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An Exploratory Case Study on Overcoming Design Fixation in Architectural Education: Autonomous and Synergic Virtual Studio

Şevket Baran Yücel
Dicle University, Institute of Natural and Applied Sciences, Department of Architecture, Diyarbakır, TÜRKİYE
sevketbaran.yucel@dicle.edu.tr
ORCID NO: 0000-0002-5590-2656

Prof. Dr. Demet Aykal
Dicle University, Faculty of Architecture, Department of Architecture, Diyarbakır, TÜRKİYE
fdaykal@dicle.edu.tr
ORCID NO: 0000-0003-2424-0407

Abstract
This study aims to systematically resolve design fixation, which hinders students' creative thinking capacities in architectural design studios, and screen-bound isolation arising from the increasingly individualized studio culture. To achieve this objective, an innovative pedagogical framework called the "Autonomous and Synergic Virtual Studio" was constructed, integrating Flipped Learning, Virtual Reality (VR) simulations, and context-sensitive gamification. Its field applicability was tested through an exploratory case study. During a two-week pilot implementation, the traditional desk-based designs of 7 heterogeneous students were comparatively analyzed alongside their VR-supported iterative prototyping processes. Cross-analysis of qualitative and quantitative data revealed that the fear of making mistakes, typically brought about by physical drawing and modeling, was successfully overcome in the VR environment. Students broke design fixation by producing multiple spatial alternatives instead of clinging to a single idea. Additionally, out-of-studio asynchronous cognitive preparation alleviated students' cognitive load, while applied gamification mechanics successfully triggered autonomous peer mentoring practices following a necessary technological adaptation period. Consequently, this research presents concrete findings demonstrating the proposed model's potential to transform the architectural studio into a collective R&D laboratory where isolation and fixation are overcome, utilizing technology far beyond a passive visualization layer.
Keywords: Architectural Education, Design Fixation, Virtual Reality (VR), Gamification, Flipped Learning.

1. INTRODUCTION

Architectural design studios, which form the foundation of design practice in architectural education, are multi-layered problem-solving environments where the student not only makes form and aesthetic decisions but also confronts real-world constraints such as regulations, urban fabric, topography, and climate (Salama, 2015). This contextual and analytical intensity leads students to lose their flexibility in the design process and experience what is termed design fixation in the literature; a situation where they avoid producing alternatives and become stuck on the first idea they find that works but lacks innovation (Jansson & Smith, 1991). This mental blockage, where students avoid taking risks, deepens further with the integration of three-dimensional modeling software into studios. With the increasingly individualized studio culture, students work isolated from the outside world in front of their screens and break away from peer learning, one of the fundamental pedagogical dynamics in overcoming fixation (Webster, 2005; Gül et al., 2012). The asymmetrical operation based on the traditional master-apprentice critique (Schön, 1983), on the other hand, can feed this fixation by offering ready-made solutions to the student and is insufficient in re-establishing the autonomous interaction where students feed off each other's projects.

The main objective of this study is to propose a new digitized studio experience to resolve design fixation that blocks productivity in architectural design studios and to break the accompanying spiral of isolation. Accordingly, an innovative pedagogical framework integrating the real-time environmental simulation and iterative prototyping power of VR technology with Flipped Learning and Gamification dynamics has been constructed. The model aims to free students from the fear of committing to a single idea, reward risk-taking through gamification, and transform the studio into a collaborative R&D laboratory where fixation is overcome.

1.1. Conceptual Framework

The contextual complexity inherent in the nature of architectural design studios draws a set of restrictive boundaries that force the cognitive capacity of the student by experiencing design fixation. This contextual blockage results in the designer terminating their search for alternatives early, avoiding risk-taking, and holding onto the first workable but mediocre solutions they find (Jansson & Smith, 1991). This situation prevents the design from following a developing, transforming, and improving process, causing the student to experience a restrictive process in design education. Current studies in the literature reveal that fixation is an unconscious blockage that affects not only novice students but also experienced designers, and that designers largely fail to perceive their own states of fixation (Linsey et al., 2010; Youmans & Arciszewski, 2014).

This mental blockage deepens further when combined with the screen-bound isolation frequently observed in today's studios. When students bury themselves in their screens and detach from autonomous peer interaction, they are deprived of different perspectives and the most important external stimuli that can break fixation (Angulo, 2013). The traditional master-apprentice relationship, on the other hand, suppresses divergent thinking and risk-taking by transforming the student into a passive receiver who merely applies instantaneous commands received from the instructor.

In overcoming this socio-pedagogical bottleneck, Virtual Reality (VR) technologies, unlike traditional 3D software, carry the potential to take architectural space out of the mere screen and transform it into an immersive simulation (Brooks, 1999). Virtual reality goes beyond being a passive visualization layer in architectural education; it offers a transformative potential where complex spatial relationships are analyzed and simulation becomes the primary tool for achieving design goals (Elbadawy & Farouk, 2025). In the context of architectural studios, VR is not merely a tool for abstract form exploration; it is a massive environmental simulator that offers the opportunity for iterative prototyping. Research by Viswanathan et al. (2012) has proven that merely verbal warnings are ineffective in overmcoming design fixation; executing the build, test, and learn cycle via physical or digital prototypes is the most effective method for overcoming fixation. Similarly, Choi and Kim (2018) emphasize that digital design environments encourage students to try more variations by removing the constraints of the physical world. VR, with its 1:1 scale experience opportunity, triggers the self-diagnosis process by making the student personally feel that architectural space is not just a geometric void, but a dynamic phenomenon integrated with perception and memory. Indeed, while discussing the effects of virtual environments on spatial perception, Schnabel and Kvan (2003) emphasize that "the 3D environment is not just a copy, but a new design language."

However, bringing this powerful hardware into the studio merely as a technological add-on carries the risk of maximizing digital isolation by severing the physical studio connection of the student wearing the headset (LaViola, 2000). Preventing this new isolation that virtual reality could create in the studio and transforming the technology into a collective fixation-breaking tool is possible by activating pedagogical buffers. At this point, Flipped Learning pushes theoretical data transfers that consume studio hours out of the classroom, creating a cognitive space. Linsey et al. (2010) state that one of the biggest causes of

fixation among architecture students is the decision-making blockage experienced due to a lack of contextual data (regulations, analysis, etc.). Flipped learning provides these data asynchronously beforehand, ensuring that students come to the studio cognitively prepared, and dedicates limited studio time entirely to alternative mass trials (Bergmann & Sams, 2012). As emphasized by Brame (2013), the success of the Flipped Learning model depends on not only shifting the theoretical load outside the classroom but also supporting this preparation with short quizzes or gamification components to motivate it.
The gamification strategy, which comes into play simultaneously, is the fundamental binder that transforms the studio into an autonomous R&D laboratory. The designed gamification dynamics reward risk-taking, making mistakes, and producing numerous alternatives, rather than a single flawless project. The literature emphasizes that integrating gamification into architectural form generation processes in virtual environments moves students from passive observation to active participation and increases cognitive processing efficiency (Bucchiarone, 2022). Gamification directly influences learning behaviors as defined by Landers (2014), ensuring that students get involved in each other's projects and autonomously initiate peer mentoring. At the same time, synergy mechanics that allow students to be included in each other's projects integrate external stimuli into the system that will unlock the mental deadlock of the student inside VR (Youmans & Arciszewski, 2014).

Consequently; traditional educational models or purely hardware-focused digitalization efforts alone are insufficient in overcoming students' design fixation in architectural design studios. To regain design flexibility, there is a need for an autonomous framework that combines the rapid, diversified, and iterative prototyping power of VR, the asynchronous data management of Flipped learning, and the dynamics of gamification that motivate alternative generation. In this context, the proposed model offers an integrated pedagogical starting point where the studio ceases to be an isolated workspace and fixation is systematically broken.

2. PROPOSED PEDAGOGICAL FRAMEWORK: AUTONOMOUS AND SYNERGIC VIRTUAL STUDIO

Overcoming design fixation for students in architectural design studios is possible not merely by changing the digital tool used, but through a structural pedagogical transformation that encourages risk-taking, trial-and-error, and multiple alternatives. An integrated framework named "Autonomous and Synergic Virtual Studio" has been constructed to resolve the mental blockage created by traditional grading anxiety and master-apprentice asymmetry. This framework aims to take the studio out of being a judgmental arena where a single correct project is defended; and transform it into a collaborative R&D laboratory where the simulation power of VR is supported by Flipped Learning and Gamification buffers. The theoretical operational cycle of this constructed autonomous and gamified framework is summarized in Figure 1.

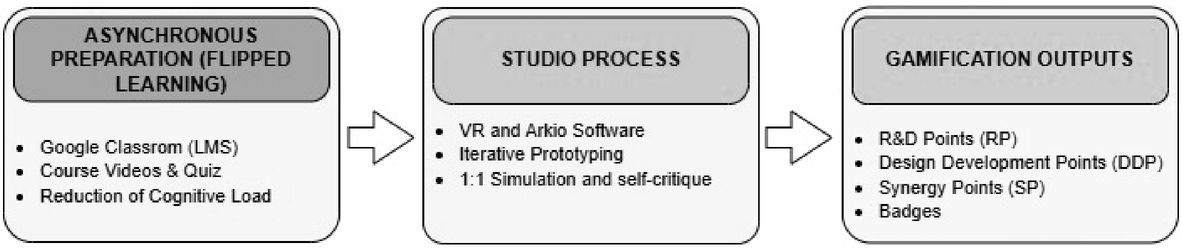

Figure 1. Pedagogical framework of the Autonomous and Synergic Virtual Studio model.

2.1. Asynchronous Preparation: Flipped Studio Process

One of the most fundamental causes of fixation in architectural design is the attempt to convey complex contextual data such as design principles, regulations, climatic data, and topographical analyses during studio hours. In the Autonomous and Synergic Virtual Studio model, this theoretical load, which causes cognitive blockage and slows down the active studio experience, is pushed out of the studio through the Flipped Learning strategy. With the flipped learning model, by moving the intensive technical and contextual data transfer required by the architectural studio outside; it is aimed to optimize the individual's limited working memory capacity for design-oriented higher-level cognitive processes (Paas et al., 2003). In this instructional model, students watch and read asynchronous content containing the technical requirements of the relevant week via the Learning Management System (LMS) designated as Google Classroom prior to the class, and take entrance quizzes at the beginning of the lesson. This preparation ensures that studio time is dedicated not to reading data, but to testing and simulating these data in the VR environment. The student comes to the studio not only knowing what to do but as a researcher who has internalized the contextual boundaries.

2.2. VR-Supported Virtual Studio

The cognitive space, cleared of theoretical and contextual data load via the Flipped Learning model, is directed to the Virtual Reality environment where design decisions are tested three-dimensionally and dynamically within the proposed pedagogical framework. At this stage, a digital ecosystem integrated into the traditional physical studio has been constructed using Arkio, a design software used in the virtual reality environment, and Head-Mounted Display (HMD) type VR hardware (Meta Quest 3S). In this digital ecosystem, the Virtual Reality hardware goes beyond being a mere visualization layer; and takes its place at the center of the 'instrumental genesis' process where a technological object is internalized by the user, integrated with mental schemas, and transformed into a design instrument (Rabardel, 1995). The VR interface used in the proposed model enables the modeling of masses in seconds in the virtual environment, instant undoing of form changes, and conducting spatial tests independent of physical constraints such as gravity in consecutive cycles. This flexible, rapid, and diversified design technique aligns with the iterative prototyping approach in the literature (Camburn et al., 2017). These possibilities brought by the VR environment and the software suited to this environment aim to eliminate the blockage created in students by physical production processes. This efficient and rapid trial-and-error cycle provides a production space where the student can produce divergent design alternatives by taking risks instead of searching for a single correct answer.

In addition, the ability of students to virtually step into the space they designed directly transforms the traditional bird's-eye design approach into a perceptual experience. Experiencing circulation narrownesses, errors, or disproportions in mass/void ratios that cannot be noticed on a two-dimensional plan plane at a 1:1 scale; allows the student to personally notice them without the need for an external instructor warning. One of the challenges that will arise in the VR-supported virtual studio experience is the risk of individual isolation that VR hardware may naturally create by disconnecting the student from the outside world. Against this risk, external projection screens (laptops) have been integrated into the studio setup. This physical-digital hybrid setup, where the image in the student's headset is simultaneously transmitted to screens in the studio environment, enables the instructor, transforming the master-apprentice hierarchy, to observe the process as a guide and support VR users with directions. Furthermore, this visual transparency, which paves the way for students to witness each other's design processes, breaks the in-studio isolation and establishes the necessary spatial infrastructure for the development of autonomous peer mentoring.

2.3. Process-Oriented Gamification Mechanics

To break design fixation and make peer mentoring sustainable, a context-sensitive gamification system operates in the background of the model. The gamification model in the study is built upon *context-sensitive design* defined by Hamari (2019) and the gamified learning theory by Landers (2014). To eliminate the architectural design studio students' resistance to avoiding innovation, gamification mechanics that reward the process rather than absolute and result-oriented grading have been designed:

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Scoring Mechanic: The student's success is not reduced to a single grade; it is measured on three different axes:

- R&D Point (RP): Awarded for the student's technical and regulatory knowledge during the asynchronous preparation process and successful architectural analyses brought into the studio from outside.
- Design Development Point (DDP): It is the direct solution proposal for design fixation. Utilizing the iterative prototyping power of VR, students are rewarded for producing multiple mass variations for the same problem and solving spatial issues in 3D.
- Synergy Point (SP): It is the mechanism that ends individual isolation in the studio. Students collect points not only with their own projects but through technical/spatial interventions and assistance provided to their peers' projects in the roles of *Co-Pilot* or *Micro-Instructor.* This turns contributing to someone else's design into an intrinsic motivation.

Badge System: Unlike points, badges are visual symbols of success indicating which competency the student has specialized in. For example; a student who quickly adapts to VR hardware and interface is rewarded with the *VR Pioneer* badge, a student who can instantly process the critique received from their instructor into the virtual model with the *Feedback Master* badge, and the student who helps their friends the most with the *Team Player* badge.

This autonomous and gamified framework; alleviates the students' cognitive load with R&D points ensuring they come prepared to the studio, encourages overcoming ideational blockage with Design Development points, and establishes a next-generation architectural education ecosystem that supports peer teaching by breaking screen-bound isolation with Synergy points.

3. PROOF OF CONCEPT AND PILOT IMPLEMENTATION

A two-week pilot study was conducted to test the applicability of the Autonomous and Synergic Virtual Studio framework, whose theoretical infrastructure was established in Section 2, in advanced architectural design studios. This application, which focuses on the flexibility of the process rather than grading the students' final project success; was methodologically structured as an Exploratory Case Study where qualitative and quantitative data are blended. The primary aim of the study is to measure in the field the power of VR-supported simulations and gamification dynamics to break the chronic design fixation in the studio and encourage students to produce multiple alternatives. Accordingly, following a one-week orientation process aimed at dampening the novelty effect of the technology; a two-week structured studio integration was conducted where asynchronous cognitive preparation, traditional desk critique, and virtual R&D simulations were operated sequentially. Since the study is an exploratory case study with a limited number of participants, an external control group was not used. Instead, the student's process of overcoming their own fixation was monitored by dividing the studio sessions into two sequential phases consisting of traditional desk critique held in the morning and VR simulation held in the afternoon.

3.1. Participant Selection and Orientation

The pilot application of the research was carried out with the existing studio section of 8 students taking the Architectural Design 4 course with 2nd-year students of Dicle University, Faculty of Architecture, Department of Architecture, under the supervision of the author. Within the scope of the project course designated as "Multi-Story Residential and Commercial Spaces," Convenience Sampling and Intact Group strategies, defined as valid methods in educational research by Fraenkel et al. (2012), were adopted in determining the participant group. Students were informed in detail about the VR-supported studio process and were offered the option to take the course via the traditional studio method if they wished. During this briefing and health declaration stage, one student was directed to the traditional studio method due to neurological/vestibular sensitivities out of research ethics, personal preference, and health risks; the remaining 7 students signed the voluntary participation form and were included in the autonomous model.

To break the novelty effect that even advanced students might experience when first encountering a new simulation technology and to minimize the extraneous cognitive load during the actual activity, a special orientation week was organized in the studio one week prior to the pilot studies. During this process, students were introduced one-on-one to the VR hardware (Meta Quest 3S) and the basic interface features, mass manipulation, and environmental testing tools of the software (Arkio) to be used for urban and architectural simulations. The use of the intact group method at this stage is of critical importance methodologically. Not including only specially selected technology enthusiast students in the research preserved the heterogeneous structure of the group consisting of different technological and spatial competency levels. This demonstrates that the constructed framework can operate successfully not in an isolated laboratory environment but within an ordinary and typical architectural project group.

3.2. Activity Design

The constructed proof of concept application was transformed into a structured daily studio routine to observe the fixation threshold between students' traditional production practices and digital (autonomous) production practices. The application was designed with a within-subject approach aiming to measure the behavioral and cognitive changes of the same participant group under different experimental conditions (Charness et al., 2012). The studio process consists of two sequential phases: Phase 1 (Morning session) is the control stage where traditional critiques are conducted and fixations in students' current design decisions are identified. Phase 2 (Afternoon session) is the intervention stage where VR simulation comes into play and the fixations identified in Phase 1 are tested autonomously. In this way, the student became their own control group, and the instantaneous effect of VR technology on fixation was isolated by minimizing external variables (different class dynamics, different instructor factors). The 7-hour studio days applied in the first and second weeks of the study after the orientation week; were conducted in three sequential stages that feed each other: asynchronous preparation, traditional critique, and virtual simulation:

Asynchronous Preparation: A few days before the studio class day, technical lesson videos prepared regarding that week's topic (E.g., Site layout principles or floor/core layout) were shared via Google Classroom (LMS). The morning session of the studio started with a quiz measuring the extent to which students internalized these asynchronous contents. This stage is the field reflection of the R&D Point mechanic theorized in Section 2 and ensured that the student alleviated the technical data load in their working memory and devoted the studio time entirely to design.

Traditional Studio Critique (Phase 1): Following the quiz application, individual desk critiques were carried out over the students' two-dimensional drawings and physical drafts, remaining faithful to the operation and continuity of the traditional studio. For this purpose, a traditional architectural studio classroom layout was created where the instructor and students gathered around a common desk (Figure 2). This ensured that the 1 student who did not participate in the research and chose the traditional method could continue their regular education without interruption. For the 7 students included in the model, this session was handled as a diagnostic phase where weak aspects of the design, proportional errors, and points of conceptual blockage were identified together with the instructor. These deficiencies, which in traditional architectural education are left as homework/revisions for the next week and usually deepen the student's existing fixation while trying to solve them alone; were directly made the instant resolution targets of the afternoon VR activities in the new setup.

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Figure 2. Traditional studio working layout.

Autonomous and Synergic Virtual Studio (Phase 2): In the second half of the day, the studio transitioned to the Autonomous and Synergic Virtual Studio model. For this purpose, the studio desk arrangement was changed, and 1.6 m x 1.6 m areas were designated where students would perform their VR activities (Figure 3).

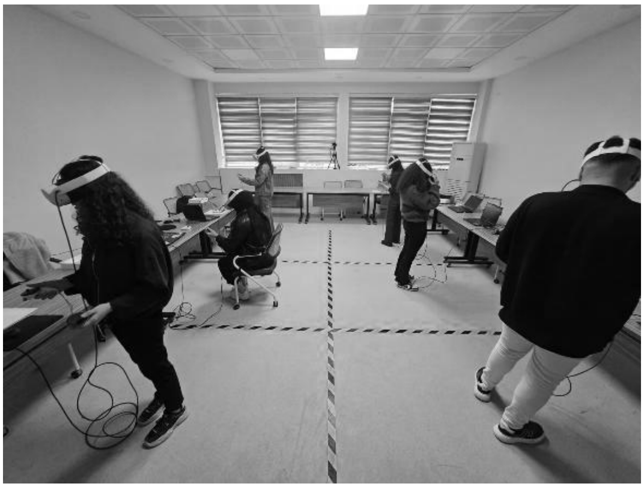

Figure 3. Autonomous and Synergic Virtual Studio working layout.

In these areas, VR devices were connected to the students' laptops via connection cables, and the VR environment was made instantly observable through the screen casting feature. In this way, the student's instant VR activities were made observable and contributable by both other students and the studio instructor. The daily operational routine of the integrated studio process involving traditional and digital phases is schematized in Figure 4.

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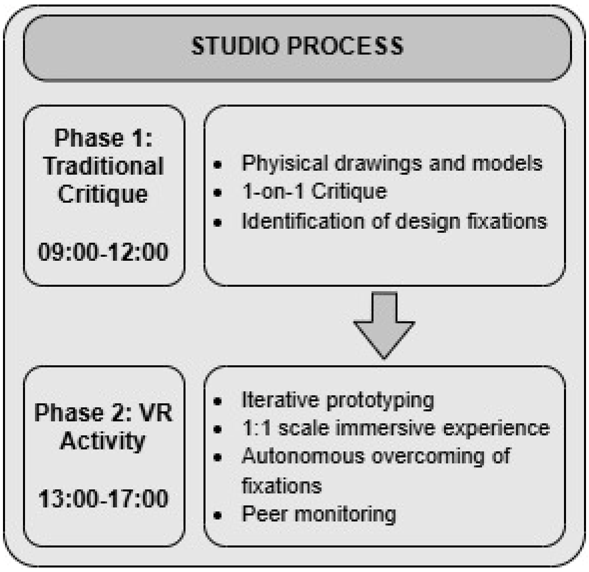

Figure 4. *Studio process diagram.*

In the learning environment created, without waiting for the next week, students performed the following activities aimed at overcoming fixation by simulating the errors and aspects needing improvement identified in the critique during the morning session in the Arkio software via the VR interface right then in the studio:

<u>Activity 1 (Week 1) - Site Decisions:</u> In the first implementation, the macro scale was focused on; students placed residential masses into the digital urban context. Without making physical models, students modeled the masses instantly and ran trial-and-error processes based on different climatic, formal, and regulatory scenarios. Screen captures of student works for the activities are shared in Figure 5.

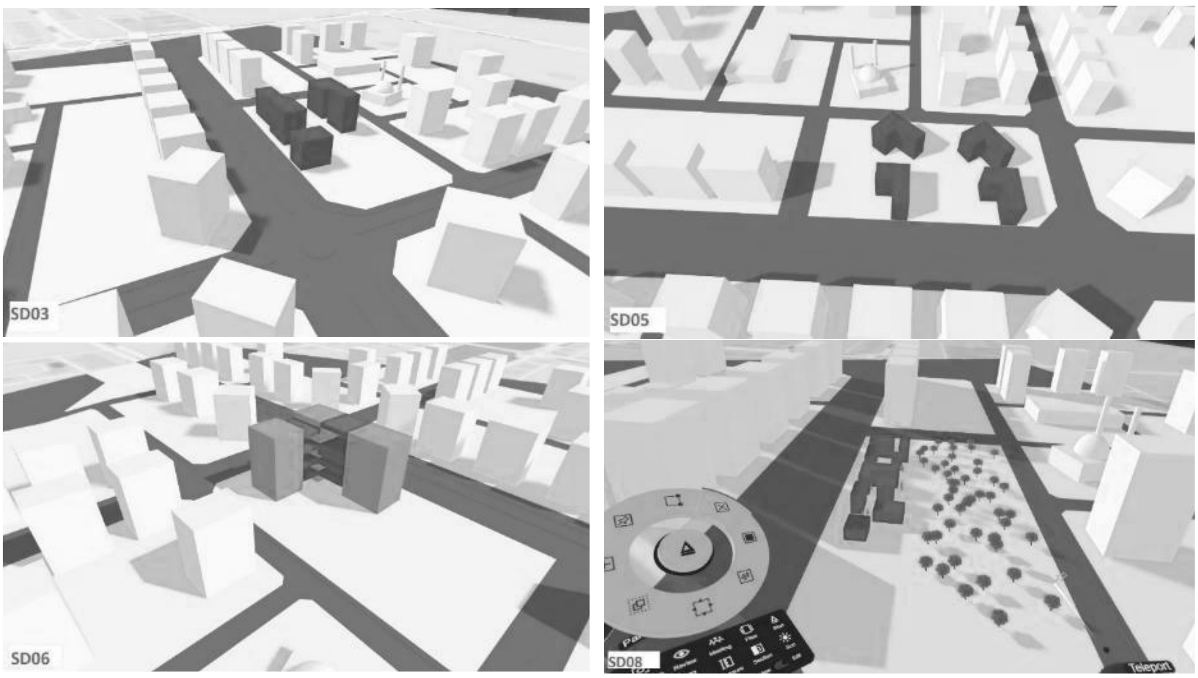

Figure 5. Screenshots Activity 1 implementation student works.

<u>Activity 2 (Week 2) - Floor Layout Decisions:</u> In the second implementation, going down to the micro scale, volumetric layouts in floor plans and spatial relationships were tested

in the VR environment. By testing the building core layout and user circulation scenario, students experienced the proportional and circulation errors unnoticed on two-dimensional plans at a 1:1 scale and reconfigured their design decisions.

During both virtual activities, the instructor followed the process by taking observer notes and guided the students with directions on design and technical (use of devices and software) issues. Additionally, after the completion of the activities, an activity evaluation questionnaire consisting of open-ended questions was administered to the students via Google Classroom. These questionnaires were used as the primary measurement tools constituting the qualitative data pool of the article, allowing students to express the difference between their blockages in the physical environment and their flexibility in the VR environment in their own words.

4. FINDINGS

This section presents the empirical data obtained regarding the capacity of the constructed Autonomous and Synergic Virtual Studio framework to break design fixation and trigger peer interaction in architectural studios. During the analysis phase of the study, the Mixed-Methods Data Triangulation strategy was adopted to increase the scientific validity and reliability of the findings. In line with this strategy, quantitative and qualitative data sets were subjected to cross-analysis in a mutually verifying manner. Quantitative data were compiled from Gamification Tracking Charts that numerically document the students' performance over the two-week virtual studio period. Gamification metrics obtained by students over the two-week implementation are presented in Table 1.

Table 1. Gamification performance distributions of students within the scope of Activity 1 and Activity 2.

Student Code	Activity 1: Site Plan Decisions				Activity 2: Floor Plan Decisions			
	RP	**DDP**	**SP**	**Badges**	**RP**	**DDP**	**SP**	**Badges**
SD01	Did not attend				30	50	-	
SD02	50	-	-		50	50	30	Space Designer, Deep Explorer
SD03	50	-	-		Did not attend			
SD04	20	-	-		30	-	-	
SD05	20	-	-		Did not attend			
SD06	20	50	-	Space Designer	30	50	-	Space Designer, VR Frontier
SD08	50	-	-		Did not attend			

The data forming the qualitative dimension of the study; were obtained from open-ended activity evaluation questionnaires collected via digital forms right after each VR activity while the experience was fresh to measure students' novelty effect and feelings of spatial flexibility, and from researcher observation notes. Qualitative data were analyzed using the thematic analysis method, coded, and these codes were gathered under three main themes: *Flexibility and Alternative Production, Reducing of Cognitive Load*, and *Overcoming Social Isolation*. Due to research ethics and data privacy protocols, all 7 students participating in the study are not referred to by their names in the findings section; but with anonymous codes such as SD01, SD02... SD08 (SD07 was excluded for exercising the opt-out option).

As a result of blending numerical gamification data with thematic codes derived from the students' own statements and researcher observation notes, the findings reached have been detailed under three themes gathered in line with the two main research focuses of the study.

4.1. Theme 1: Flexibility and Alternative Production

One of the biggest factors feeding design fixation in traditional architectural studios is the time and labor cost brought by physical model making and students' fear of making mistakes (Choi & Kim, 2018). The extent to which the constructed Autonomous and Synergic Virtual Studio model could break this fixation through iterative prototyping was examined by cross-analyzing quantitative and qualitative data. Per the study methodology, the traditional production performances and behaviors of the students in the morning session served as a control threshold for the afternoon VR activities. Quantitative gamification data reveal that the students' process of mitigating design fixation showed an increasing evolution from the first week to the second week (Table 1). In Activity 1, due to the effect of the adaptation process to VR hardware, only student SD06 showed high adaptation in the studio, earning 50 DDP and the Space Designer badge. However, moving to Activity 2 (Floor Layout) where instrumental adaptation was achieved, all students (SD01, SD02, SD06) participating in the afternoon VR session each gained 50 DDP; SD02 and SD06 were also rewarded with the Space Designer badge.

The students overcame the fear of making mistakes and not being able to revert that they experienced with physical drafts in the Phase 1 sessions of the traditional studio layout, through the iterative design freedom offered by the Phase 2 sessions in the VR-supported layout. In the Activity 1 evaluation questionnaire, student SD05 expressed this situation directly with the following words: *"In a situation like a physical model, some glitches cannot be fixed, sometimes it is necessary to start over... but this is not the case in the VR environment, glitches can be resolved."* Researcher observation notes also confirm SD05's statement; indeed, the notes reported that SD05 *"struggled a bit at first but managed to place their masses in the site plan as several alternatives."* Similarly, student SD06, who showed the highest performance in Activity 1 and received the Space Designer badge, defined the process in the questionnaire form as *"Felt easier than the physical model"* and *"Less troublesome than the physical model."* SD02's statement while evaluating the process, *"I did not encounter any difficulties encountered while making a physical model... I tried whatever came to my mind,"* supports that when physical resistance is removed, students' tendency to produce multiple alternatives increases. In addition, SD08's statements emphasizing the advantage of using the Arkio program instead of a traditional physical model, *"It was better because we can directly transfer the design in the virtual environment, it also saves us time,"* confirms that the fear of time cost feeding fixation has begun to be overcome technologically.

One of the most objective indicators that design fixation has been broken is the self-diagnosis by the student of how the two-dimensional drawings they accepted as correct or sufficient in the Phase 1 session turned into perceptual illusions in the simulation in Phase 2. The simulation process carried out in the VR environment clearly showed how the deceptive accuracy in two-dimensional plans emerged inside VR. Researcher observation notes and questionnaire responses detail how students broke the blockages in their own designs at a 1:1 scale:

- **SD06** commented on the instructor finding the size of the bridge designed between the buildings large and heavy in the Week 1 site plan studies by stating, *"thinking that it would be ineffective if the bridge got thinner, they thought it would be better for it to stay this way."* However, after experiencing it at a 1:1 scale in the virtual studio, they revised this decision, as defined in the activity evaluation questionnaire with the phrase, *"...I understood that it should be more elegant in shape."*
- It was observed that **SD08** experienced fixation in the Week 1 site plan studies (Figure 5) by stating that they *"understood but was undecided because they did not know how to do it,"* as stated in the research observation notes, regarding the critique that the sizes of their buildings they wanted to establish a greater relationship with the ground were too large and needed to be broken up into low-rise blocks. During the VR studies conducted in the afternoon (Figure 5), they

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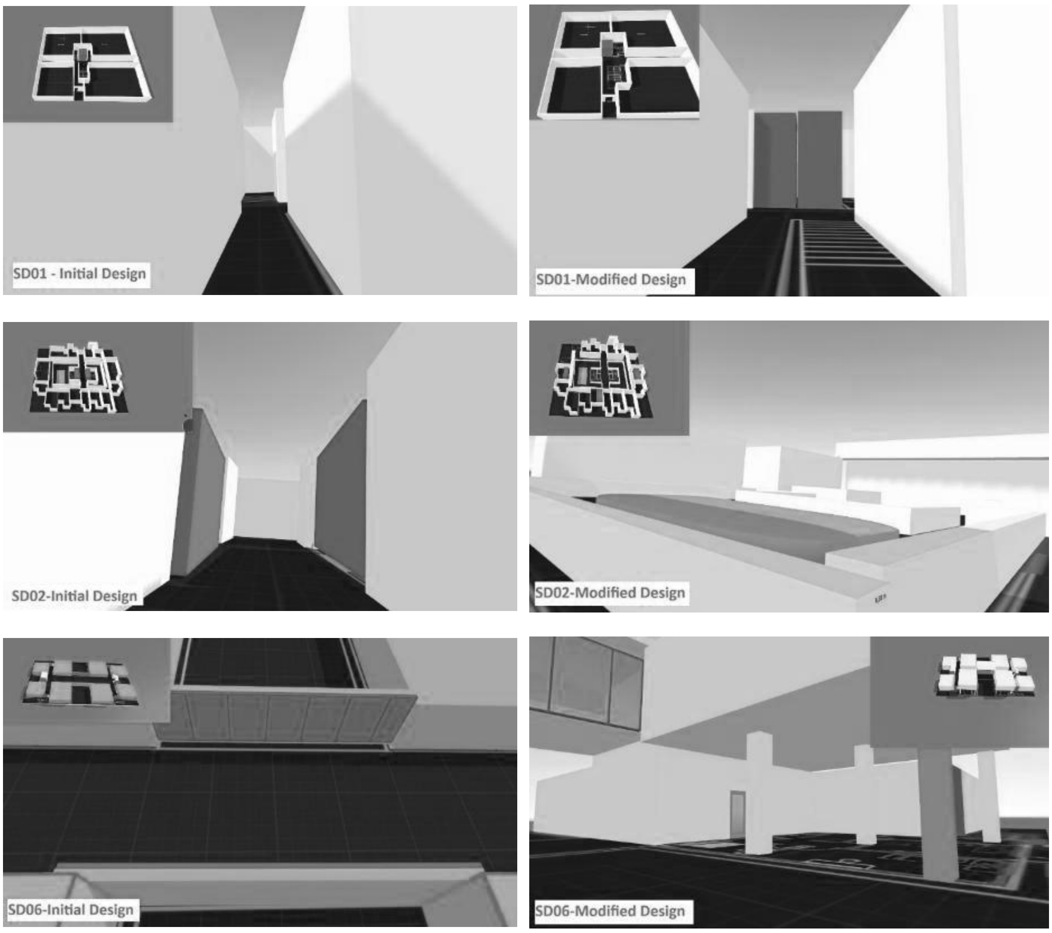
shared that seeing formally that the 4-5 story building heights and fragmented masses formed a better connection with the ground caused them to better understand the instructor's critiques.

- **SD01** in the Week 2 activity, while finding the building entrance and circulation areas they drew on paper in the morning session (Phase 1) sufficient; when experiencing the space at a 1:1 scale in the afternoon VR session (Phase 2), they personally felt the narrowness of the circulation with the guidance of the instructor and decided to revise their plan and widen the entrance. They explained this decision to change with the words, *"Normally, the circulation areas I thought were sufficient remained inadequate, experiencing it showed me my mistake; I left a more open circulation area."*
- In the research observation notes for the Week 2 morning session, it is noted that despite **SD02**'s reluctance to change a core layout that narrowed the courtyard, during the virtual experience conducted with the instructor, they accepted that a layout where circulations facing the courtyard turned into semi-open spaces, freeing the courtyard from the core, was more suitable for their ideas.
- **SD06**, in the Week 2 morning drawings, wanted to continue with their current planning despite the instructor describing the building entrance areas as large and undefined. In the afternoon virtual simulation, perceiving the emptiness of the space dimensionally, the student, as confirmed in researcher notes, decided to design two entrances at a more appropriate scale by separating the entrances suitable for the twin block layout. The student's questionnaire statement, *"I realized my entrance was very large and distant, and I changed the location of my entrance,"* indicates that virtual simulation illuminated the insolvabilities unseen in traditional plan drawings.



Şekil 6. Screenshot of the initial and edited versions of the designs of SD01, SD02, and SD06 in Activity 2.

Consequently; the students overcoming the time and labor cost of physical production and entering into multiple mass trials in the first activity, and breaking their errors unseen on the two-dimensional plan plane at a 1:1 scale (Figure 6) to transform their designs in the second activity; objectively reveal that the proposed model saved students from getting stuck on the "first working idea."

4.2. Theme 2: Reducing of Cognitive Load

In the constructed model, it was aimed to alleviate the load in working memory by pushing complex technical/contextual data, which cause architectural design fixation, out of the studio via the Flipped Learning strategy. This change in students' cognitive loads was examined through a qualitative cross-analysis based on R&D Point metrics measuring their success in the asynchronous preparation process, researcher observation notes, and students' self-reports given in open-ended activity evaluation questionnaires. When gamification scores are examined; it was seen in Activity 1 that students SD02, SD03, and SD08 successfully overcame their theoretical data loads with out-of-studio asynchronous preparation by winning both the Regulation Check-up and Research Bonus. In the same activity, SD04, SD05, and SD06 used this cognitive buffer by obtaining the Research Bonus. Moving to Activity 2; it was determined that SD01, SD02, SD04, and SD06 started the day directly with a Regulation Check-up point; and SD02 was rewarded with the Deep Explorer badge for the contextual preparation they obtained by winning both the Regulation and Research Bonus. In the same week, SD06 demonstrates their high cognitive adaptation to the digital process by earning the VR Pioneer badge.

However, despite this theoretical (intrinsic) cognitive load resolved asynchronously, it was determined that the hardware-related (extraneous) cognitive load generated by the integration of a technological tool into the studio underwent two different evolutions within the studio. In the first week of the virtual studio, despite the theoretical preparation provided by the R&D Point, the extraneous cognitive load created by hardware and interface adaptation was seen to be dominant. When Activity 1 researcher observation notes are examined; it was reported that students SD03 and SD04 struggled with the interface, while SD08 *"tried to make volumetric tests outside their own area and on the program's features"* instead of focusing on the site decisions assigned to them. The working memory of the student, dedicated entirely to figuring out VR controls and the interface, had insufficient cognitive capacity to focus on design alternatives (DDP) or peer synergy (SP). Indeed, student SD04, who failed to earn Design Development Points, Synergy Points, and badges in the first activity, explained this situation in the questionnaires with the following statements: *"I focused on learning rather than points. Right now, my priority is to learn solidly and gain points in future lessons,"* indicating their priority was instrumental adaptation. The low tendency to produce alternatives exhibited by the students in the first week constitutes an empirical example to the situation defined by Agogué et al. (2014); avoiding taking risks and being unable to step outside existing mental strategies.

When moving to the 2nd week (Activity 2) of the study, the extraneous cognitive load decreased as the technological novelty effect wore off. Asynchronous theoretical knowledge sharing via the Flipped Learning model and the R&D Points mechanic motivated the students' class preparation processes, contributing to the opening up of cognitive space in the studio. Open-ended responses in the activity evaluation questionnaires revealed that students viewed the Flipped Learning system as a tool that alleviated the technical data load in the morning session and enabled focusing on design decisions. SD01's statements *"Having things settled in our heads before class felt better"* and SD02's statements *"Because I use the information on Google Classroom while designing, I do not lose a week... because I see something my instructor would say during the design phase, they don't have to warn me this week, which speeds us up"* support this situation. This mental relief, as stated in Theme 1, directly allowed for an increase in the students' Design Development points.

4.3. Theme 3: Overcoming Social Isolation

The second main goal of the constructed model is to break the studio isolation that traps students in their own screens via the Synergy Point mechanic and initiate an autonomous peer learning. In accordance with Rabardel's (1995) instrumental genesis theory, the awakening of synergy also showed a longitudinal evolution: In the 1st Week of the study, when gamification scores are examined, it is evident that no student in the studio received a Synergy Point (SP). This lack of social interaction stemmed from the adaptation efforts the students experienced under extreme technological cognitive load. SD06's statement *"Generally no one asked for much help from anyone... I think it wasn't a problem related to the operation, our friends didn't ask for help"* and SD05's statement *"Because I worked on my own project for the first time today, I couldn't interact much with the environment because I was focused on learning and trying commands."* Their statements confirmed that in the first week everyone was isolated in their own learning process.

Moving to the second week of the studio, as the technological novelty effect began to wear off and instrumental adaptation started to be achieved, the extraneous cognitive load on the students alleviated. This mental relief allowed the expected peer synergy to begin to form. Activity 2 Gamification Table data quantitatively verify this increase in social interaction. Despite the decrease in studio attendance due to absences, student SD02 not only broke fixations in their own design; but also managed to earn 30 Synergy Points by providing spatial guidance to their friends in the studio. This situation demonstrates that students stopped seeing the interface of the Arkio program as an obstacle and started using it as a transparent tool through which they could communicate with their peers. This synergic awakening was directly reflected in the students' qualitative evaluations as well. SD01's observation, *"There wouldn't be general conversation in project classes, but thanks to VR, establishing dialogue is easier because we collaborate with our friends,"* and SD02's statement, *"Because we help those who need help, we have to talk more"*; strongly support that the technological tool breaks the individual isolation in the studio and establishes an autonomous communication network. SD06's statement, *"There still hasn't been much communication established, everyone is still in the adaptation process,"* was recorded as a valuable limitation finding indicating that the communication network cannot yet encompass the entire studio simultaneously and that the instrumental genesis phase must progress at different paces among individuals for peer mentoring to develop.

5. CONCLUSIONS

This study tested the applicability of the Autonomous and Synergic Virtual Studio framework constructed to overcome two fundamental crises progressively deepening in architectural design studios –design fixation and screen-bound isolation. The empirical findings obtained support with concrete data the potential of Virtual Reality (VR) technology's environmental simulation power; when supported by Flipped Learning and Gamification dynamics, to transform the studio culture from a passive receiver environment into a collective R&D laboratory.

The first and most prominent finding of the study is that the 1:1 environmental simulation and iterative prototyping opportunity provided in the VR environment significantly breaks the design fixation in traditional studios. As emphasized by Jansson and Smith (1991) and Youmans and Arciszewski (2014), designers usually get stuck on the first working idea due to labor and time costs. However, in this study, it was seen that students overcame the fear of making mistakes and not being able to revert brought by physical model making in the VR interface and produced numerous alternative masses by autonomously diagnosing their own errors. Thanks to the within-subject design; the fact that two-dimensional decisions students deemed sufficient in the morning session (Phase 1) were found erroneous and revised by themselves in the afternoon simulation phase (Phase 2), shows that the flexibility achieved depends directly on the perceptual depth offered by the model. This situation supports Choi and Kim's (2018) argument that the digital context increases flexibility by removing physical limitations. Furthermore, Howard et al. (2013)'s theory that *"fixation will be overcome as the amount of generated ideas increases"* was validated in the field via the Design Development Point mechanic applied in the study. Instead of defending a single, safe project out of grading anxiety, students turned to trying variations in the risk-free environment offered by gamification.

The most original contribution of the research to pedagogical literature is revealing the importance of pushing complex technical data out of the studio via Flipped Learning and R&D Points and diagnosing the situation of social delay experienced in the integration of powerful technologies like VR into the studio. Students' self-reports (SD01, SD02) confirm that asynchronous preparation is a catalyst that opens up the cognitive space in the studio and enables focusing on design decisions. In the study, although the intrinsic cognitive loads of the students were alleviated with asynchronous preparations, it was determined that the extraneous cognitive load originating from hardware initially outweighed. The situation of lack of social interaction experienced in VR integration was interpreted as a natural reflection of instrumental genesis. This excessive cognitive load created by learning a new simulation interface initially blocked the students' capacity to help others. However, moving to the second week, it was seen that as mental adaptation to the technological tool was achieved, social isolation began to break, and peer mentoring practices autonomously started with the encouragement of gamification. The increase in synergy observed here goes beyond a mere technological novelty effect; it is the result of a transparent communication network created by projection screens and the Synergy Point mechanic. However, the mixed data analysis findings obtained; show that a powerful and isolating technology like VR in architectural design studios, even when supported by gamification, does not directly create peer synergy. It was revealed that for peer mentoring to function, students must be given an instrumental genesis period (at least 1-2 weeks) during which they will get used to the interface, alleviate their cognitive loads, and internalize the technological tool. This discussion shows that merely bringing hardware into the studio is not sufficient on its own in architectural education; it is mandatory to incorporate cognitive adaptation processes into the design so that technology becomes transparent and transforms into a social interface.

5.1. Limitations and Future Studies

Although the scalability of the proposed model harbors cost and hardware constraints for large student groups, the peer mentoring practices provided by the system can optimize the workload on the instructor, ensuring the formation of more efficient studio processes. As this research is designed as an exploratory case study, it has limitations regarding the statistical generalizability of the findings, such as sample size (7 students) and implementation duration (2 weeks). Although this limitation poses an obstacle in measuring the effects of gamification mechanics on long-term intrinsic motivation, the proof of concept presented by the study forms a critical ground in understanding the mechanism of mitigating fixation. It is recommended that future research focuses on longitudinal studies where the proposed Autonomous and Synergic pedagogical framework spans an entire educational semester, conducted with larger sample groups and consecutive Design-Based Research (DBR) cycles. Ultimately, this study shows that, as an alternative to approaches that view technology merely as an aesthetic presentation tool; Virtual Reality can be transformed into an integrated analytical thinking tool that facilitates overcoming design fixation and triggers peer synergy via gamification.

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This research was conducted in full compliance with scientific ethics principles. To conduct the study, ethical approval document dated 11.07.2025 and numbered 961555 was obtained from the Dicle University Social and Human Sciences Ethics Committee.

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