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Applied Research Article

Team Design Training: Learning Preferences as a Factor for Identification and Prediction of Students' Abilities in Design Teams

Babak Khorshidi[1], Omid Dezhdar[2*], Saied Haghighi[3]

[1] *Ph.D. Candidate of Architecture, Department of Architecture, Hamedan Branch, Islamic Azad University, Hamedan, Iran*

[2*] *Assistant Professor of Architecture, Department of Architecture, Hamedan Branch, Islamic Azad University, Hamedan, Iran*

[3] *Assistant Professor of Architecture, Department of Architecture, Hamedan Branch, Islamic Azad University, Hamedan, Iran*

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ABSTRACT: It is vitally important to recognize the differences in abilities among learners and then adapt training programs to their characteristics in team design training (TDT). According to this background, the present study aims to identify and predict students' team design ability and its dimensions, content, and process, using their learning preferences (LPs) within the modes of receiving/perceiving information, viz., abstract conceptualization/concrete experience (AC/CE) and processing/internalizing it, namely, active experimentation/reflective observation (AE/RO) in Kolb's Experiential Learning Theory (KELT). In this respect, the self-and-peer assessment (S&PA) outcomes in the design teams indicate a significant correlation between the students' bipolar LPs (BLPs) and their team design ability along with its dimensions, implying that their team design ability can be well predicted from their LPs. It is thus expected that learners who prefer to exploit AC in receiving/perceiving information and AE in processing/internalizing it and those correspondingly choosing CE and AE for the same purposes will have better ability in the content and process dimensions of team design, respectively. Considering the impact of both dimensions and their effectiveness ratio on the overall team design ability, it is concluded that learners who wish to process/internalize information by AE will exhibit higher team design ability.

Keywords: *Team Design, Team Design Training, Learning Preferences, Team, Design Studio*

INTRODUCTION

At present, individual training in design studios is being criticized by some design thinkers in favor of collaborative learning (CL) based on Social Constructivism Theory (SCT) (Eigbeonan, 2013; Pressman, 2014, 53). From their standpoint, design knowledge is naturally implicit and social; thus, its teaching and learning should be fulfilled within a collaborative framework (Rodriguez et al., 2018; Mor & Mogilevsky, 2013). In the words of Boyer and Mitgang (1996, 97), design students can no longer personally learn the essential skills in isolation and away from each other, and they should learn design in a team. On the other hand, in the professional world of architectural design, design has become a collaborative activity, and designing even the simplest architectural projects is a collaborative effort, which requires designers to work together to achieve a single goal. In general, it can be said that the nature of design in architecture is changing from an individual activity to a team design.

Team design is a collaborative activity where a team of individuals with various specialties brainstorms and discusses challenges and solutions to foster effective design teamwork (Calhoun, 2014). Team-based activities accordingly address tasks (viz., what needs to be performed) and teamwork (viz., the way individuals interact to fulfill the assigned tasks) (Grossman et al., 2017; Kozlowski & Ilgen, 2006). Morgan et al. (1986) have further distinguished between describing team-based activities, particularly task-related and teamwork ones, and suggested that content is related to the activities accomplished, and the process is associated with collaborative and communicative relationships among team members.

Researchers involved in team design have additionally applied this separation model between content and process, and they found that approximately two-thirds of the total activities in teams were allocated to design framework (viz., content), but social interactions and team relationships (viz., process) accounted for one-third of the total activities in teams (Austin et al., 2001; Cash et al., 2020; Stempfle & Badke-Schaub, 2002).

This segmentation and model enable us to divide complicated activities in a design team into small parts and analyze them with

*Corresponding Author Email: ***hO.dezhdar@iauh.ac.ir- 0000-0002-2323-2432***

various methods and tools, thus giving an accurate picture of what design teams do in reality. The team design process could thus be best described as constantly intermingling content- and process-oriented sequences, both taking a certain amount of time.

Team design can provide benefits such as raising motivation (Emam et al., 2019), developing critical thinking and interpersonal skills (Espey, 2018; Sgambi et al., 2019), promoting inclusive education (Muñoz & Porter, 2020; Cohen, 1994), transitioning from passive to active learning (Coorey, 2016), improving creativity (Casakin & Timmeren, 2014), boosting peer learning (Van den Berg et al., 2006), and fostering lifelong learning capabilities (Hanrahan & Isaacs, 2001; Dillenbourg, 1999), for students. Additionally, teamwork skills and the ability to engage in team design are essential for architecture students preparing to enter the labor market. These skills are emphasized by many prestigious bodies, such as the Royal Institute of British Architects (RIBA, 2010) and the National Council of Architectural Registration Boards (NCARB, 2012).

Therefore, considering the importance that team design learning can have for architecture students and their future, students at the university level should be trained in teamwork and practice team-based design (Emam et al., 2019; Barkley & Major, 2020, 114). To meet these objectives, educational planners and teachers involved in design should devote much more attention to CL, team design training (TDT), and teamwork skills development in curricula and instructional materials.

For TDT, trainers should use an effective and comprehensive training program to teach team design in architectural studios (Sottilare et al., 2018). One of the most important steps to developing this form of educational program is to know the factors affecting the quality of teaching and learning of team design and the details related to how these factors influence (Khalil & Elkhider, 2016). By controlling and managing these factors, instructors can create a suitable and desirable educational platform for students that follows the educational needs of students and the different conditions of design studios. Tucker (2017) identified four main areas, viz., task-related, individual-level, team-level, and process-related characteristics. In this context, the individual-level characteristics were associated with those of design team members, which could help teachers recognize students with reflections on their age, gender, learning preferences, sociocultural background, education, motivation, attitude, and personality type since they could influence students' team design ability and their learning quality. Accordingly, students' learning preferences (LPs) can generate diverse learning styles as one of the most important characteristics influencing team members' performance at the individual level and among the most significant factors inspiring student design teams (Brown et al., 2005). On the other hand, according to Figure 1, LPs alter the features of teams, teams' performance, as well as team training and learning through team composition and diversity in members (Anderson et al., 2018; Webster & Sudweeks, 2006; Martin & Paredes, 2004).

On the other hand, in the design of effective educational programs, the matches of the educational program with the abilities, desires, and needs of students are the key to the success of an educational program, and in all educational models, the first step is to know the learners (Sottilare et al., 2018). Therefore, in the development of the TDT program in architectural studios, identifying and predicting the ability and skills of students in team design and its' dimensions (content and process) and specifying the educational needs and demands of students based on their strengths and weaknesses in these both dimensions is very important.

Several studies have shown that one of the most important factors affecting students' ability and performance in design is their learning characteristics (Carmel-Gilfilen, 2012; Demirbas & Demirkan, 2003, 2007; Demirkan & Demirbaş, 2008; Demirkan, 2016; Kvan & Jia, 2005; Roberts, 2006). Students' learning characteristics can be identified by learning preferences and learning styles. The difference between these two parameters is that learning preferences are a more basic concept and cause learning styles. Most of the studies regarding the effect of students' learning characteristics on their design ability and skill have been done using learning styles. Using the concept of learning styles due to placing a large number of students in one group, who in reality may have different learning characteristics and accordingly have

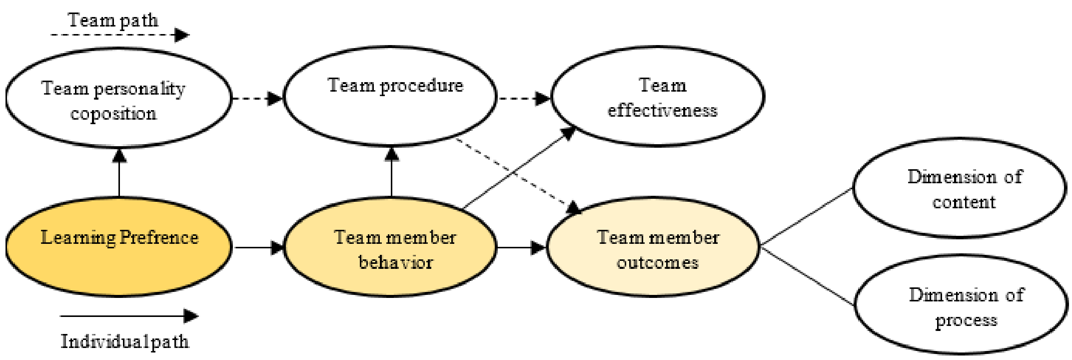

Fig.1: Paths in which students' learning preferences can influence the design teams' performance

different abilities in team design, does not have the necessary efficiency and accuracy. It is probably for this reason that the results obtained by these studies only show that the learning characteristics of students affect their ability and performance, and they have not been successful in predicting how the ability and skill of students will change.

Some studies that have attempted to make predictions using learning styles have obtained different results because they have utilized learning styles, and certainly, the number of students with different learning styles in different studies has not been equal. Also, in a specific study, the results are unreliable because the number of students with different learning styles is not close to each other (Demirbaş & Demirkan, 2007; Carmel-Gilfilen, 2012; Kvan & Jia, 2005). To avoid these issues, this research investigates the relationship between learning characteristics and their ability and skill in design in a more detailed manner, regardless of learning styles, and uses the concept of learning preferences. This aims to provide more accurate and detailed information for developing team-based design training programs in architecture studios to benefit instructors and educational designers.

LPs refer to individuals' approaches, tendencies, or preferences once receiving, processing, organizing, and using information (Felder & Silverman, 1988, 676). Inherently, such preferences develop from speculations based on observing behaviors and personal statements, resulting in various theories. LPs may be thus assumed to have varying characteristics influenced by personal, contextual, or educational factors over time (Tucker, 2017). There are different methods to identify learning characteristics and students' LPs. Newland categorizes learners as common sense, dynamic, contemplative, and zealous (Newlan et al., 1987). Leary classifies a person's behavior along two axes: dominant versus submissive and friendly versus critical (Leary, 2004, 211). Felder examines learning under sensory versus intuitive, visual versus auditory, inductive versus deductive, and active versus reflective dimensions (Felder & Silverman, 1988, 680).

One of the most well-known methods used in many pieces of research in the field of design to identify students' learning characteristics is KELT. As stated by Kolb (2014, 5), KELT was established under the influence of a set of theories, such as Lewin's Social Psychology (1997, 119), Dewey's Philosophy of Pragmatism (2008), and Piaget's Cognitive Development (1970). In keeping with these principles, Kolb has defined learning as transforming knowledge into experience, which occurs in a four-stage cycle: CE, RO, AC, and AE. Kolb further suggests that CE is dialectically opposed to AC; likewise, RO is dialectically in opposition to AE. This contrast induces BLPs, consisting of AC/CE, related to receiving/perceiving information, and AE/RO, associated with processing/internalizing information by learners (Figure 2). Depending on their life experience, inherent characteristics, and preferences for building knowledge, learners accordingly choose one pole in BLPs, which leads to the emergence of four learning styles (Kolb & Kolb, 2005; Kolb, 2014, 10).

While much research has shed light on the effects of learning characteristics on individual design and learning (Carmel-Gilfilen, 2012; Demirbas & Demirkan, 2003, 2007; Demirkan & Demirkan, 2008; Demirkan, 2016; Kvan & Jia, 2005; Roberts, 2006), only a limited number have investigated the way learning characteristics form team-based design. In this line, Sharp (1998) explored students' performance using Kolb's Learning Style Inventory (KLSI) for two design teams of engineering students and obtained significant results concerning the impact of learning styles on their team design performance. Comparatively, Carrizosa & Sheppard (2000) analyzed effective communication between engineering design team members and successful transfer (viz., sending, receiving, and processing) of information regarding the Felder-Silverman Learning Styles Model. Tucker (2007) also compared LPs in the first- and third-year design students, employing the KLSI, and pointed out that the differences were related to the years of study in the multidisciplinary collaborative design studios.

In these studies, it can be seen that the concept of learning styles has been used to identify students' learning characteristics, which, as explained, cannot be a suitable tool for identifying students' personality characteristics, and based on that, students' skills and abilities in team design. It is also observed in these studies that to measure the skills and abilities of students in team design, the point that team design consists of two dimensions of ability, content and process, has not been taken

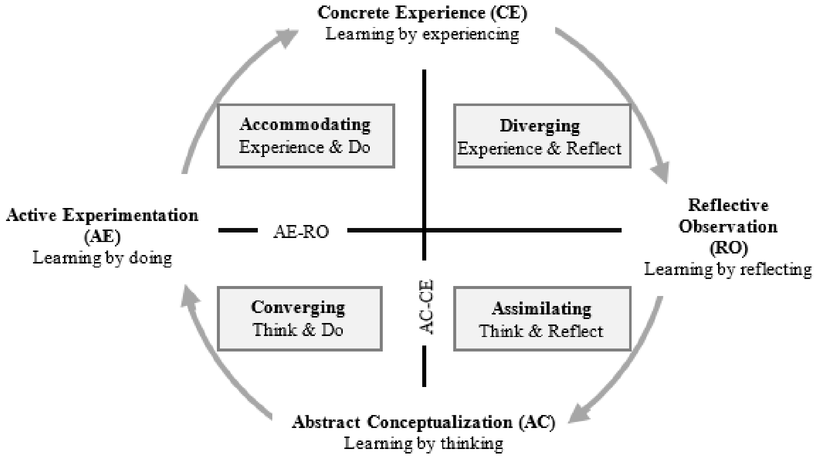

Fig.2: Four learning phases of Experiential Learning Theory (Kolb, 2014, 4)

into account because it is very likely that a student will show completely different performance and abilities in these two dimensions.

Therefore, it can be concluded that team design cannot be taught in architectural design studios without investigating students' LPs and knowing the relationship between their ability and skills in team design based on the same regular, predetermined program. From these investigations, it is clear that none of the previous studies have specifically investigated the relationship between students' LPs and their skills and abilities in team design and its dimensions, and they cannot guide planners and trainers in this field to develop TDT educational programs.

To bridge this gap and to help trainers and educational planners train team design in architecture studios, these questions should be addressed: "What is the relationship between students' LPs and their skills and abilities in team design and' both dimensions?" And "Is it possible to identify and predict students' abilities and skills in team design and' both dimensions utilizing students' LPs?"

For this purpose, the primary objective of this study is to identify and predict students' team design ability using the modes of bipolar LPs (BLPs), namely, abstract conceptualization/concrete experience (AC/CE) and active experimentation/reflective observation (AE/RO) in Kolb's Experiential Learning Theory (KELT) in architectural design studios. This study also examines the relationship between BLPs and students' performance in both dimensions of team design (viz., content and process). The study findings are expected to help design studio teachers adapt TDT programs to learners' characteristics, particularly their strengths and weaknesses.

Theoretical Framework

As stated in team design training, one of the factors affecting the quality of training and learning in architectural design studios is the recognition of students at an individual level. In this recognition, learning preferences are among the most important factors affecting students' ability. These different LPs in students may affect different aspects of their behavior and performance in team design. Previous research has confirmed that adjusting educational activities to students' LPs leads to an upturn in their learning (Layman et al., 2006; Cardoso et al., 2019), which supports the importance of understanding the activities that complement specific learning Characteristics as well as utilizing tasks, assignments, and programs that match LPs and augment academic achievement (Khalil & Elkhider, 2016). Therefore, based on the following hypotheses, the present study seeks to show whether it is possible to predict students' ability and skill in team design and its dimensions by knowing the position of their learning preferences in the AC/CE and AE/RO BLPs of KELT.

Main Hypothesis

Their LPs can predict the students' overall team design ability based on the AC/CE and AE/RO BLPs of KELT.

Sub-Hypothesis 1

The student's ability in the team design content dimension can be predicted by their score in the BLPs (namely, AC/CE and AE/RO) of KELT.

Sub-Hypothesis 2

The student's ability in the team design process dimension can be predicted by their score in the BLPs (viz., AC/CE and AE/RO) of KELT.

Identifying and predicting students' strengths and weaknesses considering their LPs in TDT can further assist teachers in developing training programs to improve learning abilities in proportion to their characteristics in the content and process dimensions. Based on the proposed theoretical foundations, Figure 3 shows the theoretical framework followed in this research.

MATERIALS AND METHODS

The current study was applied in terms of purpose and was Descriptive-Correlational research in methods with a quantitative approach.

The reason for using a quantitative approach in this research was that most studies that have investigated the relationship between learning characteristics or personality characteristics on the performance and ability of design team members had used this type of research method (Patrício & Franco, 2022; Urionabarrenetxea et al., 2021; Anderson et al., 2018). To identify and predict students' team design ability and the content and process dimensions in this study, two separate tasks (each one lasting five hours) were implemented for the selected statistical samples in two sessions in architectural design studios with a 10-day interval. The size of design teams in two separate tasks was limited to 3 5 by the studio teachers, and the selection of the team members was free and up to the students themselves. The students were placed in a team with assorted members in each task. Before doing the tasks, the students' LPs were known by KLSI (II), and at the end of each task, the student's performance and ability were evaluated using the self-and-peer assessment (S&PA) method.

For each task, a different design problem was raised as a conceptual volumetric composition model adequate to students' knowledge and skills. In the first task, the students using six volumes had to create a volumetric composition with a specific concept, and in the second task, they had to create a partition of the college campus wall with modular parts based on the concept of permeability in that wall. Administering two tasks under different conditions could increase the study's validity because the students' abilities might be influenced by their moods and the diversity of team members. Therefore, two separate tasks were practiced to achieve the true results of students' team design ability in both dimensions. The mean scores obtained during both tasks were calculated for each person to determine the students' abilities.

Participants

The statistical population of this research included all first-year architectural engineering students. The first-year students were selected because training at the university level had not yet affected their LPs. Using convenience sampling, 71 architecture students were recruited as the statistical samples from this statistical population in four different studios recruiting in the Preparatory Design Course II. The reason for using convenience sampling was that the first researcher had the role of an instructor in two of these four studios, and it made it possible for us to do team tasks and intervene in two studio programs. Also, the instructors of the other two studios are colleagues of the researchers, and they gave us this possibility.

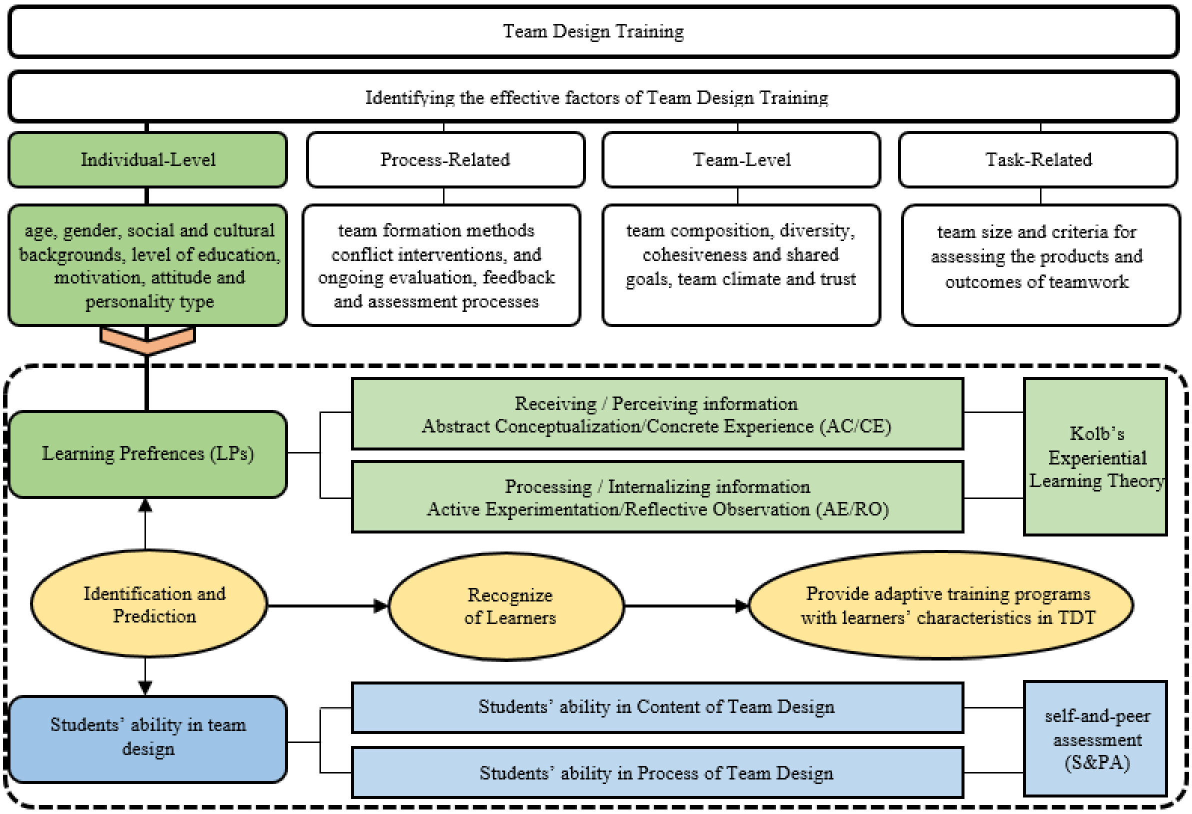

Fig.3: The theoretical framework of this study

During the second semester, this study was conducted in the academic year calendar 2021-22. Two parallel studios were at the University of Kurdistan, Sanandaj, Iran, and two other studios were held at Islamic Azad University (IAU), Sanandaj Branch, Sanandaj, Iran. The reason for selecting Preparatory Design Course II for this study was that the curriculum released by Iran's Ministry of Science, Research, and Technology (MSRT) was the one in which the students could do team-based design tasks.

Measurement Tools

The present study collects initial data about students' LPs and their abilities in team design and dimensions using the following methods and tools.

Learning preferences (LPs)

This study exploited KELT to determine BLPs (AC/CE and AE/RO). This was achieved using the KLSI (II), a modified version of the KLSI (I) published in 1976. The KLSI (II) consists of 12 items in which respondents explain their LPs by rating four statements corresponding to four learning cycle stages. Ranking the items in each row (based on forced scaling) is thus conceptualized as paralleling the learning process, which confines respondents to decide between contrasting abilities. The AC-CE and AE-RO scores obtained from this inventory can be thus employed as a measure of respondents' LPs on receiving/perceiving (viz., AC/CE) and processing/internalizing (namely, AE/RO) bipolarities, respectively (Kolb, 2014).

Considering that the present study was conducted in Iran. So, the students' LPs were established using the Persian version of the 12-item KLSI (II) (1999) (Kolb, 2007, 143), whose validity had been already confirmed by Hosseini Largani (1998) and Taghvaei (2002). Its reliability was further measured through Cronbach's alpha coefficient, and the results were then equal to 76%, 72%, 81%, 72%, 79%, and 70% for the CE, RO, AC, AE, AC/CE, and AE/RO indicators, respectively.

Learners' Team Design Ability Assessment

The assessment of design teams in educational fields can be defined in both dimensions, viz., the team performance in the assigned task, estimated through the assessment of the results obtained, and the performance of team members and the degree of influence of each member on achieving the goal through the analysis or reporting of active members in a design team, which can be evaluated through observations, interviews, and questionnaires (Tucker, 2017). To weigh up the team member's performance in the team design content and process dimensions, the assessment by other teammates, called self-and-peer assessment (S&PA), was utilized as a practical tool to individualize the students' outcomes in team design to assist teachers (Raban & Litchfield, 2007; Walker, 2001). This assessment system has already been operated in various studies with different objectives. For example, Cassidy and Eachus (2000) investigated the relationship between students' assessment of their academic skills, learning styles, and academic achievement. The S&PA is thus a reliable tool in team design (Busseri, 2000) since it provides feedback and helps formulate instructional policies (Adachi et al., 2018).

In this study, the student's ability was ascertained by measuring their performance in design teams, considering the ratio of two-thirds and one-third in the team design content and process dimensions, respectively. Moreover, their performance in the content and process dimensions was assessed via S&PA and a researcher-made 12-item questionnaire containing six items related to content (viz., the ability to design) and six items associated with process (viz., teamwork ability and skills). This questionnaire was then given to the students at the end of the team design task to assess their team members' performance in team design, based on grading from 0 to 10. These 12 items were extracted from the related research on teamwork and team design (McEwan et al., 2017; Riebe et al., 2016; Tucker, 2013). The items of commitment and responsibility, flexibility and taking criticism, decision-making skills, attention to others' opinions, solving intra-team conflicts, and helping other team members could accordingly reveal the students' performance in the dimension of the process. The items of the perception design problem, level of creativity and idea generation, transforming ideas into solutions, reflection, and criticism, and evaluating design ideas and skills could help measure the student's performance in the content dimension.

Moreover, the face validity of this questionnaire was qualitatively examined and then revised with the help of 10 first-year architecture students to understand the appropriate meaning of the items. To check its content validity, five experts involved in team design were further invited to leave their comments on each questionnaire item, so the content validity ratio (CVR) for each item ranged from 0.73-0.91. Besides, the total questionnaire means the value was 0.79, based on expert opinions. To measure the construct validity, the Pearson correlation coefficient was utilized concerning the convergent validity of the items, and a correlation coefficient of 0.68 was obtained, which was acceptable. To shed light on reliability, 40 architecture students completed the questionnaire during a preliminary test, and Cronbach's alpha coefficient was found to be 0.82. Given that, the questionnaire had the required validity and reliability to assess the student's performance in team design through S&PA in both dimensions of team design content and process.

RESULTS AND DISCUSSION

Pearson correlation coefficient and stepwise regression were employed in this study to analyze the data and test the research hypotheses. To do so, the Kolmogorov-Smirnov (KS) test was performed as a non-parametric method to establish the normality of data, and Levene's test was implemented to find the homogeneity of variances and regression gradients. The results of testing the hypotheses in this study are as follows;

First, the Pearson correlation coefficient was performed to test the hypotheses, whose results are provided in Table 1. Accordingly, a strong direct relationship was observed between the students' team design performance in the content dimension and their AE/RO BLPs. It meant that the students with higher AE-RO scores in the KLSI (II) had higher ability and performance in the content dimension and vice versa. This test also demonstrated a significant direct relationship between the students' team design performance in the content dimension and their AC/CE BLPs, as measured by their AC-CE scores in the KLSI (II).

Correspondingly, the correlation results regarding the students' team design performance in the process dimension validated a significant direct relationship between this performance and the students' AE/RO BLPs, as measured by their AE-RO scores in the KLSI (II). A strong inverse relationship was then spotted between the student's performance in the process dimension and their AC/CE BLPs, implying that the students with lower AC-CE scores in the KLSI (II) had better ability and performance in the process dimension and vice versa.

For the students' overall team design performance, obtained by aggregating their performance scores in the team design process and content dimensions, the correlation results additionally confirmed a strong direct relationship between the student's performance and their AE/RO BLPs, in the sense that the students with higher AE-RO scores in the KLSI (II) had better overall team design ability and performance, and vice versa. The results, however, established no significant

Table 1. Pearson's correlation coefficient between the students' two BLPs, their team design performance in the content and process dimensions, and their overall team design performance

	Independent Variable			
	AC/CE		AE/RO	
Dependent Variable	r	ρ	r	ρ
Team Design Content Dimension	0.280	0.018	0.766	0.000
Team Design Process Dimension	-0.731	0.000	0.279	0.018
Overall Team Design	-0.057	0.637	0.825	0.000

relationship between the student's overall performance and their AC/CE BLPs.

Next, stepwise regression was performed to test the research hypotheses. The results regarding sub-hypothesis 1 showed the AE/RO BLPs in the first step and the AC/CE ones in the second step, which was then imported into the regression analysis. For this sub-hypothesis, related to the team design content dimension, the results (the adjusted R-squared [R2] of Pearson correlation coefficient) indicated that the first model (namely, AE/RO) could explain 59%, and the second model (AE/RO and AC/CE) accounted for 66% of the variance in the performance scores in the content dimension. This suggested that the students' BLPs could justify their performance in the team design content dimension. The results of the regression analysis correspondingly established that the students' performance in this dimension could be significantly predicted by the first model (that is, AE/RO) (F(1.69)=97.788, p<0.01) and the second one (namely, AE/RO+AC/CE) (F(2.68)=65.521, p<0.01), respectively.

According to Table 2 and the standardized β for the first model, the one standard deviation (SD) change in the students' AE/RO score resulted in the 0.766 variance in their performance in the team design content dimension. In line with the second model, the one SD change in the students' AE/RO and AC/CE scores caused the 0.762 and 0.268 SD variances in their performance in the content dimension. In keeping with the stepwise regression results, initially, the model managed to explain about 59% of the variance in the performance scores in the content dimension when the students' AE/RO scores alone were tapped in the regression, and then the given model rationalized the extra 7% of the cited variance once the AC/CE scores were entered.

The results of testing sub-hypothesis two also illustrated the AC/CE BLPs in the first step and the AE/RO ones in the second step, which was imported into the regression analysis. For this sub-hypothesis, related to the team design process dimension, the results (the R2 of Pearson correlation coefficient) revealed that the first model (namely, AC/CE) explained 53% and the second model (viz., AC/CE+AE/RO) justified 62% of the variance in the performance scores in the process dimension. This meant that the students' BLPs could account for their performance in the team design process dimension. The regression analysis results similarly proved that the students' performance in this dimension could be significantly predicted by the first model (viz., AC/CE) (F(1.69)=79.239, p<0.01) and the second one (namely, AC/CE+AE/RO) (F(2.68)=55.271, p<0.01), respectively.

According to Table 3 and the standardized β for the first model, the one SD change in the students' AC/CE score resulted in the -0.731 SD variance in their performance in the team design process dimension. As per the second model, the one SD change in the students' AC/CE and AE/RO scores induced the -0.736 and 0.291 SD variances in their performance in the process dimension. Concerning the stepwise regression results, the model managed to explain about 53% of the variance in the performance scores in the process dimension when the students' AE/RO scores alone were exploited in the regression, and then the given model could justify the extra 9% of the said variance once the AC/CE scores were entered.

Regarding the main hypothesis, as shown in Table 1 and Pearson correlation coefficient results, no significant relationship was detected between the students' AC/CE BLPs and their overall team design performance. Therefore, simultaneous regression was just performed for their AE/RO.

The results (the R2 of Pearson correlation coefficient) also indicated

Table 2. Regression coefficients for the prediction of the students' team design performance in the team design content dimension by two BLPs

Model	B	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		Std. Error	Beta			
1	(Constant)	6.410	.151		42.391	.000
	AE.RO	.133	.013	.766	9.889	.000
2	(Constant)	6.096	.161		37.781	.000
	AE.RO	.132	.012	.762	10.743	.000
	AC. CE	.047	.012	.268	3.787	.000

Table 3. Regression coefficients for the prediction of the students' team design performance in the team design process dimension by two BLPs

Model	B	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		Std. Error	Beta			
1	(Constant)	6.718	173.		38.804	.000
	AC. CE	-.119	013.	-.731	-8.902	.000
2	(Constant)	6.628	159.		41.564	.000
	AC. CE	-.120	012.	-.736	-9.828	.000
	RO .AE	.047	012.	.291	3.887	.000

Table 4. Regression coefficients for the prediction of the students' team design performance in the overall team design by AE/RO BLP

Model B		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		Std. Error	Beta			
1	(Constant)	6.214	.096		64.451	.000
	AE.RO	.104	.009	.825	12.105	.000

that the AE/RO BLPs could explain 68% of the variance in the performance scores in the overall team design. This confirmed that the students' AE/RO BLPs could justify their performance in team design. The regression results further established that the student's performance in overall team design could be significantly predicted by the first model (namely, AE/RO) ($F(1.69)=79.239$, $p<0.01$). According to Table 4 and the standardized β based on the AE/RO BLPs, the one SD change in the students' AE/RO score resulted in a 0.825 variance in their performance in the team design.

This study investigated the possibility of predicting students' ability and performance in three parts: team design content, team design process, and overall team design performance by means of the BLPs (namely, AC/CE and AE/RO) based on KELT. The main reason for using the KELT BLPs instead of the learning styles approach practiced in numerous studies in the field of individual design training was the tendency of this method to put a wide range of students with different abilities to receive/perceive and process/internalize information and LPs into the same category. By comparison, the BLPs defined in KELT could provide a more accurate and clear understanding of the students' characteristics and LPs.

This study further observed a direct relationship between the students' team design ability and performance in content and process dimensions and their LPs. The students' BLPs (AE/RO and AC/CE) accordingly explained 66% of their performance in the team design content dimension, though this was much more related to AE/RO than AC/CE (59% vs. 7%). The correlation coefficients also showed that the students whose LPs leaned toward AE on the AE/RO continuum and AC on the AC/CE one exhibited better ability and performance in the team design content dimension, which could help them play a more effective role in this area (Figure 4). This could be attributed to the student's ability to provide a logical analysis of design problems, maintain unemotional perspectives, demonstrate decision-making power (Kolb, 2014), and practically express their ideas (Kvan & Jia, 2005).

Moreover, the students' BLPs (viz., AE/RO and AC/CE) could account for 62% of their performance in the team design process dimension, though this was much more linked to AC/CE than AE/RO (53% vs. 9%). The correlation coefficients also showed that the students whose LPs bent toward CE on the AC/CE continuum and AE on the AE/RO one had higher ability and performance in the team design process dimension and could properly communicate with their teammates (Figure. 4). This was endorsed by the student's ability to show interest in gaining new experiences with others, perceiving through emotion, and taking more risks (Hsu, 1999).

These findings were consistent with the results in Kolb and Kolb (2005), introducing the northern axis of the learning style cycle grid for those having collaborative power, as well as the reports in Gardner and Korth (1998), wherein the accommodating, converging, and diverging learning styles had been presented as the preferred ones while confirming that individuals with an assimilating learning style were not inclined to get involved in teamwork. Moreover, the findings conflicted with the outcomes released by Newland et al. (1987),

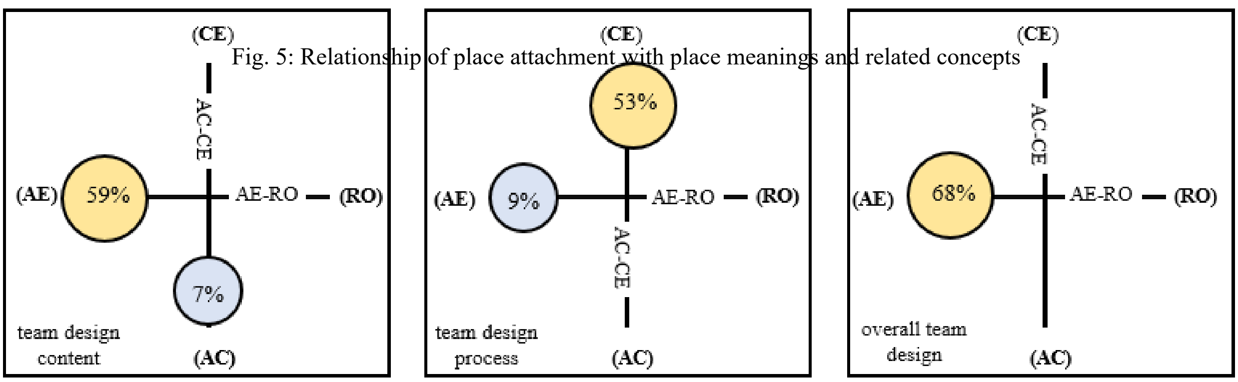

Fig. 4. The effect size of students' learning preferences in predicting the student's abilities in team design, content, and process.

describing those with an accommodating learning style as self-centered but incompatible team members.

In the overall team design, the students' BLPs (AE/RO) managed to explain 68% of their performance in the team design. The correlation coefficients also showed that the students whose LPs leaned toward AE on the AE/RO continuum exhibited better ability and performance in the overall team design (Figure. 4).

These findings contradicted most studies reflecting on the influence of students' LPs and learning styles on their performance in individual design. Previous research (Carmel-Gilfilen, 2012; Kvan & Jia, 2005; Marriot, 2003; Tezel & Casakin, 2010; Karimi Moshaver, 2012; Karvan, 2021) had typically highlighted the possibility of success in students with assimilating and diverging learning styles, often in the eastern axis of the learning cycle grid. Kolb & Kollb (2005) further introduced architecture students as learners with an assimilating learning style, demonstrating the correlation between the design students' performance in the individual design and the AE/RO BLPs. From this perspective, the more the students' LPs were toward RO, the more successful they were. This inconsistency with the research findings showed to a large extent why most students had been successful in their studies in the field of design by doing individual projects, but they might lose their proper performance as they enter the labor market and start their careers due to the team-based nature of the projects.

Knowing the strengths and weaknesses of each student with different LPs in team design and its dimensions (viz., content and process) is thus of utmost importance for teachers and students (Coffield et al., 2004). In this way, teams can be created with the right composition of members, who can help each other learn to design and reinforce the collaborative spirit (Yazici, 2005). In addition, teachers can use the characteristics shaped by LPs to choose their instructional policies to strengthen their students in the areas where they feel the extra effort is required (Cools et al., 2009). Moreover, students can better understand such discrepancies by recognizing and comparing their differences with others in terms of thinking and acting (Sharp, 1998). For this purpose, respecting abilities and all LPs, establishing effective communication with design team members, and resolving conflicts, thereby improving better understanding, empathy, and interactions in the design team, need to be facilitated (Kyprianidou et al., 2012; Tucker et al., 2014, 87).

CONCLUSION

In this study, the analysis of the team design performance was done through conceptual design tasks as teams in architectural design studios and students' S&PA in both dimensions of team design content and process, which showed that the students' LPs had an impact on their ability and performance in both content and process dimensions and overall team design performance. It was also established that the student's overall team design performance and their ability in both dimensions could be predicted to a great extent by their LPs in the AE/RO BLPs, concerned with the student's ability to receive/perceive information and in the AC/CE BLPs, associated with the abilities to process/internalize information.

Based on the study findings, it is predicted that students who prefer to receive/perceive information by abstract conceptualization and process/internalize it by active experimentation will exhibit better ability in the team design content dimension, and those who choose to receive/perceive information by concrete experience and process/internalize it by active experimentation will have greater ability in team design process dimension. Considering the impact of both dimensions (namely, content and process) and their effectiveness ratio on the overall team design, it is concluded that students who wish to process/internalize information by active experimentation will exhibit better team design ability.

Therefore, by knowing students' learning preferences and using the findings of this study, instructors can predict students' abilities and skills in the content and process of team design. Identifying and predicting learners' abilities can help design studio teachers devise TDT programs consisting of specific measures to improve their learning indicators in the team design content and process dimensions according to their characteristics.

In general, there were several limitations facing this study. The present study was based on two team design tasks in four studios at two universities, so the generalizability of the findings using the data from several other educational centers is desirable. The study results were also obtained based on S&PA. Thus, other methods or combinations can be examined to report more accurate results. This study was conducted in architectural design studios, but the results should be tested for design studios in other fields. In addition, there might be cultural differences affecting the students' LPs or even the way they view collaboration. Therefore, it is suggested to perform the same studies in different countries.

Future studies can further investigate other factors along with LPs, such as team design and diversity in design teams, to accurately identify and predict learners' performance in team design. The effects of such factors on students' ability with different LPs should be addressed. Besides, necessary practical solutions based on the conditions of architectural design studios should be developed to improve the weaknesses of students with different LPs.

AUTHOR CONTRIBUTIONS

B. Khorshidi designed the study, performed the literature review and collected initial data, analyzed and interpreted the data, and prepared the manuscript text and edition. O. Dezhdar and S. Haghighi Contributed to the research conceptual framework, controlled tasks, and provided good advice throughout the paper; they supervised the whole work and led the research in general. All authors have read and approved the final manuscript.

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CONFLICT OF INTERESt

The authors declare no potential conflict of interest regarding the publication of this work. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication or falsification, double publication and, or submission, and redundancy, have been completely witnessed by the authors.

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