Focus on architectural design process through learning styles

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Learning as an interactive process is an important issue in architectural design education. This study aims to focus on architectural design process through learning styles that are 'accommodating', 'diverging', 'assimilating' and 'converging' as stated in the Experiential Learning Theory of Kolb. A research was conducted to evaluate the effects of learning style preferences on the performance of design students in a design process. It was found that there were statistically significant differences between the performance scores of students having diverse learning styles at various stages of design process. Also, it was found that performance scores of all students having different learning styles had increased at the end of the design process where the progress of assimilating learners were the highest and accommodating learners the lowest.

Keywords: Architectural design, Design process, Design education, Learning styles

In architectural design education, the curriculum should be structured to facilitate and advance student learning. The programme must provide courses to be interrelated and reinforced throughout the curriculum. In general, the architectural curriculum is composed of fundamental courses that develop design knowledge; technology based courses that develop scientific formation of architecture; artistic based courses for strengthening architectural expression; and, finally the design courses, being a combination of the former three and constitute the most crucial part of design education. The design studio where the design courses are conducted is an environment that is different to a traditional classroom from pedagogical, sociological, ideological and epistemological points of view[1]. Most of the recent studies on architectural design education and the design studio are based on computer-aided design or distant learning[1–7]. Some other studies

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deal with the design studio as an environment or with the process within the studio[8–21] but unfortunately, there are few studies on learning styles of designers.

Based on an empirical study on practising architects, in the context of improving design information transfer Newland et al.[22] identified four kinds of design learners that are mapped directly onto Kolb's typology. Durling et al.[23] investigated the cognitive styles of art-based design students and concluded that there is a match between teaching and learning in UK design schools using Myers–Briggs-type indicator as a tool for the assessment of learning styles. Ashton[24] explored the interaction between students in the design studio and pointed out its importance in learning experience.

This study aims to consider architectural design activity through studio process in the scope of learning styles as a new perspective. It is claimed that there is an experiential learning process in design education within the studio environment from the very beginning to the end of any design problem. So, it is hypothesised that different stages of design studio learning require different learning styles or in other words, the performance scores of students having different learning styles vary according to the content of various stages of studio process. Therefore, design education could be considered through the Experiential Learning Theory of Kolb[25,26]. In this study, the effects of learning preferences are also considered according to different learning activities within the studio process.

1 Architectural design studio

The design studio should function both as a learning centre and a complex social organisation like other learning environments[27]. Teymur[28] described design studios as places where real cities, buildings etc., are designed, improved and transformed. In design education, design studios are the places in which the simulation of the real situation occurs[29]. Design studio process is quite important in design education since it is the core of the curriculum and all the courses taught in design eduction are related to the design studio[17,29,30]. The design studio is concerned with the definition of design education, its' problems, relations and contents at sociological level and its relation to other disciplines at epistemological level.

The critique process that held in a design studio is not only a lecture given, but also a social interaction between the teacher and the students and among the students. In a way, communication is a key word in defining the design studio. As Wender and Roger[20] claimed, the significant component of a design studio in architectural education is the verbal interaction

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17 Uluoğlu, B Mimari tasarım eğitimi: Tasarım bilgisi bağlamında stüdyo eleştirileri Ph D. Thesis. Istanbul Teknik Üniversitesi, Istanbul (1990)

18 Uluoğlu, B 'Representation of design knowledge in studio critiques' in **Ö Akın and G Sağlamer** (eds) *Descriptive Models*

between the occupants (student to student, student to teacher). Also, Ashton[31] claimed that the interaction between student and teacher is very important for students' learning experience and she added that " If the crits reduced their focus on the artifact, students might be encouraged to talk about what they learned" (p. 68).

It can be stated that the treatment of theoretical issues and the preparation of the architecture student for the world of practice are structured by the human relationships set up within this space[32]. The design studio is concerned with the relations of design education with design practice at ideological level. Design studio offers an atmosphere that is conducive to a free exchange of ideas[33] through an information processing which may be considered as an organisational and social process[34] for both the students and the instructors. Design serves as a mediator between mental activity (invention) and social activity (realisation)[35]. It is an open-ended process of problem solving, and design theory functions as an instrument theory that supports the cognitive abilities of the designer[36]. In solving the design problem, the extent of the experience of the designer is more important than the facts and rules[37]. This is a factor that can only be achieved through time and the design studio in architectural education is the first place that the candidate of the profession can get his/her first experience in the profession.

Consequently, the role of the design studio can be considered with three steps: (a) learn and practice some new skills, say, visualisation and representation; (b) learn and practise a new language as Schön[15] described design as a graphic and verbal language; (c) learn to 'think architecturally'[12] as Ledewitz explained as the "way of thinking" referring "to a particular domain of problems and solutions that characterize, and are fundamental to, professional performance" (p. 2). The educational experience in the design studio covers these three stages at the same time in relation with each other. So, the organisation of necessary knowledge and the ways of presenting this knowledge that is accessible to every student by design instructors are the important factors in the design studio at epistemological level. The design studio is concerned with various learning paradigms at pedagogical level.

Each design instructor has his/her strategy while communicating with the student. Some prefer telling and others prefer demonstrating. Actually, most design instructors prefer both. Thus it can be said in the design studio, design instructors' telling and showing are interwoven, as are the students' listening and imitating. Each process can help to fill the communication gap inheritant in the other. Schön[15,16] proposed referring to all of these

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29 Demirbaş, Ö O. The relation of learning styles and performance scores of the students in interior architecture education. PhD thesis Bilkent University, Ankara (2001).

means of communication as reflection-in-action. The student reflects on the action of the instructor and the instructor reflects on the action of the student. These mutual reflection activities form the critique process. In this sense, understanding the learning process of design students is critical for the design instructor for better teaching.

2 Learning

2.1 Learning process

Educational leaders nowadays recognise that the process of learning is critically important and the way individuals learn is the key for an educational improvement[38,39]. An individual's preferred method for receiving information in any learning environment is the learning style of that individual[40]. Learning can be defined as an internal process that is different for every individual and learning style can be described as the way individuals acquire new information. Fox and Bartholomae[41] described learning styles as a biological and developmental set of personal characteristics that is defined by the way individuals process information. Each learner's preferred ways of perception, organisation and retention of new information are distinctive and consistent[42,43]. It is possible to find different studies on learning styles in the literature. Most frequently used learning style models are the Myers–Briggs-type indicator (MBTI), Hertmann Brain Dominance Instrument (HBDI), Felder–Silverman Learning Style Model and Kolb's Learning Style Inventory (LSI)[44]. Although all the styles classify different learning types in different manners, their aim and approach are similar. Felder[44] claimed that since the instructional approaches around the cycle of the models are essentially identical, it is not important which model has been chosen. In this study, LSI 2, which is the revised version of Kolb's Learning Style Inventory is used as an instrument for figuring out learning styles since it was tested many times.

2.2 Experiential learning theory

Experiential learning theory considers learning as a cycle that begins with experience, continues with reflection and later leads to action that becomes a concrete experience for reflection[25,45]. There are four stages of experiential learning model (see Fig. 1) [30]. According to this circular process, concrete experience is followed by observation and reflection; this leads to the formulation of abstract concepts and generalisations, and later the implications of concepts in new situations are tested through active experimentation[25,26].

Willcoxson and Prosser[46] stated that the four learning modes of Kolb's Experiential Learning Theory form two bipolar learning dimensions as

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33 **Tate, A** The Making of Interiors: An Introduction Harper & Row, New York (1987)
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40 **Kraus, L A, Reed, W M and Fitzgerald, G E** 'The effects of learning style and hypermedia prior experience on behavioral disorders knowledge and time on

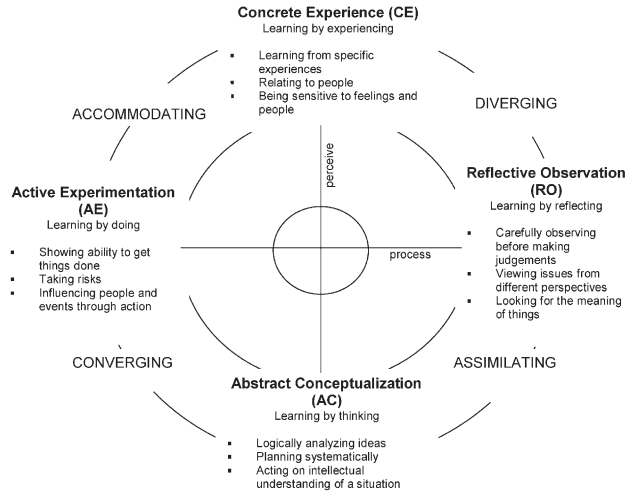

Figure 1 Four learning modes of Experiential Learning Theory.

concrete/abstract (the perceiving axis in Fig. 1) and active/reflective (the processing axis in Fig. 1). From a hypothetical point of view, any learner would consciously move through all the modes of the learning cycle[25,26,46,47]. Nevertheless, most of the practical experiences and researches on the subject showed that not all the learners equally experience each stage of this cycle. The preferences of learners among the stages of the cycle do not make them better or worse learners. Each individual has a preferred learning style resulting from the tendency to either learn through experiencing called concrete experience (CE) or through the construction of theoretical frameworks that is abstract conceptualisation (AC) combined with the tendency to either learn by doing through active experimentation (AE) or through reflection by reflective observation (RO).

2.3 *Learning styles inventory (LSI)*

Kolb sugessted that an individual learner's style may be identified by assessing her/his position on each of the bipolar dimensions by using a test called learning styles inventory (LSI)[25]. There are 12 open-ended questions that have four different alternative responses in LSI. Each question asks respondents to rank-order four sentence endings in a way that best describe their learning preference in any learning setting. After answering all 12 questions, by using the key of the test, four scores are calculated. These scores are clustered under four modes of the learning cycle as CE, RO, AC, and AE. In the next stage, by subtracting CE from AC and RO from AE scores two combined scores are found out. These combined scores show the position of the individual learner in the two bipolar scales. More specifically, they refer to the major different ways by which students learn: the first (AC–CE) is 'how a student perceives' new information or experi-

task: A case-based hypermedia environment' *Computers in Human Behavior* Vol 17 No 1 (2001) 125–140
41 Fox, J and Batholomae, S 'Student learning style and educational outcomes: Evidence from a family financial management course' *Financial Services Review* Vol 8 No 4 (1999) 235–251
42 Chou, H W and Wang, T B 'The influence of learning style and training method on self-efficacy and learning performance in WWW homepage design training' *International Journal of Information Management* Vol 20 No 6 (2000) 455–472
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45 Rogers, C Experiential learning TIP: Theories. Retrieved from http://www.gwu.edu/~tip/rogers.html (16 March 1999).
46 Willcoxson, L and Prosser, M 'Kolb's learning style inventory (1985): review and further study of validity and reliability' *British Journal of Educational Psychology* Vol 66 (1996) 251–261
47 Learning to Learn IMC tutors guide. Retrieved from http://www.mcb.co.uk/services/courseware/tutguide/tut-003.html (17 March 1999).

ence, and the second (AE–RO) is 'how a student processes what s/he perceives'. In other words, these combined scores give the learning style preference of that individual[48].

The learning style preferences resulting from the two bipolar scales of the learning cycle were described by Kolb[25] as accommodating (AE/CE), divergent (CE/RO), assimilating (RO/AC) and convergent (AC/AE). These four different learning styles were labelled according to the individuals' preferred information perceiving and processing modes. In other words, the place of any individual both in the vertical and horizontal axis represents the exact learning style of that individual. Each learning style has its own strengths and weaknesses but that does not mean that one is better than the other.

Accommodating learners are best at CE and AE, the greatest interest of accommodating learners lies in doing things[25,26]. As Hsu stated[43] accommodating learners grasp their environments concretely through their feelings and utilize action to transform information obtained. Accommodating learners are risk-takers and they enjoy seeking out new experiences. This kind of learners tends to solve problems in an intuitive, trial-and-error manner and instead of their own analytic ability, they rely on others for information[25,26,43].

Diverging learners are best at CE and RO. This kind of learners are interested in people and tend to be imaginative and emotional[26]. As Hsu[43] proposed, diverging learners have the ability to synthesize and/or assimilate a wide-range of totally different observations into a comprehensive explanation that enables them to generate many ideas. They are less concerned with theories and generalisations. Their approach to situations is in a less thoughtful, systematic or scientific way, therefore their abilities to make decisions are inhibited.

Assimilating learners have the opposite learning strengths of accommodating learners. Their dominant learning abilities are AC and RO. Assimilating learners' experience their world symbolically and transform it to information through thought. They are less interested in people and more concerned with abstract concepts, but are less concerned with the practical use of theories[26]. It is more important for assimilating learners that the theory is logically sound and precise.

Converging learners have opposite learning strengths of the diverging learners. The dominant learning abilities for converging learners are AC and AE. Hsu[43] stated that converging learners bring a logical, pragmatic and

48 **Kolb, D A** Learning Style Inventory Hay/McBer, Boston (1999)

unemotional perspective to any situation. Converging learners are more concerned with the relative truth than absolute truth. The knowledge of converging learners is organised, so that through hypothetical-deductive reasoning, they can focus their knowledge on specific problem[26]. According to Smith and Kolb's[26] description, converging learners are unemotional and prefer to deal with things rather than people.

In this study, design education is considered through experiential learning theory, since students are facing different learning situations and experiencing different learning modes through a critique process. The effects of different learning preferences of LSI (accommodating, diverging, assimilating and converging) are considered according to the various learning activities within the studio process. It is aimed to find out the effects of different learning styles in various stages of design studio education through a design experiment.

3 *Empirical research*

3.1 *Participants*

The sample is comprised of 2000–2001 academic year freshman students of the Department of Interior Architecture and Environmental Design at Bilkent University, Turkey. The reason for selecting the first-year students is that the profession has not yet affected their learning styles. There were 88 subjects whose age range was between 17 to 25 in the sample group. The mean age was 20.14 and the standard deviation was 1.60. There were 51 (58%) males and 37 (42%) females. Participation was on a voluntary basis and the research was conducted through a studio course. Participants were informed individually about their learning style preferences at the end of the research.

3.2 *Design experiment*

3.2.1 *LSI*

Firstly, the learning styles of the freshman design students were determined by using the Learning Styles Inventory test version 3 (LSI) of Kolb[26,48]. According to the LSI test, concrete experience (CE), reflective observation (RO), abstract conceptualisation (AC) and active experimentation (AE) scores of each participant were established. After this process, by subtracting each student's CE scores from AC scores and RO scores from AE scores, the exact learning styles of the participants were established as accommodating, diverging, assimilating and converging.

3.2.2 Design problem

3.2.2.1 Stage 1: The research and the report

The first stage consisted of two steps. In the first step, the students were to conduct research on staircases as homework. They were free to use any method in collecting information for their research. The content of this research was to identify the description of a staircase with the functional requirements, list the structural components of staircases and present some visual examples. They could acquire knowledge from various sources such as books, periodicals or the Internet, observe the realised staircases or interview some experts. Also, they could use combinations of these sources. After this step, they had to prepare a report on the conducted research. The students had 1 week to conduct the research and submit the research report.

3.2.2.2 Stage 2: The lecture and the first studiowork

The second stage also consisted of two steps; namely, a lecture and a drawing exercise on staircases. This stage was conducted within 4 h time in a studiowork session. The first step was a lecture on staircases that was conducted by the instructor in 60 min. In this step, all the expected information that had to be acquired in the first stage was discussed. In addition, the technical drawing rules related to drawing staircase were taught. After a 15-min break, the second step of the second stage lasted for 180 min. Although this stage was realised through two steps, the second step was used to obtain the performance outcomes. In this step, the students were given the orthographic plans and sections of a three-storey house and asked to design and locate a staircase that would provide the vertical circulation for the given house project. They were free to design an L-type, U-type or wide U-type staircase within the limits of given requirements. After this decision process, the students were asked to draw the orthographic views (three plans from three different floor levels and one section) of the designed staircase at 1/50 scale (Fig. 2). At the end of the studio session, the student works were collected and assessed for the performance outcomes of this stage.

3.2.2.3 Stage 3: The model

The third stage of the study was making a model of a staircase at 1/20 scale. Students were asked to build up a model of their staircase that they had designed and drawn in stage 2 as homework. So the model was the performance outcome of the third stage (Fig. 3).

3.2.2.4 Stage 4: The second studiowork

After these three stages, it was assumed that the students had learned all the necessary information on staircases and about drawing a staircase through

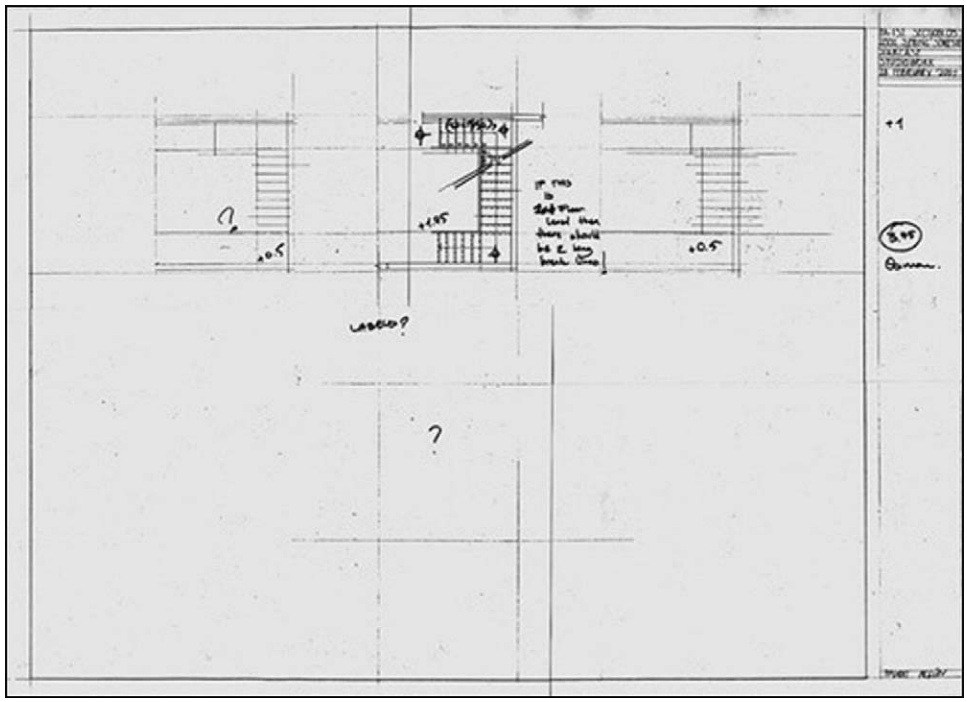

Figure 2 Product of stage 2 (first studiowork exercise of student no. 25).

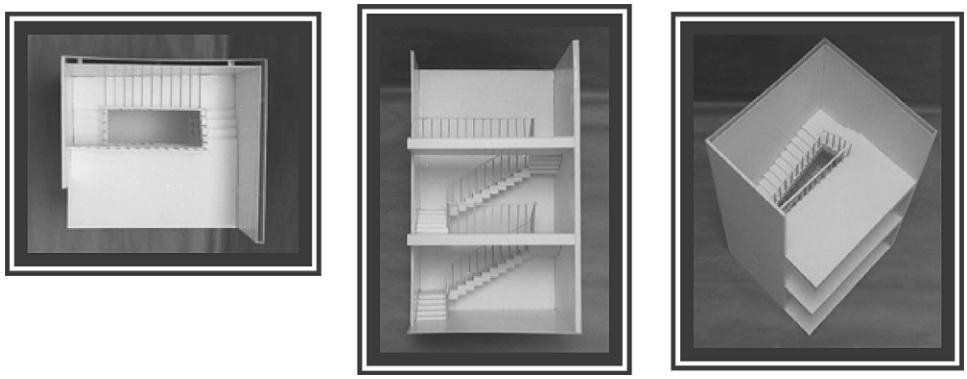

Figure 3 Product of stage 3 (three-dimensional model exercise of student no. 25).

experiencing different learning modes. In this stage, the students were asked to do the orthographic drawings (three plans from three different floor levels and one section) of the staircase that they had designed, drawn and built up a model in the previous two stages, during the studiowork

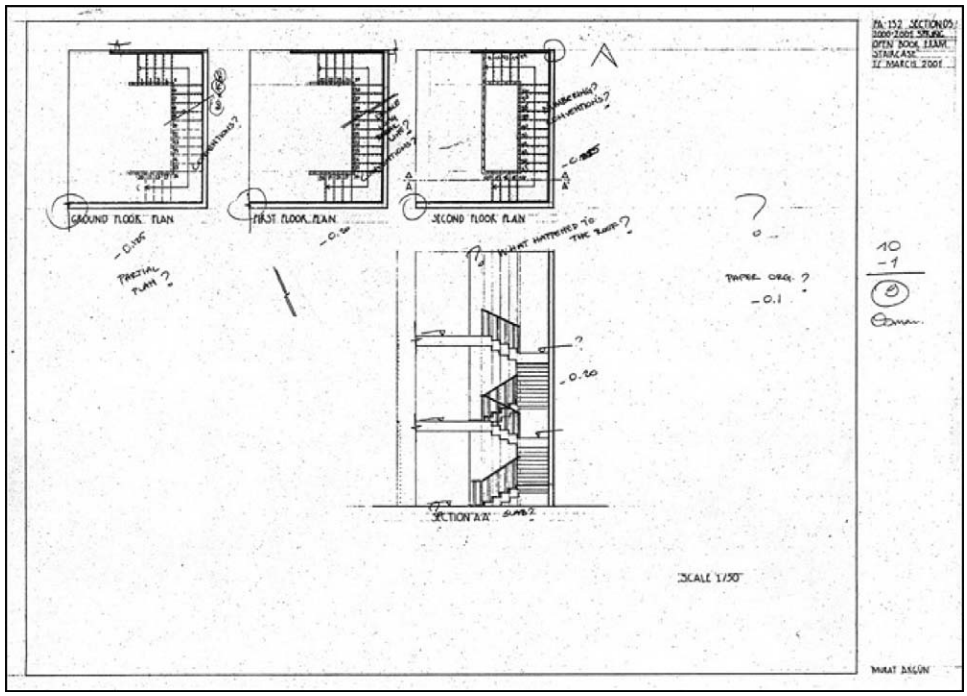

Figure 4 Product of stage 4 (second studiowork exercise of student no. 25).

session that lasted for 180 min at 1/50 scale (Fig. 4). At the end of this stage, the student drawings were collected and evaluated as the performance outcomes.

3.2.3 *Assessment instruments*

The products of each stage (research file for the first stage, drawings for the second and fourth stages and model for the third stage) were collected from the students as the assessment materials. The assessments were more focused on the products than the process. According to the requirements of each stage a different scoring instrument was designed for the performance assessment of students' works[49.50].

For the first stage which was conducting a research on the topic and preparing a research file, a 'scoring rubric' was designed (Appendix 1). In the report, it was expected that the description of staircase would be done clearly, the components listed and some visual examples of different staircase types presented. The presentation quality of the research report itself was another factor in considering the performance outcomes of this stage. The 'scoring rubric' was designed that had four scales and for each item a score was given between 3 to 1 (excellent, average or poor) according

49 **Gronlund, N E** Assessment of Student Achievement Allyn and Bacon, Boston (1998)
50 **Haladyna, T M** Writing Test Items to Evaluate Higher Order Thinking Allyn and Bacon, Boston (1997)

to the quality of it and 0 for incomplete. The sum of the scores of four items defined the overall assessment of stage 1.

Since the requirements of the second and fourth stages were similar, the same instrument was used while assessing these two stages. A 'rating scale' was designed for these two stages (Appendix 2). The products of these stages were assessed under three item headings; correctness of the staircase (design features), application of technical drawing rules (technical drawing features) and presentation quality (artistic features). Each item was assessed through some sub-items for each drawing work (first plan, second plan, third plan and section). So, if one drawing was not present, the sub-items were also not considered for that drawing piece. The sub-items of correctness of the staircase and technical drawing rules were assessed through a three-scaled rating as correct to incorrect and in case of an absence of a sub-item '0' was added. Another three-scaled rating (good to bad) was designed for presentation quality of the products. The sum of these three scores gave the overall score out of 180 for the existing exercise.

The third stage was a take-home exercise where students were asked to build up a model of the staircase designed in stage 2. The model was the product for the performance assessment of this stage (Appendix 3). For the assessment of this stage besides constructing a properly functioning staircase, material selection and craftsmanship were also considered. Through the 'checklist', the sub-items of completeness were assessed as complete or incomplete. Correctness of the model was assessed through either correct or incorrect. The specified sub-items were given '1' if correct and '0' if incorrect. The sub-items of craftsmanship were assessed through either good or bad. In the overall, students were graded out of 20 by the help of this 'checklist'.

4 *Results and discussion*

4.1 *Learning style characteristics of the sample group*

According to the results of LSI test, the distribution of the subjects in the four learning styles was determined. The number of accommodating students was lower than the other learning style preferences, where most of the students' learning style preferences were converging and assimilating (Fig. 5).

4.2 *Reliability and Pearson correlations in LSI*

Cronbach alpha reliability of the Learning Style Inventory is depicted in Table 1. The alpha scores are quite satisfactory since the participants of the existing study had a very constant profile as being freshman design

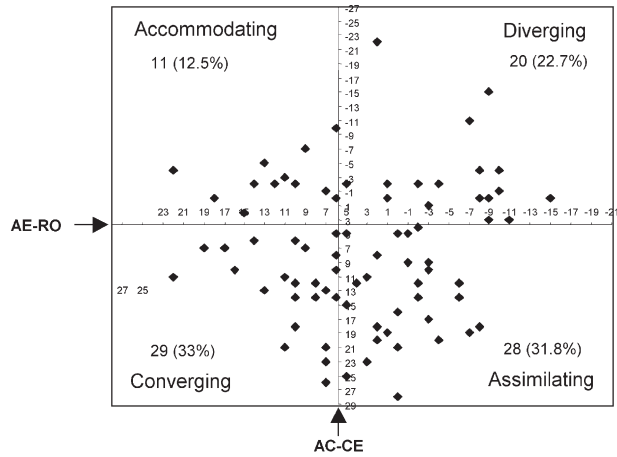

Figure 5 The distribution of the sample through the learning styles.

Table 1 The reliability scores

	Cronbach's standardized scale alpha
Concrete experience (CE)	0.70
Reflective observation (RO)	0.62
Abstract conceptualism (AC)	0.70
Active experimentation (AE)	0.63
Abstract–Concrete (AC–CE)	0.73
Active–Reflective (AE–RO)	0.57

students, with a small age range, and sample size. The lower percentages of accommodating and diverging styles (see Fig. 5) in the sample might be the reason of decreasing the reliability scores of RO and AE scales.

Table 2 represents the correlation between the four learning styles and two combined scores. The highest correlation score was noticed between the

Table 2 Pearson correlations among learning modes and combined scores

	CE	RO	AC	AE	AC–CE	AE–RO
CE	1.000					
RO	−0.29[a]	1.000				
AC	−0.38[a]	−0.43[a]	1.000			
AE	−0.40[a]	−0.16	−0.29[a]	1.000		
AC-CE	−0.82[a]	−0.10	0.84[a]	0.06	1.000	
AE-RO	−0.08	−0.76[a]	0.09	0.76[a]	0.10	1.000

[a] Correlation is significant at the 0.01 level (two-tailed).

correlation on AC to AC–CE as 0.84. This correlation showed that when abstract conceptualisation score is high, learning activity on the vertical axis of learning cycle shifts towards learning by thinking (see Fig. 1). All the subjects of this study were design students, so there may be the effect of concept formation in the design discipline for this positive correlation between AC with AC–CE. The Pearson correlation table shows that while AC has a positive correlation between AC–CE, CE has a negative correlation with AC–CE. According to these scores neither AC nor CE had a correlation with AE-RO.

4.3 *Validity of performance scores*

For the validity of performance scores, instead of using the assessments of a single instructor, the raw average scores of two studio instructors' assessments were considered. Two instructors assessed and graded each student's works independently; thus the possibility of affecting each other while grading the products was eliminated. After both of the instructors finished the assessment of all students' products for each stage of the design experiment, the raw averages of the two scores were calculated for the final performance score. It was hypothesised that there would not be a significant difference between the assessments of two instructors. To control this, the means and standard deviations of the scores given by two instructors for the products of each stage of the design experiment were calculated and *t*-tests were conducted. The *t*-tests for each stage did not indicate any statistically significant difference between instructors, and the correlation coefficients showed a high inter-rater reliability for the performance assessments in stages 1 to 4 (0.98, 0.98, 0.87 and 0.91, respectively).

4.4 *Related to learning styles versus performance scores*

The response rate was very low for stage 1. Out of 88 students, the products of 47 (53.4%) students were incomplete. 17 (19.3%9) products were excellent, 15 (17%) were average and nine (10.2%) were poor. No statistical evidence was found that different learning styles were affecting the performance scores of stage 1 through analysis of variance test. The main reason of this result is assumed to be the low response rate for this stage due to their lack of research habit in their high school years.

The analysis of variance (ANOVA) tests were conducted in order to find out if the learning styles had any effect on the performance scores in different stages (stage 2, stage 3 and stage 4) of the design experiment. The ANOVA showed that there are statistically significant mean differences across learning styles in the performance scores of stage 2 ($F_{stage\ 2}$ = 3.08, df = 3, 84, p = 0.032, η^2 = 0.099) and stage 3 ($F_{stage\ 3}$ = 12.38, df = 3, 84, p = 0.001, η^2 = 0.307), but not in stage 4 ($F_{stage\ 4}$ = 1.90, df = 3, 84, p = 0.136, η^2 = 0.063).

Table 3 Means and standard deviations of stage 2, 3 and 4

Learning styles	Stage 2		Stage 3		Stage 4		N
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	
Accommodating	83.91	22.29	11.27	2.37	122.27	21.23	11
Diverging	69.00	26.70	11.00	3.06	121.75	23.40	20
Assimilating	58.18	24.05	15.14	2.01	126.57	19.83	28
Converging	71.07	25.58	11.97	2.99	133.97	15.71	29
Total	68.10	25.87	12.67	3.14	127.38	19.95	88

4.5 *Related to learning styles in multiple comparisons*

Since there are four different learning styles, in order to determine the learning style that differs significantly, multiple comparison tests were handled for each stage. The Bonferroni test[51] indicated that only in stage 2 the accommodating students differed from the assimilating students ($p = 0.029$), but no other significant difference was found. In stage 3, the assimilating students differed from the accommodating students ($p = 0.001$), the diverging students ($p = 0.001$) and the converging students ($p = 0.001$). No significant differences were found between the means of four learning styles for stage 4. Table 3 shows the means and standard deviations of the performance scores of four learning styles in all three stages.

In stage 2, the mean for the accommodating students was considerably high compared to others. The accommodating learners combine the learning steps of AE (learning by doing) and CE (learning by experiencing), they have the ability to learn primarily from 'hands-on' experience. Since the product of stage 2 was a drawing exercise and it was just handled after a lecture about the topic, this result sounds logical.

In stage 3, the mean of the assimilating students was the highest and as Bonferroni test results showed it differed from all other three learning styles in stage 3. It could be concluded that the assimilating students were the best in the performance scores of stage 3. Since assimilating learners combine learning steps of RO (learning by reflecting) and AC (learning by thinking), people of this style are more interested in abstract ideas and concepts. The exercise in stage 3 was the construction of a three-dimensional model of the designed staircase; in other words it was an abstraction of a real staircase. This might be the reason of this result, although it was expected that the mean of converging students would be the highest in stage 3, since the converging style is dealing more with abstract concep-

51 **Howitt, D and Cramer, D** A Guide to Computing Statistics with SPSS for Windows Pearson Education Limited, Harlow (1999)

tualisation and active experimentation. In other words people in this style prefer simulations and practical applications.

4.6 Related to repeated measures

For all learning styles, it was expected that there should be an increase in the performance grades from stage 2 to stage 4, since the exercise in stage 4 was the repetition of stage 2, and the students had gained experience and knowledge in stage 2 and stage 3. So, in order to verify this hypothesis a correlated *t*-test was done to find out the difference between the average scores of these two stages. The mean performance score of stage 2 (M = 68.10) and stage 4 (M = 127.38) differed statistically significantly ($t = -21.807$, $df = 87$, two tailed $p < 0.001$). The mean difference was 59.28 and the 95% confidence interval for this difference was 53.36 to 64.07.

Since the assignments of stages 2 and 4 were similar and correlated, the analysis of variance tests for repeated measures was also done through the consideration of learning styles. The one way correlated analysis of variance showed that there was a statistically significant mean difference for the two stages ($F = 418.28$, $df = 1, 84$, $p = 0.001$, $\eta^2 = 0.833$) and also the interaction between the learning styles and performance scores changes over stages were statistically significant ($F = 4.98$, $df = 3, 84$, $p = 0.003$, $\eta^2 = 0.151$).

The estimated marginal means that show the progress in the performance scores of the students who belonged to four different learning styles through stage 2 to stage 4 are presented in Fig. 6. As seen in the figure, although there was considerable progress in the performance scores for all learning styles, the progress of the accommodating students was different from the students of other learning styles.

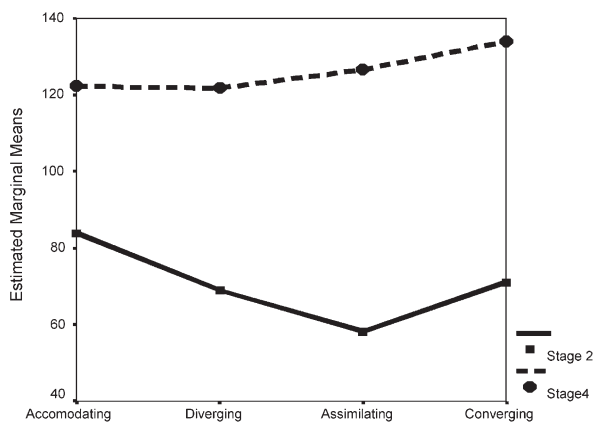

Figure 6 The estimated marginal means of four learning styles through stage 2 to stage 4.

5 *Conclusion*

In the design experiment, stages that had different learning processes were devised for testing the effects of different learning styles on the performances of students. It was found that, different learning styles were effective on the performance scores of students in different stages of a design problem through the studio process.

As a conclusion, these results provided a sound basis for the hypothesis that there is a relation between learning style types and different stages of the design process. At the end of the design process, it is found that performance scores of all students having different learning styles increased. When learning style types are considered separately, it is noticed that assimilating learners had the highest progress where the increase in the performance scores of accommodating learners were the lowest, although accommodating learners have been the most successful ones in the first studiowork. In this empirical study, it is concluded that there is a shift from learning by experiencing (CE) and learning by doing (AE) to learning by reflecting (RO) and learning by thinking (AC).

Since design is regarded as a combination of crafts, technologies and other disciplines, its education contains all of the stages of the experiential learning cycle. In other words, all of the four learning styles occur in the design studio process. Thus, instead of concluding that any one of the four learning styles is more suitable for design education, it is better to claim that different stages of design education should be associated with different learning styles. Learning in an architectural design studio depends upon the communication of creative ideas and the fit between the way of instructions and the learning styles of the students. The key for an effective learning is to understand the range of learners' styles and to design the instructions in a way that they respond the learning needs of all individuals.

Appendix 1.

See Appendix Table 1

Appendix 2.

See Appendix Table 2

Appendix 3.

See Appendix Table 3

Appendix Table 1 Scoring rubric for stage 1

	Excellent (3)	Average (2)	Poor (1)	Incomplete (0)
Description of staircase and functional requirements	Completely accurate	Somewhat accurate	Inaccurate	No description
Listing the architectural components	All listed (min. 6 components)	Most listed (5–3 components)	Some listed (2–1 components)	No list
Presence visual examples	Satisfying (3 different types)	All acceptable (2 different types)	Not enough (only one type)	No example
Presentation quality	Excellent	Average	Poor	No presentation
Total score				

Appendix Table 2 Rating scale for stages 2 and 4

	First plan				Second plan				Third plan				Section				Total
Corr. of the staircase	C	PC	I	ND	C	PC	I	ND	C	PC	I	ND	C	PC	I	ND	DF
Tread width	3	2	1	0	3	2	1	0	3	2	1	0	3	2	1	0	
Total run	3	2	1	0	3	2	1	0	3	2	1	0	3	2	1	0	
Riser height	–	–	–	–	–	–	–	–	–	–	–	–	3	2	1	0	
Total rise	–	–	–	–	–	–	–	–	–	–	–	–	3	2	1	0	
Nosing	3	2	1	0	3	2	1	0	3	2	1	0	3	2	1	0	
Handrail	3	2	1	0	3	2	1	0	3	2	1	0	3	2	1	0	
Balustrade	–	–	–	–	–	–	–	–	–	–	–	–	3	2	1	0	
String	–	–	–	–	–	–	–	–	–	–	–	–	3	2	1	0	
Tech. drawing rules	C	PC	I	ND	C	PC	I	ND	C	PC	I	ND	C	PC	I	ND	TDF
Drawing label	3	2	1	0	3	2	1	0	3	2	1	0	3	2	1	0	
Level diff. signs	3	2	1	0	3	2	1	0	3	2	1	0	3	2	1	0	
Climbing dir. arrow	3	2	1	0	3	2	1	0	3	2	1	0	–	–	–	–	
Staircase numbering	3	2	1	0	3	2	1	0	3	2	1	0	–	–	–	–	
Staircase convention	3	2	1	0	3	2	1	0	3	2	1	0	–	–	–	–	
Long break line	3	2	1	0	3	2	1	0	3	2	1	0	–	–	–	–	

(*continued on next page*)

Appendix Table 2 Rating scale for stages 2 and 4 (*Continued*)

	First plan				Second plan				Third plan				Section				Total
Presentation quality	G	F	B	ND	G	F	B	ND	G	F	B	ND	G	F	B	ND	AF
Line type	3	2	1	0	3	2	1	0	3	2	1	0	3	2	1	0	
Line quality	3	2	1	0	3	2	1	0	3	2	1	0	3	2	1	0	
Scale	3	2	1	0	3	2	1	0	3	2	1	0	3	2	1	0	
Neatness	3	2	1	0	3	2	1	0	3	2	1	0	3	2	1	0	
Lettering	3	2	1	0	3	2	1	0	3	2	1	0	3	2	1	0	
Total score																	

–, non-applicable issue, 0, if related view is not drawn. c: Correct; PC: partially correct; I: incorrect; ND: not drawn; G: good; F: fair; B: bad.

Appendix Table 3 Checklist for stage 3

Completeness		Complete	Incomplete
Structural elements	Walls	1	0
	Ground floor	1	0
	First floor	1	0
	Second floor	1	0
Vertical connection	First staircase	1	0
	Second staircase	1	0
Stair components	Handrail	1	0
	Balustrade	1	0
	Slab thickness	1	0
	String	1	0
	Nosing	1	0
Correctness		**Correct**	**Incorrect**
	Staircases	1	0
	Tread width	1	0
	Riser height	1	0
	Handrail	1	0
	Balustrade	1	0
	String	1	0
Craftsmanship		**Good**	**Bad**
	Landings	1	0
	Cutting and fixing	1	0
	Stability	1	0
Total score:			