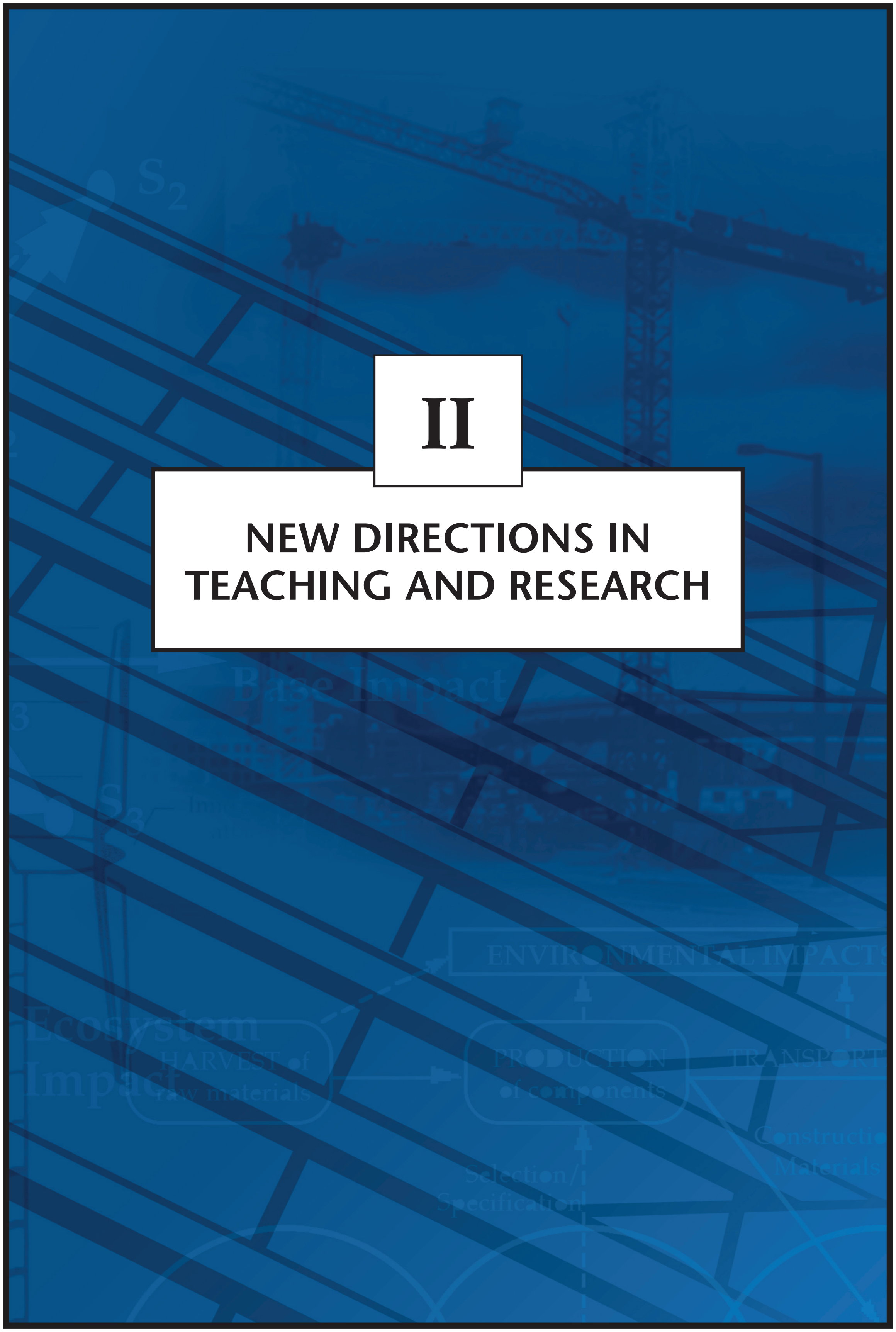


II

NEW DIRECTIONS IN TEACHING AND RESEARCH

RESEARCH INTO A STABLE DIFFUSION-BASED HUMAN-MACHINE-HUMAN TEACHING MODEL FOR ARCHITECTURAL DESIGN COURSES

Sheng Du, Xiaoyue Lu, Zimo Chen, Zixiao Cai, and Lei Chen[1]

ABSTRACT

Conventional methods of teaching architectural design have flaws like fuzzy information exchange, limitations of thought dispersion, and disconnection of theory and practice because of the different cognitive levels of teachers and students. This paper explores the interactive and collaborative "human-machine-human" mode of utilizing Stable Diffusion image generation technology to teach architectural design and achieve artificial intelligence. To enhance the quality and effectiveness of instruction, the model uses artificial intelligence for image generation, optimization, and presentation in accordance with the three stages of architectural design teaching that are developed in this paper. Mainly using the Northeastern University youth hostel design course as an example, this paper compares the new "human-machine-human" mode with the traditional "human-human" mode, assesses the necessity and viability of the AI intervention, and offers examples for future architectural course teaching reform and the comprehensive integration of AI and architecture. In the interim, it offers resources and recommendations for the deep integration of AI and architecture, as well as recommendations for future teaching reform of architecture courses.

KEYWORDS

artificial intelligence, human-machine collaboration, architectural design teaching, teaching model

1. INTRODUCTION

1.1 Artificial Intelligence Assisted Design

In traditional architectural design education, the primary means of expression and communication used by instructors and students is "human-human" interaction modes, including sketching, sketches, and other media. Zhanglingling claims that limitations with this approach involve the teacher transmitting abstract and complex material, with a significant amount of information being lost during the transmission process, and that the students' experience is

1. Lei Chen, associate professor, MD; Department of architecture, JangHo Faculty of Architecture, Northeastern University, China; E-mail: chenlei@mail.neu.edu.cn, corresponding author

inadequate to adequately receive this information (Zhang, L., and Li, C. (2014)). This issue arises from the teacher's abstract and complicated message, the students' inexperience and poor reception skills, and the excessive amount of information lost during transmission.

Early on in the building industry's history, repetitious work was reduced in order to shorten the design cycle [1]. Several specialized computer-aided design (CAD) drafting and parametric design software programs were created in the early stages of the architectural industry with the goals of reducing design cycle times, eliminating repetitive tasks, increasing design freedom, and improving drawing accuracy [2]. Recent research is now focusing on how architects may use artificial intelligence to speed up and simplify the design process. Stanislas Chaillou of Harvard University trained a machine learning model to generate room layouts and find windows, doors, and furniture for a particular apartment size using a database of over 800 apartment floor plans. He was able to successfully expand the machine learning model and use the same reasoning when designing residential buildings [2]. Therefore, the university architecture education system should utilize AI technology to carry out reform practices that impact on the design process and creative thinking of architects, given the current rapid growth of generative artificial intelligence (AIGC) technology.

Although AI cannot yet fully replace the work of architects, it can help teachers and students communicate more effectively and incorporate design thinking into architecture education (Lujinyan 2018 and Weina 2021) [3][4]. The Weitzman School of Design at UPenn proposed a new program in 2021. The school offered a practical course in AI intervention in facade design where students and faculty collaborated to obtain graphic inspiration using Chatgpt, Stable Diffusion and Midjourney. They used Rhino, Grasshopper, and Maya to model and present the building through 3D printing. This allowed students to quickly and intuitively visualize their design concepts while expanding their creative thinking and integrating architectural design with other disciplines. In this paper, the authors propose using the more mature and controllable Stable Diffusion to inform the teaching process of architectural design. They aim to build a bridge of communication between teachers and students and change the traditional "human-human" education mode of architecture into a new "human-machine-human" education mode. This touches on the concepts of architectural design as well as the concept of "human-machine-human" education mode. It involves the conception stage of architectural design and enables deep intervention of AI in the process [5]. The outcome of using Stable Diffusion is predictable. This is expected to decrease information loss in the conventional "human-human" method, improve students' information reception efficacy, and introduce a novel aspect of collaborative innovation in architectural education. Additionally, it will diversify, illustrate, and make concrete conceptual language, sketches, and other hazy materials that

FIGURE 1. Changes in intent during the stage of brainstorming.

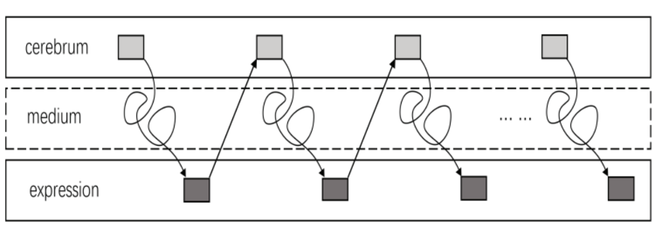
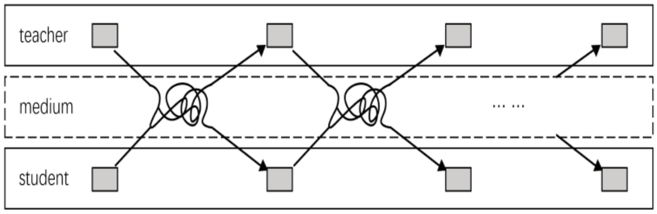


FIGURE 2. Multi-agent information interaction.



are produced throughout the teacher-student communication process. The novel method of creativity and collaboration involves artificial intelligence, teachers, and students.

2. BACKGROUND

2.1 Characteristics of teaching architectural creation and architectural design

The stages of perception, conceptualization, and expression of the subject (the architect) on the object (the design object) are all included in the architectural production process (Zhang L and Li C (2014) [6]. The first two stages of the creative process in architecture are essentially internal to the architect. To construct an overall image of the design project, the subject receives knowledge about the complex procedural status quo during the perception stage and synthesizes it using their logical reasoning. During the conceptualization phase, the subject builds on the perception phase's discoveries with continuous input from internal and external sources (Figure 1). Huyiling from ECNU asserts that while this process has been thoroughly examined in a variety of complex science-based scientific domains, the "emergence" of creative thinking is not a typical occurrence (Hu Y, Zhao Z, and Wen F (2022). Science still does not fully understand the "emergence" of creative thinking, particularly when it comes to the conceptualization phase of the creative process [7]. This is particularly valid for the creative ideation stage. Qualitative concepts like ambiguity, chance, abstraction, and complexity are still used to characterize this process.

In reality, teaching architectural design is a process of several subjects working together to create an architecture (Figure 2). Drawings, molds, and words are the primary forms of communication between various subjects, according to Zhanglingling (Zhang L and Li C (2014)) [6]. The student body experiences numerous difficulties in the process of receiving information because of the abstractness and ambiguity of the communication medium itself. This is especially true in the early stages of the creative process when the student body lacks design techniques, an incomplete knowledge system, and the ability to fully express their ideas. The drawing should also be changed by the teacher due to its conceptual errors, ambiguity, and polysemy, which often give the impression that the subject "does not understand" and causes other issues. Rapid information loss, poor communication effectiveness between teacher and student and other negative effects are the direct results of this phenomenon, producing questionable instructional value.

2.2 Opportunities for Integrating Stable Diffusion with Architectural Design Teaching and Learning

Tang Fan's work demonstrates how the quick advancement of AIGC technology opens up new avenues for architectural creation education [8]. AIGC is a tool that helps designers rapidly evaluate several design options and produce an attractive design that meets the needs of all stakeholders. Instead of having to laboriously model and edit each option one at a time, designers may use these tools to rapidly test various design solutions and arrive at an aesthetically appealing solution that pleases everyone. Text-to-image applications like Dall-e and Midjourney, which are also built on AI and machine learning, provide us with practical examples of how AI may assist designers in producing one-of-a-kind works of art in a matter of seconds. The designer's role shifts in the process. Rather than creating the job by hand, we can achieve the desired aesthetic design and result by just choosing the appropriate cues. As a result, AI tools like Stable Diffusion are adaptable to the features of the current architectural teaching system. The dispersive image generation produced by Stable Diffusion helps architectural students communicate their abstract intentions more effectively and saves communication time. This paper further subdivides the "human-machine-human" interaction and collaboration model into the problem definition phase, the iterative feedback phase, and the output presentation phase based on the three phases of architectural design teaching. It also conducts additional research and subdivision on the AI intervention in the conceptualization phase (thought diffusion phase). We also created the workflow for AI-assisted architectural design instruction and further split and studied the conceptualization stages of AI interventions (thought dissemination, prototype iteration, and program convergence, see Figure 3); at the same time, the workflow's importance for changing the architecture education system in colleges and universities is further discussed when it is compared and contrasted with the conventional "human-human" teaching mode in terms of teaching effectiveness, teaching quality, and teacher and student feedback. The AI tools and debugging techniques utilized in the teaching practice phase are listed below.

- Stable Diffusion is a text-to-image model that supports localized repainting (inpainting), image-to-map (image2image), and basic text-to-map (text2image) functions. It may also be used with controlnet, lora models, and other plug-ins and models that restrict divergence outcomes and style orientation [9].
- Lora model training is an important way to integrate human-driven thinking into AI-generated results in the human-computer-human architectural design teaching model. AI users can customize the style of the generated images through self-trained lora models and thus obtain the results that users need and that are dominated by the users' wishes. The general steps of model training can be divided into four phases: preparing the dataset, configuring the training environment and parameters, initiating training, and testing the model.

3. OBJECTIVES

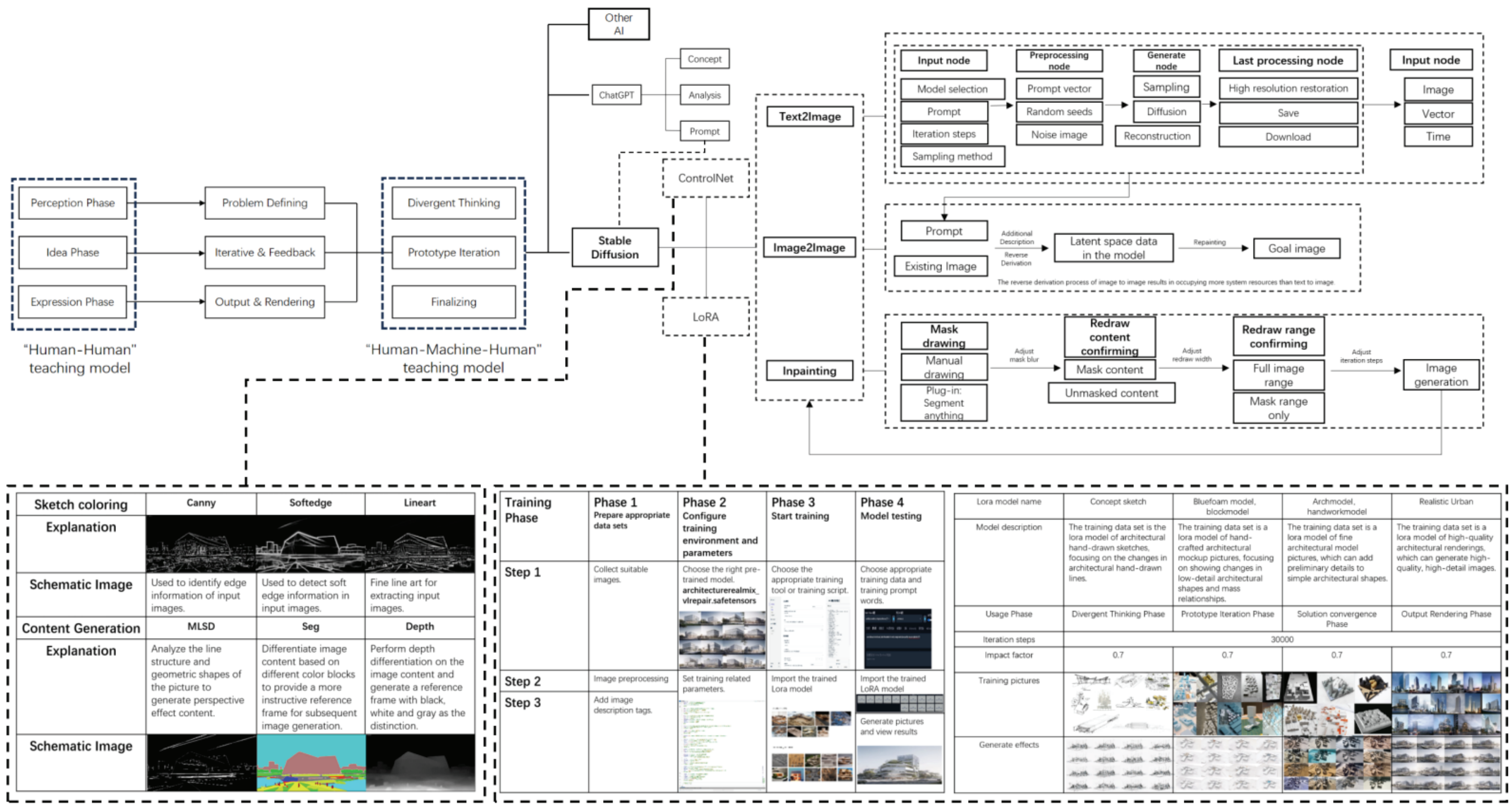
The research attempts to use and encourage the following:

A. Stable Diffusion (SD)-based image-generating AI to boost the effectiveness of architectural practice and education;

B. Employing image-based generative artificial intelligence techniques in architectural education that offers suggestions for how to change the curriculum for teaching architecture in the era of AIGC;

C. Encourage the interdisciplinary study of construction and artificial intelligence.

FIGURE 3. The whole process of exploring the "human-machine-human" teaching model using Stable Diffusion



4. METHODOLOGY

4.1 Stable Diffusion Intervention in Architectural Design Teaching Research

We have included artificial intelligence (AI) in some of the senior and intermediate undergraduate courses on architectural design at Northeastern University. The curriculum comprises three design courses: design for high-rise hotels, design for youth hostels, and design for libraries. Our explanation of the research process was based on the data and technical procedures from the experiments conducted in the phases previously stated. We tested the process of teaching artificial intelligence-assisted architectural design for a total of sixty-four hours, using the stabilized diffusion technique to intervene multiple times during the youth hostel's design course. The primary goal of the youth hostel course design is to give students the opportunity to consider how the environment and the building interact, to create a functional flow plan and good zoning, and to concentrate on learning the fundamental operations of small hotels and the corresponding spatial composition and organization. In order to conduct group experiments, 40 first-class design objects—students—and 4 second-class design objects—teachers—were split into 4 groups. The detailed teaching procedure is depicted in Figure 4 (Figure 4). After the teaching session, a number of feedback data were compiled; at the conclusion, the compiled data were contrasted and examined with the feedback data from the initial course design (the "human-human" teaching mode) without the use of artificial intelligence. In order to assess the quality of instruction in both the "human-machine-human" and "human-human" teaching models, the summarized data were finally compared and analyzed with feedback data from prior comparable course designs without AI intervention.

4.2 Data gathering tools

The focus of this study is on undergraduate Bachelor of Architecture programs. Since the architectural design program is based on teaching the process of creating architectural solutions, the study can be categorized based on the stages of creating architectural solutions. The teaching of architectural design can be categorized into three main stages:

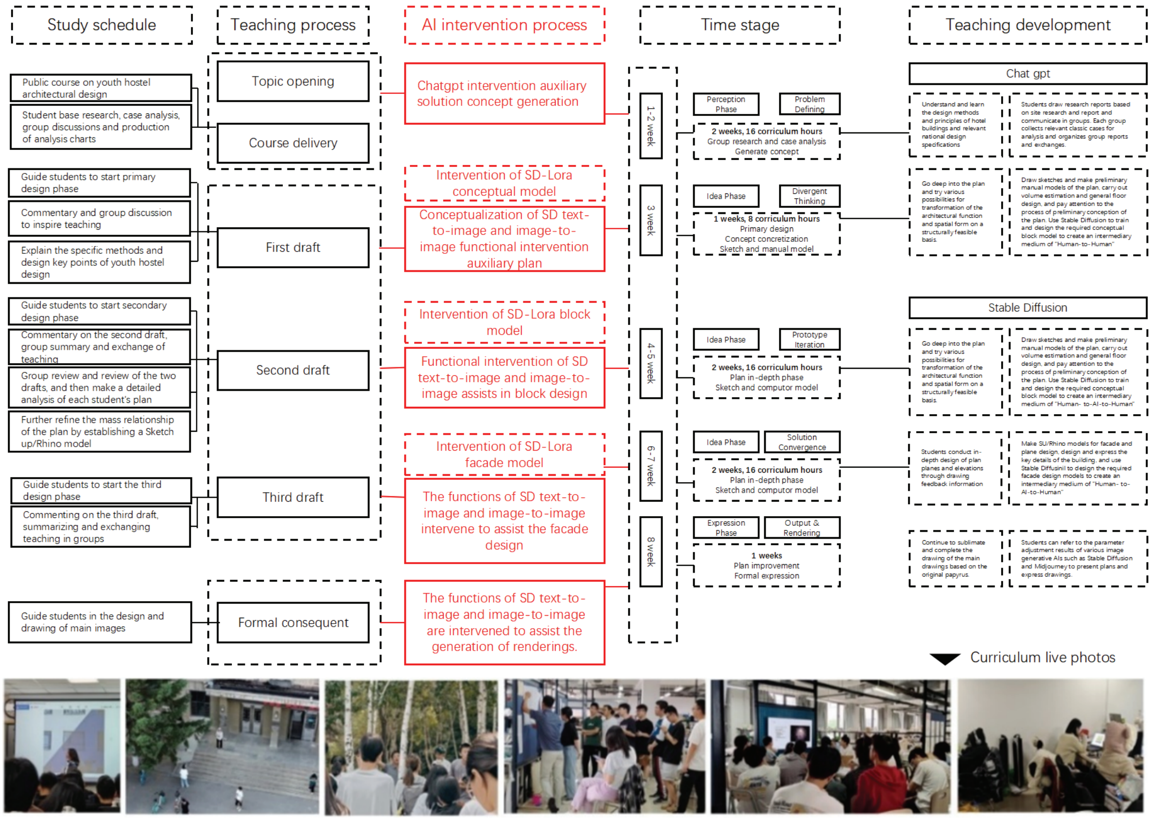
- Divergent thinking phase
- Prototype iteration phase
- Programmatic convergence phase

These three major phases were measured as a percentage of the overall architectural design instructional program by the percentage of time they spent at different points in the 7-week program. The thought generation phase is approximately 42.8% of the time and is located in weeks 1–3 of the 8-week architectural design teaching schedule; the prototype iteration phase is approximately 28.6% of the time and is located in weeks 4–5 of the 8-week architectural design teaching schedule; and the program convergence phase is approximately 28.6% of the time and is located in weeks 6–7 of the 8-week architectural design teaching schedule.

To assess the effectiveness of the use of Stable Diffusion at all stages, the teaching modes of the course after its introduction were studied and analyzed. The different teaching modes in the course were categorized into two groups representing different levels of AI intervention:

- Human-human teaching model (no generative AI intervention)
- Human-machine-human teaching model (with generative AI intervention)

FIGURE 4. The experiment process of "Human-Machine-Human" teaching model



Interviews and information were gathered from those who instruct architectural design courses, including several professors and lecturers at Northeastern University, for use by course instructors.

Course participants were surveyed via online questionnaires and emails, or through interviews with instructors of the architectural design course.

The data were split into two categories: subjective and objective. The subjective level included subjective ratings of teaching quality, subjective ratings of teaching methods, course teaching time, and the selection of teaching results. The objective level included teacher-student mutual ratings and comparison ratings with the "human-human" teaching model, among other things.

A table represents the data that was gathered above. Using a single evaluation criterion of 60–100 points, the table presents the comparative analysis of the feedback data for the two instructional techniques (Figure 5).

5. RESULTS

5.1 Instructional Use of Stable Diffusion's Figurative in the Diffusion of Thought Stage

5.1.1 Problems with the "human-human" model of teaching and learning

This stage occurs roughly in the first three weeks of the eight-week architectural design course schedule. Prior to this, students have already conducted a variety of research and have a sense

FIGURE 5. Feedback data comparison table

Teaching Quality Assessment Survey

Educational model	Educational quality	Educational methods	Course duration	Level of interaction	Achivement	Overall feedback
"Human-Human" teaching model						
Villa Design	85	80	85	80	80	82
Small book bar design	90	75	90	85	85	85
Kindergarten Design	90	85	75	80	80	82
Average	88.3	80	83.3	81.7	81.7	83
"Human-Machine-Human" teaching model						
Youth hostel design	90	90	85	85	90	88
Library design	90	85	90	85	85	87
High-rise hotel design	90	90	80	90	90	88
Average	90	88.3	85	86.7	88.3	87.7

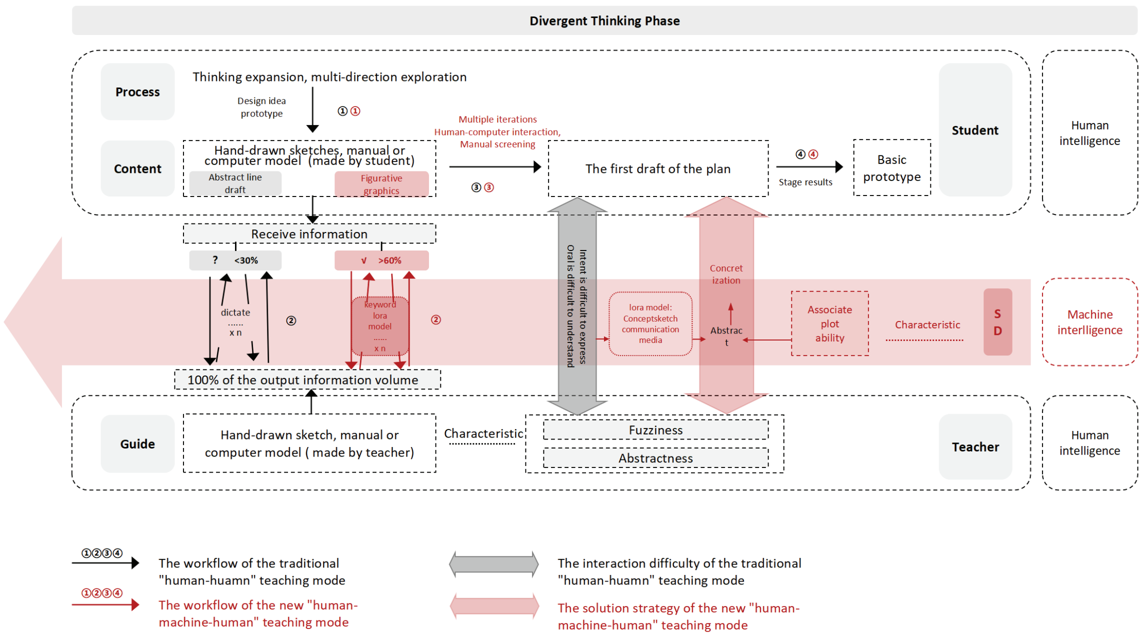
of the program's embryonic stage based on their perception of the preliminary information reserves. They therefore need to conduct multidirectional and multipossible exploration during this phase to ultimately determine the program concept that will serve as the foundation for the block.

Dictation, sketching, and modeling are the primary means of communication between teachers and students in the traditional "person-to-person" style of instruction. Teachers and students typically have communication issues since the sketches they do while teaching students' ideas are sometimes very conceptual, ambiguous, and abstract. For instance, it could be difficult for students to express their design concepts properly or to comprehend the teacher's design sketches. This could cause misunderstandings, make it harder to accomplish the intended goals, and so on [10]. This may result in misunderstandings, poor communication, and challenges reaching the intended educational goals between the two parties.

5.1.2 Technical route to the "human-machine-human" teaching model

Because of its strong visual and drawing abilities, Stable Diffusion can be used as a medium of communication for the "human-human" teaching mode, creating a new "human-machine-human" education mode, compensating for the shortcomings in students' abstract intention expressions, visualizing teachers' imprecise abstract intention expressions, minimizing communication gaps, and resolving issues that have arisen in the "human-human" teaching mode thus far. At this point, it can eliminate communication gaps, visualize teachers' imprecise representations of abstract goals, compensate for students' deficiencies in doing so, and resolve issues that arise in the "human-human" teaching method. (Figure 9).

FIGURE 6. Technology road map in the thinking divergence stage.



5.1.3 Experiments in teaching the "human-machine-human" model

Using the youth hostel course design for second-year students as an example, the design site for the project has a certain slope and is surrounded by nice foliage. To make the building blend in with the surroundings suitably, the student wants to design it depending on the site's current conditions. The teacher provided the students with a schematic drawing during their conversation that showed how the environment and the building's basic structure relate to one another from a human standpoint (Figure 10). As can be observed, the teacher's sketch includes multiple essential details: building, low wall, trees, and grass. However, the instructor needs to explain the connotative details in the drawing. These can include, but are not limited to, the ideas that the building is buried beneath the surrounding landscape, that the volume is moderate, or that the building has been pierced by nature. Younger students usually do not fully understand the teacher's illustrations, so they have doubts about how a building might be considered to blend in with the surroundings. What size is suitable? How can the natural world get inside a building?

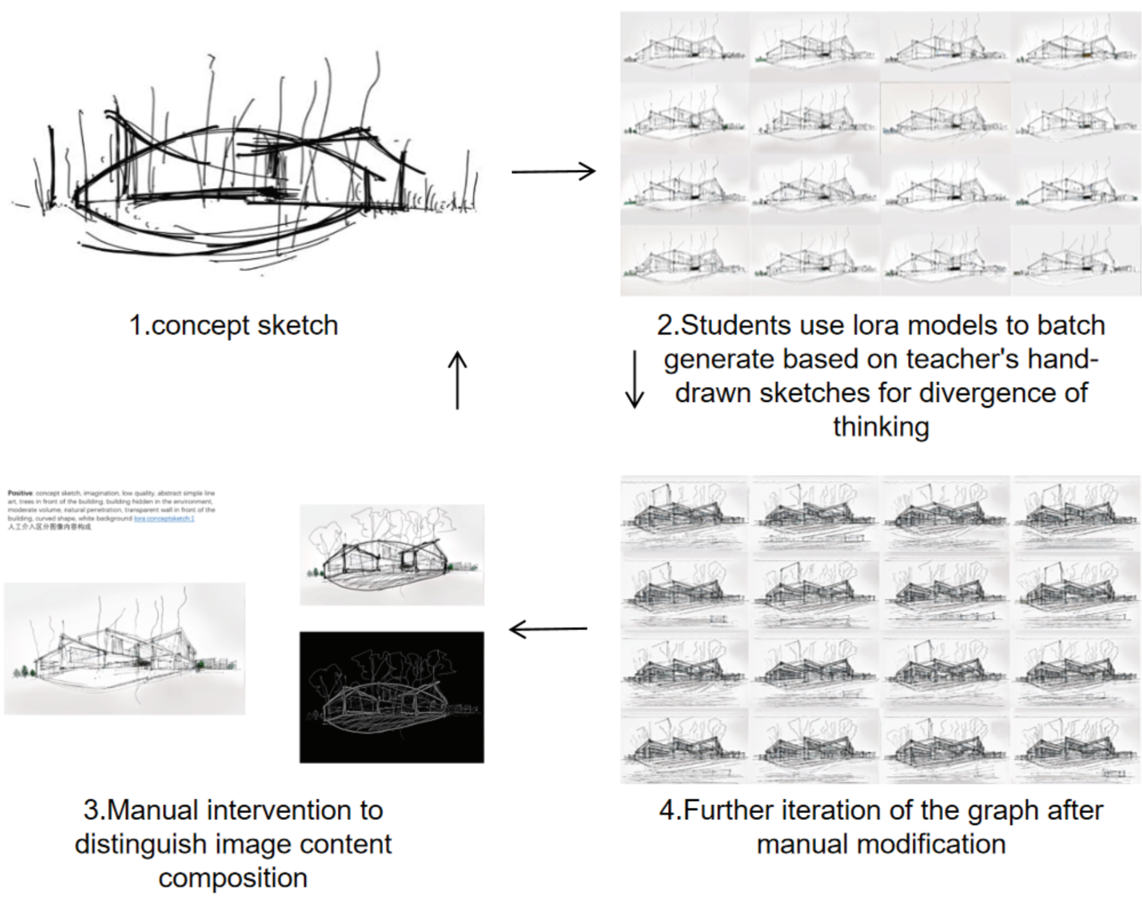
Students can address these problems by using Stable Diffusion to provide the impact of transforming abstraction into figuration, which will improve program advancement and comprehension. Although the purpose of this stage is to help students visualize the sketch's ambiguity, a certain amount of ambiguity, abstraction, and impracticability are still necessary for the use of Stable Diffusion to aid in the generation of results. This requires a rich variety of variations, visualization, concreteness, and diversification. This can help students understand and think outside the box without giving them an overly concrete impression or confining their thinking. Therefore, this stage requires the targeted use of models with a fuzzy style, such as the self-trained Lora model of this study: concept sketch. Students can refine the teacher's oral explanation of the connotative information of the sketch and add their own ideas to form the descriptors, such as concept sketch, imagination, low quality, abstract and simple line art, trees in front of the building, the building fades into the environment, the volume is moderate, natural penetration, the building in front of the building, a transparent wall in front of the building, curved shapes, and a white background, and then use a concept sketch model to batch generate images (Figure 11).

Thereafter, students were required to manually select images that they felt met the requirements based on their own aesthetic and conceptual intentions and to differentiate the content composition of the images (architecture, landscape, depth of field) through hand-drawn interventions after manual selection. After manual selection, hand-drawn interventions were used to differentiate the content composition of the images (architecture, landscape, depth of view), and the manually modified images were imported for further iteration to gain inspiration (Figure 7), forming a human-computer interaction. The final sketches are gradually visualized in the communication between teachers and students and the iteration of machine intelligence, and the students further define the design concepts in the design of the program, forming the prototype of the basic blocks of the program.

5.2 Pedagogical Use of Stable Diffusion's Infinity in the Prototype Iteration Phase

The term "prototype iteration" describes the assessment and filtering of design concepts and solutions produced by Stable Diffusion. Students must carefully examine and investigate the

FIGURE 7. Experiment of concept sketch improvement by using self-training LoRA in Stable Diffusion.



fundamental prototypes that were acquired throughout the diffusion phase, as well as consider the potential outcomes of other combinations within. Subsequently, the early prototypes are employed to hone and enhance the viable design ideas, resulting in an ongoing development of the design that gets increasingly refined.

5.2.1 Problems with the "human-human" model of teaching and learning

This phase, which takes place around weeks 4–5 of the 8-week architectural design schedule, is where students identify the fundamental building blocks and work to further develop their block articulation, block compositional relationships, etc. The outcome of these efforts affects the floor plan's spatial layout, the structural decisions made, and the sculpting of the featured spaces.

The teacher-student dynamic under the conventional "human-human" teaching paradigm is "one to many." Teachers frequently have to balance how long they spend teaching pupils in the limited time allotted in class. Teachers and students typically run into certain issues during the design and creative process because of the constrained nature of their information exchange. As a result, during the design and creation phases, the two frequently run across certain issues. For instance, students may run into bottlenecks because of the exchange's brief duration and their immaturity when it comes to exercising divergent thinking. Because of the idea's limits, individuals might also think in linear terms and follow a program through to the finish, making it hard to modify and create a vibrant and engaging space.

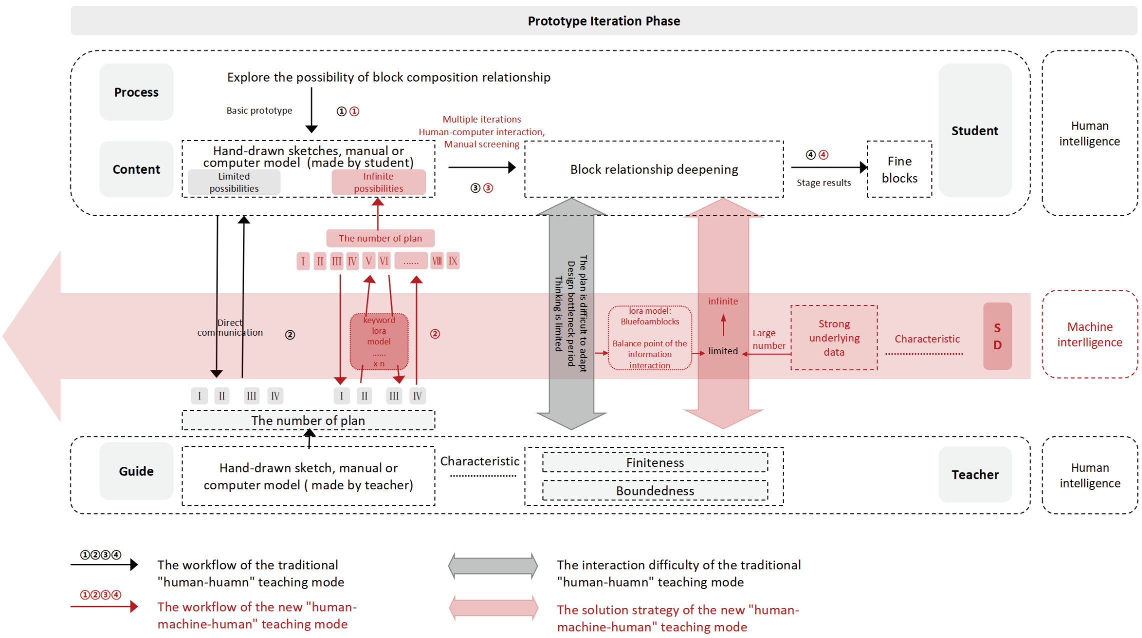
5.2.2 Technical route to the "human-machine-human" teaching model

Stable Diffusion has a powerful underlying database, which can be used as a balance point for the "human-human" teaching model, forming a new "human-machine-human" education model, providing students with a constant stream of considerable experience, diversifying the basic programs, and deepening the adjustments for the possibilities of AI computation. The program can be diversified and continuously adjusted to the possibilities of AI computing (Figure 8).

5.2.3 Experiments in teaching the "human-machine-human" model

Using their Youth Hostel course design as an example, the second-year students engaged in multiple conversations with the teacher using the "human-machine-human" mode of instruction during the divergent thinking stage. Based on the concept of integrating architecture with the environment and the iterative assistance of machine intelligence, they ascertained the program's starting point and roughly conceptualized the arrangement of five radiating building blocks on the site to achieve the goal of infiltrating the site's natural scenery into the building's interior. The fundamental prototypes of the five radiating building blocks are depicted in the sketches and models (Figure 9). These blocks are intended to meet the goal of integrating the site's natural surroundings into the interior of the structure in various directions. At this point, the instructor typically gives instructions in the form of dictation, pointing out things like how the five blocks make a thin courtyard, how the five balanced blocks lack rich variations, how there is no relationship between the five blocks and the courtyard, etc. The teacher also provides one block, which is a drawing for the courtyard, and offers one or two potential diagrammatic guidelines in the form of sketches. However, due to several issues, including time restraints and mental limits, further options could not be listed, and there was little to no communication between the two sides. Younger students may be predisposed to believe that there are only a limited number of block combinations and linkages. As a result, they may work through a single option mindlessly, losing the opportunity to use their own judgment and gain experience.

FIGURE 8. Technology road map of prototype iteration stage.



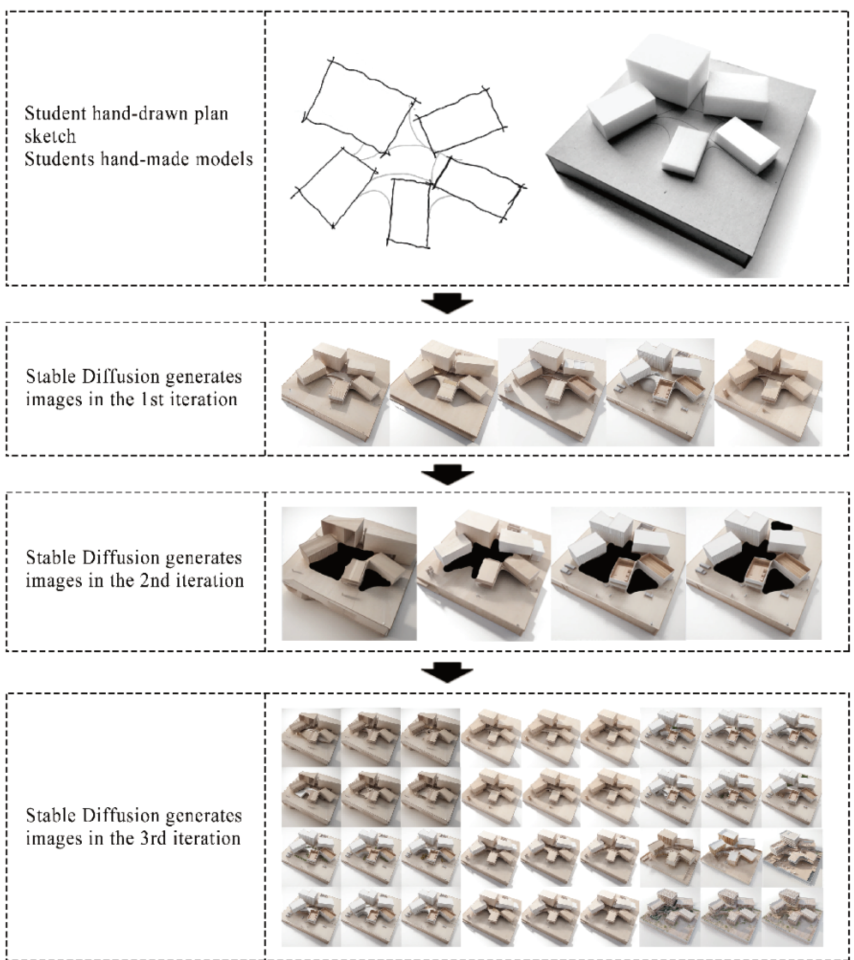
Students can consider and select the optimal solution by using Stable Diffusion to move from the finite to the infinite in these issues. During this phase, Stable Diffusion should result in a strong sense of the block, diversified, clear logic, and not too specific details of the results so that students can come up with a variety of references to block relationships without having too many details get in the way of their analysis of the composition of the block. As a result, this stage calls for the targeted employment of block modeling models, such as the blockmodel and BlueFoamModel, self-trained Lora models utilized in this study. In order to participate in an exploration of the potential connective relationships between the five body blocks, students can submit hand-drawn drawings and photos of the sketch model to the teacher. With permission, they can also enter descriptors such as "low mass, architectural model, drone view, group of buildings, and so on," imaginative, white squares, random, fragmented, around the main square, similar size, white, simple background.

Using several rounds of iterations, Stable Diffusion produced a large number of images quickly (Figure 9) based on the data supplied by the students. These images showed various connections between the five body blocks, including large step, curved, and straight-line connections. The instructor thought that there was potential for development in both directions and suggested that the students could next make more detailed sketches to push the options. During the class discussion, students showed the instructor the large number of images generated by Stable Diffusion and intended to deepen the curved connection or the straight ramp (staircase) connection.

Following multiple conversations with the teacher, the students concluded that if they connected the blocks with curved ramps (staircases), they should have a better feeling of volume; if they connected the blocks with straight ramps (staircases), they should also employ curved shapes to build an organic whole with each other. Subsequently, the students uploaded their updated sketches into Stable Diffusion and input various textual specifications, like "shaped building, the curved platform" and "building block, large steps, courtyard," to investigate the connections between the five blocks and ultimately eliminate them. One direction out of the four was chosen in the end. After that, the students drew sketches based on their concepts and the pictures that Stable Diffusion had supplied. It was decided to accept directions one and two for the following stage of the program design after talking with the teacher in class about how the consequences of directions three and four differed from the original plan. Students merged their own design notions and created a model for in-depth speculation on the relationship between the blocks after a lot of iteration using machine intelligence and screening (Figure 9).

Following a discussion with the teacher in class, the design double main body decided that the linear staircase corridor and various courtyard spaces not only addressed the issue of transportation connectivity but also had the potential to utilize the narrative flow space to direct people toward reading Shenyang's history and establish a meeting and communication area that best suited the ideas of the student body as a whole. Since the effect and form of the connection between the two directions are currently lacking, it was decided to combine the advantages of directions one and two for the next stage of the program design, concentrating primarily on the organization of the narrative space flow and the form of various courtyard spaces. Ultimately,

FIGURE 9. Experiment of prototype iteration stage.



after teachers and students discussed the basic prototype and a great deal of machine intelligence iterations served as inspiration, students gradually refined the block composition and connection relationship to produce a refined block model (Figure 10).

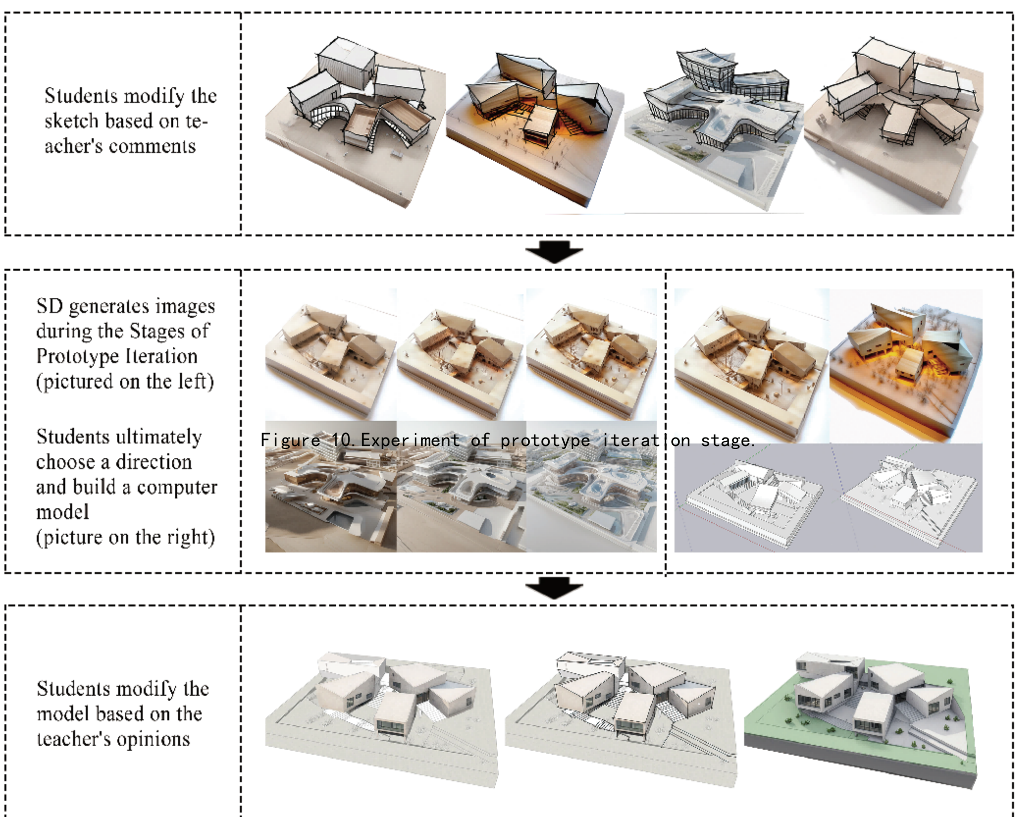
5.3 High-Performance Computability of Stable Diffusion for Pedagogical Use in the Convergence Phase of a Scheme

Scheme convergence is the process of gradually improving the program overall based on prototype iterations, bringing many design aspects together in an organic way to create the final design scheme. In order to construct the final design plan, students must now revise and fine-tune the block elevations while considering the building's economy, aesthetics, and environmental issues [11].

5.3.1 Problems with the "human-human" model of teaching and learning

This phase occurs roughly in the sixth or seventh week of the eight-week architectural design curriculum. Prior to this, the students had already ascertained the ultimate compositional relationship between the blocks and the floor plans of every level. They still need to finish the block elevation designs, material selections, detailing, and other tasks. Along with the design itself, the teacher will also impart some theoretical knowledge, although it will be more challenging for the younger students to apply this knowledge to their design programs. Additionally, the teacher will impart some detailing, building materials, and other theoretical knowledge during

FIGURE 10. Experiment of prototype iteration stage.



this stage of the teaching process, in addition to the program design itself. However, it will be more challenging for the lower grades to apply this knowledge to their design program. Theory and practice do not always mesh well in the student design process; this phase of the issue is mostly shown in the "difficulty to apply theoretical knowledge." As of right now, "it is difficult to apply the theoretical knowledge concretely," which is the primary issue.

5.3.2 Technical route to the "human-machine-human" teaching model

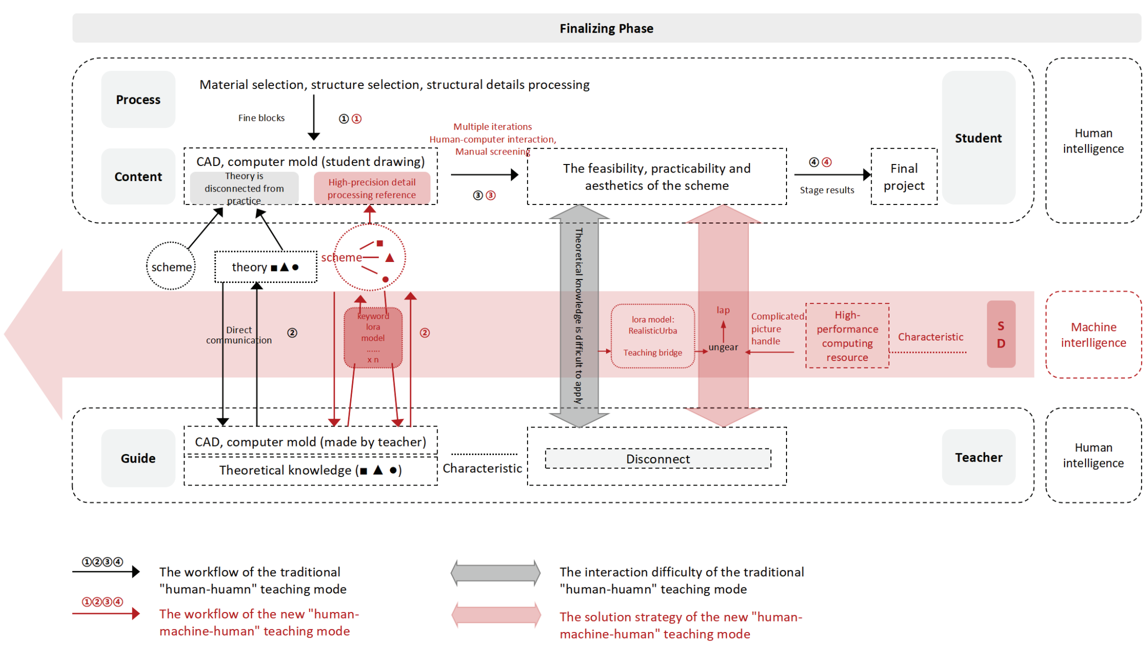
With its high-performance computing capabilities, Stable Diffusion can serve as a link to create a new "human-machine-human" teaching model that enables pupils to absorb and comprehend complicated visuals. It can minimize needless time loss, aid in the understanding of the true structure and the numerous applications for diverse materials, and help students comprehend and produce polished designs more quickly. (Figure 11)

5.3.3 Experiments in teaching the "human-machine-human" model

Using the Youth Hostel course design for second-year students as an example, the students engaged in multiple conversations with the teacher during the prototype iteration stage, utilizing the "human-machine-human" teaching mode. With the assistance of numerous machine intelligence iterations, they created a fine block model (Figure 11), which essentially established the overall layout of the building along with the floor plans of each level, and they were ready for the elevation design. While younger students may be perplexed about how to establish a rhythm between truth and lie, teachers typically highlight the contrast between reality and untruth, the usage of materials, and the treatment of details in the guidance process. How can I pick appropriate materials? What distinct effects do various materials have?

This stage calls for the targeted use of models that focus on the materials of the building facade, the composition of the facade lines, and the details of authenticity, such as the Lora

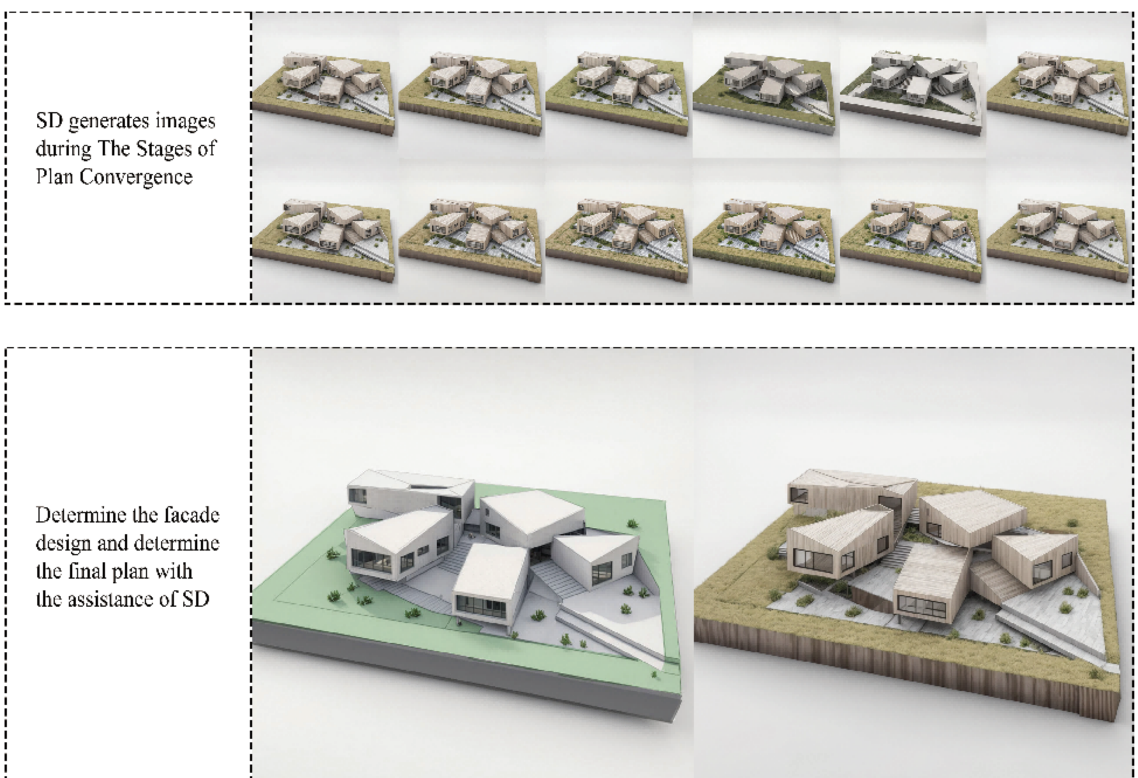
FIGURE 11. Technology map of finalizing stage.



model that was self-trained for this study: the Archmodel and handwork model. In response to these issues, this stage allows students to use Stable Diffusion to reconnect disconnected theory and practice, advancing the program to form a more realistic and feasible program.

Students decided to utilize materials with a sense of volume and small window apertures on all elevations but the viewing surface to enhance the block's sense of volume at this point. The student body inputs the photos of the built Rhino model and the text request "small window openings on the facade, materials, construction details" into the Lora model: Archmodel, carries out the highest iteration step of AI skin diffusion, generates the corresponding autonomous understanding of the surrounding environment, and finally comes up with a large number of recommendations for the selection of building materials, the deepening of the facade, and the development of the building. The end product is a huge collection of intricate photos that may be used to describe the final drawings, deepen elevations, choose building materials, and unify the surrounding area. In the plaza area, students experimented with wood, stone, and lawn pavement materials as well as masonry, wood, and fair-faced concrete facade materials. The pictures that Stable Diffusion offered gave the students ideas for a makeover. Both the teacher and the students decided throughout the session that the stone plaza and the timber facade were suitable for the surrounding area and the intended architectural effect. After that, the pupils revised their work even more, keeping in mind the teacher's suggestions. The final program satisfied everyone's expectations after going through multiple changes (Figure 12).

FIGURE 12. Experiment of finalizing stage.



6. RECOMMENDATIONS

The researchers identified the following factors to consider in order to improve architectural education in higher education's quality, effectiveness, and outcomes:

- It is imperative that artificial intelligence technology be used in architecture education. Colleges and universities' education reform departments should integrate artificial intelligence into the conventional architectural curriculum with the understanding that this integration should not interfere with human autonomy in creating new ideas. For instance, in order to avoid creating dependence, generative artificial intelligence shouldn't be utilized to support instruction when students' general capacity for design thinking is still developing.
- It is still crucial to educate fundamental literacy in the field of architecture. Researchers' teaching practice investigations, conducted over three phases, revealed that students' subjective thinking still needs to be communicated rapidly through traditional hand-drawing and written expression. This serves as a foundation for the dissemination of artificial intelligence.
- It is advised that the conceptual and schematic design stages take advantage of the available generative AI technology. Because generative AI that can understand specific architectural terminology and accurately represent and model images is not yet available as of January 2024, applying AI technology to make program modifications later on is not more efficient than not using it at all.
- Artificial intelligence and operations technology proficiency are required of both educators and learners. This study demonstrates how the "human-machine-human" teaching mode significantly increases the effectiveness of communication between educators and learners. As a result, the promotion of this teaching mode is predicated on the ability to operate artificial intelligence technology.
- There is an urgent need to cultivate the underlying algorithmic logic and orchestration of artificial intelligence at the architectural level. The construction industry requires talent that is deeply intertwined between their own disciplines and artificial intelligence to explore and develop the corresponding artificial intelligence technology in a targeted manner. Artificial intelligence is a broad and rapidly developing basic technology.

7. CONCLUSION

With the use of artificial intelligence (AI), this paper concludes that, in contrast to traditional media, the subject can more precisely visualize design thinking. This effectively addresses the communication issues that arise when teaching architectural design to students. Stable Diffusion, however, is always somewhat unpredictable and needs a lot of machine languages and models to be learned before it can reliably and efficiently support the teaching of architectural design. Second, the current AI image-generating software only uses machine learning to illustrate the surface logic of architectural design; it is unable to satisfy deeper design logic. Students who depend too much on Stable Diffusion will thereby lose control over the program and design rationale, and lecturers must regulate its use in a reasonable manner.

Based on the present rapid advancement of AI, employing Stable Diffusion is becoming less expensive, while the applicability of different models and machine languages is growing. By considering how to use AI's generative logic to play a positive teaching role in the creation of a collaborative network for architectural design education, we can foster the advancement of the architectural discipline and expand the possibilities for a new model of architectural design education, rather than worrying about the negative effects of AI on architectural design education.

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