawings and help understand the construction of buildings and spaces. 2D and 3D integrated models can easily be cut into sections or elevations.	
Space Planning/Devel opment	AutoCAD is more accessible and simpler for 2D drawing.	The settings make it easier for students to design complex objects because the object settings can be arranged in detail.	
File Conversion	File conversion is more manageable using AutoCAD.	Revit drawings can be converted to AutoCAD, PDFs, and SketchUp.	
Speed		Revit makes it easier and faster to create construction drawings and complex objects because of its automatic setting that automatically follows drawing standards.	
Neatness		Construction drawings are neat because the settings automatically follow standards.	

Table 5 below presents the results of the FGD analysis concerning the weaknesses of Autodesk AutoCAD, Autodesk Revit, and PlanFinder software based on the components that determine the layout design process.

Table 5. Analytical rubrication related to software weaknesses resulting from Focus Group Discussion

Component	Tested Software		
	Autodesk AutoCAD	***Autodesk Revit***	***PlanFinder***
Scale		Limited image headers and settings are more complicated than AutoCAD.	
Design Alternatives			Editing the resulting design is too complex.
Space scale/Anthropometrics			
Furniture Depiction	If an object is downloaded from an external source (web), the scale usually does not match, and the lines do not blend well.	The setting is too complex.	
Symbolization		The material setting is complex and has a foreign language/term barrier.	
Line Thickness	Manual settings make it difficult to determine the line thickness according to standard.		
Standardizationof Construction Drawings		Automatic settings make it challenging to re-touch the drawings or manipulate visuals based on student preferences.	
Construction			
Space Planning/Development		Students do not understand Revit settings well because they have only been learning the software for weeks.	
File Conversion		Converting Revit files to AutoCAD sometimes causes the image size to change and not match. Converting a Revit file to SketchUp takes quite a long time.	
Speed		Creating perspective/color drawings in Revit is more complicated than in SketchUp software. Rendering images using Revit takes a long time because the files are detailed and heavy.	
Neatness			

In Table 5, it is evident that Autodesk Revit boasts numerous advantages but exhibits several weaknesses. These weaknesses include challenges with scale settings, furniture depiction, symbolization, line thickness, standardization of construction drawings, space planning or development, file conversion, and speed in rendering images. On the other hand, Autodesk AutoCAD is disadvantaged in furniture scale settings and requires manual adjustment of line thickness on the layout. Meanwhile, PlanFinder's drawback lies in the difficulty of editing the final design, which is tailored to be highly automated and compact but less flexible for editing purposes.Conclusions from the FGD results with sample students as research objects based on Table 4 and Table 5:

- Scale. Revit enabled students to create construction drawings for furniture layouts more easily because every furniture object inserted into the building plan automatically has its scale adjusted to the scale of the plan. However, students experience difficulty plotting layouts onto image headers of a specific size. This difficulty is caused by the limited size of the image header

available in Revit and the complex setting of the image header, which is more complicated than AutoCAD software.

- Design alternatives. Revit enabled students to create alternative designs faster because of its integrated settings regarding dimensions, materials, and 3D visuals. However, if the alternative designs created are only 2D drawings, such as furniture layouts, students found it easier to use AutoCAD because the creation process is simpler. PlanFinder is also considered easy to use in creating design alternatives because users will get guidance in determining the function of the room, room size, and arranging furniture in the room at once (Fig. 5). However, the weakness of PlanFinder is the editing process after the design generated by AI.

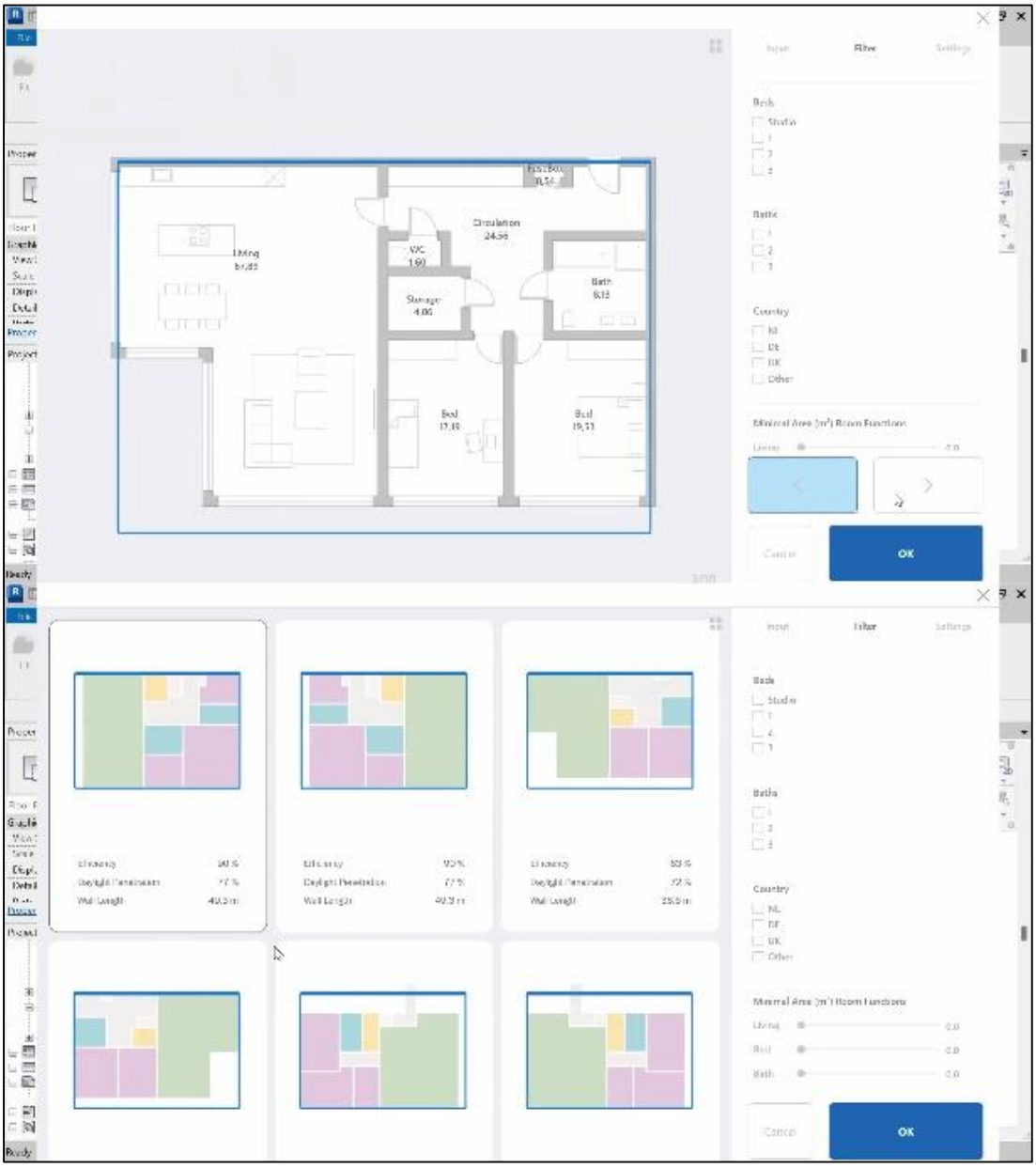

Fig. 5. Example of an alternative interior layout process with PlanFinder

- Space scale/anthropometry. Revit made it easier for students to feel space (scale, distance, and atmosphere) and circulation between furniture because every object (space and furniture) created can be seen directly in 3D visualization (Fig. 6).

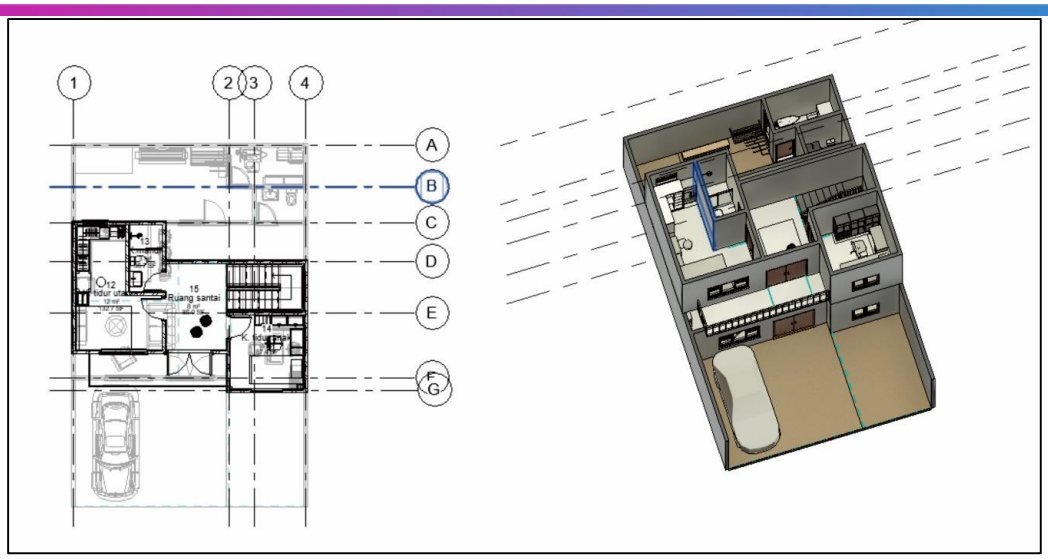

Fig. 6. Example of the layout design process with Revit software

- Furniture depiction. Students were not used to designing furniture using Revit because the settings felt complicated. They found it easier to design furniture using AutoCAD as a 2D drawing because the settings are simpler. However, the weakness of AutoCAD is that if an object is downloaded from an external source (web), the scale usually does not match, and the lines do not blend well.
- Symbolization. Students found it easier to create material symbolization in Revit because of its automatic setting. However, the material setting is quite complex, and they have a foreign language/term barrier as an Indonesian.
- Line Thickness. Automatic settings in Revit enable students to draw with the appropriate line thickness. Students felt the same thing when using PlanFinder. Meanwhile, when using AutoCAD, students found it challenging because they had to determine the line thickness themselves (manually) for each object (Fig. 7).
- Standardization of construction drawings. Automatic settings in Revit followed the standard, making it easier and faster for students to create well-constructed drawings. However, automatic settings made it challenging to re-touch the drawings or manipulate visuals based on student preferences (Fig. 7).

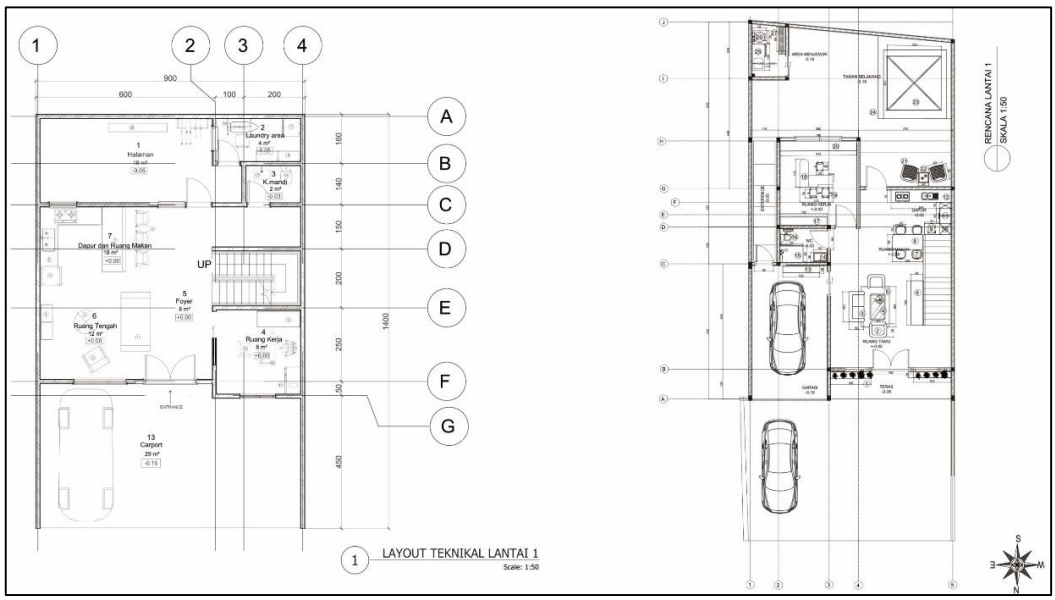

Fig. 7. Comparison of interior layout with Revit (left) and AutoCAD (right) software

- Understanding construction. Integrated construction settings made it easier to create construction drawings and help students understand the construction of buildings and spaces. 2D and 3D integrated models can easily be cut into sections or elevations. Errors in making construction drawings can be minimized, and it supports the BIM concept [17], [18].
- Space planning and development. Revit supported students in designing complex objects because the object settings can be arranged in detail. However, a lack of experience in Revit settings made them think AutoCAD is more manageable and simpler, especially if the object needed is in 2D drawing.
- File conversion. Drawings created in Revit can be converted to AutoCAD, SketchUp, and PDF files. However, the lack of students' experience in converting images from Revit to AutoCAD, resulting unscale and sloppy drawings. Meanwhile, converting a Revit file to SketchUp takes quite a long time. Students felt that converting drawings created in AutoCAD to other programs/software is more effortless.
- Speed. Revit effectively accelerated the creation of construction drawings, such as windows, doors, and complex objects, because every object created in Revit is integrated into 3D and has automatic standards (material, symbols, and sizes). However, creating perspective or color drawings in Revit is more complicated than in SketchUp software. Rendering images using Enscape from Revit takes longer than Enscape from SketchUp because the files are detailed and heavy.
- Neatness. Construction drawings produced in Revit are neat because the settings automatically follow standards (material, symbols, dimensions, notation, text).

Autodesk Revit is considered the most effective in supporting students in designing and creating layout drawings. The first reason is that each scale of the furniture object included in the layout drawing automatically adjusts to the scale of the floor plan drawing, making it easier to create furniture layout designs. Second, every object created has standard materials and sizes and is integrated into 3D models, making it easier to feel space and circulation, more accessible to create alternative designs for objects, faster to create complex objects, and easier to understand and create construction drawings. Third, every object created has been automatically set for symbols, materials, and line thickness. The drawing also has been set standardly for dimensions, notations, and text (letters and numbers), making it easier and faster to create working drawings from objects, such as doors and windows. These results support previous research related to BIM, a technology integrated between 2D and 3D, and can predict and minimize errors in the construction field [17], [18]. However, several obstacles cause students to prefer other programs, such as AutoCAD and SketchUp, over Revit when creating color or presentation drawings. First, the limited size of the image header available in Revit and the image header settings are more complicated, making it challenging to convert files to PDF for printing images. Second, the settings in Revit are considered complicated if used only to create furniture layout designs or furniture in 2D form. Third, the object's setting is complicated due to language barriers and unfamiliar terms. Fourth, there needs to be more flexibility when creating working drawings because the settings in Revit are considered complicated. This result supported the statement in prior research [24] regarding the complexity of implementing BIM in Indonesia, which still needs to become familiar with BIM technology. Therefore, students should study Revit for an extended period to become familiar with its settings and English terms that may be unfamiliar to them.

The PlanFinder software has been found to have limited effectiveness and a significant impact on the interior layout design process, as evidenced by a case study involving Indonesian students. This is primarily due to the limitations of the AI in PlanFinder, which is more suited for rectangular and single-story plans. Additionally, most of PlanFinder's design libraries are sourced from European countries and do not currently support layouts relevant to Indonesian design needs. As PlanFinder's user base primarily consists of European users, the library content reflects this; however, increasing Indonesian users could lead to expanding the library to accommodate Indonesian layout requirements. Research indicates that BIM and AI have great potential in interior design education. Digital native Gen Z students are known for quickly adapting to the latest technology. The complexity of BIM Revit software was found to expedite the design process and construction drawing creation, as per the SPSS and FGD analysis results. This suggests that using Revit in interior design education could positively impact both design and construction processes for students specializing in this field. Further research

is needed on the condition that students have been using the Revit program for longer and are using better hardware/computer facilities. The current research compares AutoCAD, which the students have used for a year, to Revit and PlanFinder, which was only introduced in a few weeks for research purposes. The results of this research can be used to evaluate other potential uses of the Revit program in the design process and in creating construction drawings in the future. Even though PlanFinder's AI-based plugin is still not very effective and significant in helping the interior design process, the way AI works has the potential to be further studied and optimized in interior design learning.

4. Conclusion

According to research findings, Autodesk Revit is the most efficient software for simplifying and expediting students' interior layout design, elevation, and section view drawings. Some drawbacks of Revit include the complexity of creating models and settings, as well as language barriers and unfamiliar terms, which may pose challenges for students from Indonesia. Additionally, there is a need for greater flexibility in creating construction drawings, indicating that students should gain more experience using Autodesk Revit for this purpose. On the other hand, Autodesk AutoCAD is recognized as the most effective software for enhancing students' comprehension of interior layout design due to its ease of use. However, AutoCAD is less effective than Revit in the construction drawing process, as it often requires manual reprocessing when finalizing the drawings. Interestingly, survey results indicate that Revit is more effective than AutoCAD, even for students with only one month of experience with the software. Adaptive Learning Systems can be implemented by allowing students to choose software according to their capabilities, needs, and preferences. The three software/plugins tested in this research can be used as selected or combined software in the Interior Design II course. It is suggested that the PlanFinder plugin be utilized at the initial stages of the design process to explore various design considerations and alternatives. Following this, BIM Revit software can facilitate integrated design work, transitioning from 2D to 3D views. In contrast, AutoCAD software can simplify personalized and customized designs for the finishing stages or conversion to other software such as Trimble SketchUp or Adobe Photoshop. For future research referenced in (Fig. 8), it is advisable to conduct a more comprehensive sample study on the use of BIM and AI software in adaptive learning systems to strengthen the significance of the data further. It is also recommended that AI tools other than PlanFinder be explored within the context of interior design education, allowing for a comparative study with PlanFinder, which has shown limited effectiveness in supporting interior layout design for Indonesian students. Extending the workshop and evaluation duration to approximately one year would enable students to acclimate to the software under test, considering factors such as tool complexity, language barriers, and individual student preferences and abilities. Future research could follow a similar comparative method based on the current study's findings while refining the methodology related to workshop duration and evaluation period

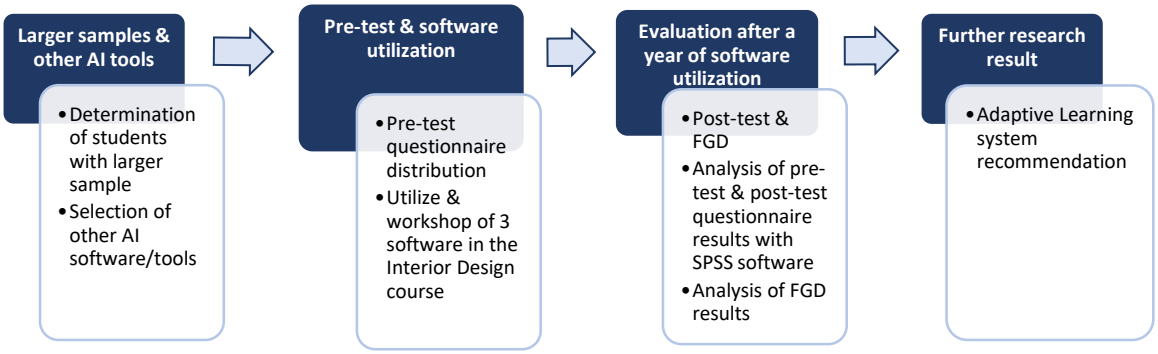

Fig. 8. Future research roadmap

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