

Sustainable Architectural Design Education: An Improved Experimental Method in a 3rd Year Design Studio

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Abstract

The design studio is a unique class format within the architectural curriculum education, in which learning is based on student-instructor interaction and learning by experiences while architectural design is the collective of knowledge and skills to accomplish a unique expectation of a product. Sustainable design has been incorporated into many architecture curriculum education programs but there has been lack of merging in design studio project. This study introduces an improved method of the first experimental Sustainable Architectural Design Studio (SADS) with restructured teaching tools for integrating sustainability principles in design studio along with the studio outcome. In additional, it presents the evaluation and the assessment of the improved method as well as the finding along with the recommendations for the future experimental.

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Keywords

Architectural education; Design studio pedagogy; Sustainability.

1. Introduction

Architecture plays a major role in providing basic human needs for shelter. The challenge for modern architects is to incorporate the principles of sustainability into their designs, without compromising their utility or style. This will require a fundamental reorientation of architectural education to emphasize the conservation of energy and natural resources in new and existing buildings and facilities (Taleghani, Ansari, & Jennings, 2011). Architectural education has a special core subject, which is the design. The reorientation of architectural education consists of three categories. The first includes basic courses in the liberal arts such as humanities, social science and creative arts. The second includes technical courses covering important aspects of architectural design such as materials and construction, building structures and environmental control systems, and the third consists of learning through practicing design, i.e. “apprenticeship” in the architecture studio, which is the special core subject in architectural education.

Design is known as a complex and multi-dimensional activity that embody various skills and tendency such as communication, interpretation, research, knowledge integration, and problem-framing (Kahvecioglu, 2007). Meanwhile, Design studio is a place where designs is making under the periodic guidance of the design instructor who intervenes in the student's designing, generally in reaction to the student's explicit design (Oxman, 1999). Design studio as a special working place requires a space that has good light quality, natural ventilation, drawing tables with flexible movable chairs, tables for model making, group meeting area, panels, lecture space, and space for rest and beverages (Attoe & Mugerauer, 1991).

Sustainable design considers resources and efficiency, ecologically and socially sensitive land use, healthy buildings and materials, and aesthetic sensitivity (UNESCO, 2011), while sustainability has been defined as fulfilling the

demands of the present without discounting the ability of future generations to fulfill their own demands. Sustainability education is an emanate imperative that requires a paradigm shift in academic and professional training (United-Nations, 1987) (Altomonte, Reimer, Rutherford, & Wilson, 2014). Buildings are the most heavily energy consuming sector therefore, it shall be priority for government policies makers. “The United Nations Environment Program (UNEP), 2007 reported that between 30-40% of global energy consumption is used by building sector” (Tommerup, Rose, & Svendsen, 2007).

There is need to adopt some principles to improve the undergraduate education, which can be used to come over some of the integration of sustainability into design studio (Chickering & Gamson, 1987). Meanwhile, integrating sustainability into design studio required great consideration of restructure of both traditional studio culture and modules (Nikolic, Messner, Lee, & Anumba, 2010) (Sarhan & Rutherford, 2014). It is essential to use innovative design process techniques that follow time module structure and varies teaching tools to be able to integrate sustainability principles into architectural design project (Mohamed & Elias-Ozkan, 2017) (Mohamed & Elias-Ozkan, 2019).

2. Problems and Objectives

Published research pointed out various obstacles facing the integration of sustainability in architectural education as follows:

- Outdated pedagogy of architectural education that focuses mainly on the form and artistic (Lofthouse, 2013).
- Architectural schools use digital technology as a CAD tool. While digital technology should be fully integrated into the whole design process (Yu, 2014).
- The studio instructors do not possess the required knowledgebase nor the practical professional experience (Altomonte, Rutherford, & Wilson, 2014).
- Lack of clear teaching pedagogy and instructive teaching tool for sustainable design studio (Mohamed & Elias-Ozkan, 2017).

The objective is to integrate the sustainability principles into design studios producing a sustainable design solution for the student’s architecture project. While the study aims to:

- Create an integration method of sustainability principles in design studio project.
- Assess the integration method.
- Evaluate the method’s impact on the student learning level and the level of integration on the designed projects.

3. Methodology

The Sustainable Architectural Design Studio (SADS) strategy meant to focus on the design process along the semester period rather than the final produced designed project. In additional, it considered all recommendations of the first experimental of SADS study, which reflected on modification of pedagogy structure and the improved of instructor-teaching method.

Teaching method guidelines

The method references of second SADS experimental studio were similar to first SADS in additional to the recommendations of first SADS study, which are presented as follow:

- The three principles of Ecole education: freedom, competition, and variety (Carlhian, 1979).
- The Bauhaus prime education objectives depended on integrating theory and application (Whitford, 1992).
- Constructivist design studio concepts (Kurt, 2012).
- Integrated public interest design studio concept (Anderson, 2012).

- Charrette design studio technique (Pernice, 2013).
- Embracing deep learning approach for principles and practices of sustainability (Sarhan & Rutherford, 2014).
- Learning pyramid principles that supported deep leaning not service learning. Therefore, the questions were started with; explain, compare, and construct not describe (Wood, 2004).
- The recommendations of the first experimental of Sustainable Architectural Design Studio (SADS) (Mohamed & Elias-Ozkan, 2017).

The design process was divided into four periods; four weeks for conceptual idea, four weeks for project development, four weeks for materials and testing, and two weeks for finishing and presentation. Each period ended with an open jury.

4. Materials and Method

The study took place at the Architecture Department in Izmir Institute of Technology, in Turkey. The research was conducted in the third year design studio (AR 301 Architectural Design III) in the fall term in 2015, with 25 students (16 female and 9 male). Two instructors conducted the design studio as a team supervising all students with the help of one teaching assistant. The class had twelve working hours per week in the studio.

The teaching methods mentioned above were included in the SADS as well as the restructure of the method which was recommended from the first experimental (Mohamed & Elias-Ozkan, 2017) (Mohamed & Elias-Ozkan, 2019), as it is shown in Table 1. The environmental aspect of the sustainability principles was the only concern for the second SADS experimental studio. The other two, i.e. social and economic aspects of sustainability were not considered. The entire evaluation of the students' work was divided into two parts. First was design process evaluation, embracing the sustainability integration (40% of total grade), with 5% increase over first experimental to emphasize on design process issue. Second, was finished project evaluation (60% of total grade); of which is 60% was dedicated purely to the design aspect and 40% for the degree of integration of the sustainability principles in the project Table 2.

Table 1. SADS's instructor teaching method of second experimental studio modified elements that are shown in red. learning technique reference to the learning pyramid of (Wood, 2004).

No	Learning Technique	Second Experimental Teaching Method of SADS Fall 2015
1	<i>Learning by teaching others.</i>	One case study was presented by each students (25 case studies). Finished in the first 6 weeks. Case studies presentation had 5% of total class grade.
2	<i>Practice by doing and group discussion</i>	Students were required to write the project program individually then in a small group of three then in a group of eight. The project size was reduced by 30%.
3	<i>Practice by doing</i>	Students were required to construct study models during the project design development process (6 models) with various scales.
4	<i>Deep learning</i>	Weekly panel reviews were conducted (9 panel reviews) in two formats:
	<i>Group discussion</i>	A) Group discussion of the design process and project development were conducted
	<i>Learning by demonstration</i>	B) Students criticized each other's project by asking each student to present his her project to the group
5		Technical trips to
	<i>Practice by doing</i>	A) The project site and surrounding area. Existing exemplary' project owned by the client.
	<i>Learning by demonstration</i>	B) Existing exemplary' projects

Table 1 continued

6	<i>Practice by doing</i>	Instructors conducted weekly charrette design assignments during the design process (6 assignments)
7	<i>Practice by doing</i>	Various digital technologies were used throughout the design process
		A) Conceptual design period; climate consultant and Sketchup
		B) Design development period; Revit, Auto CAD: and Sketchup
		C) Design evaluation period; Rivet only
7	<i>Practice by doing</i>	D) Final drawing and presentation; Rivet Auto CAD: 3D Max, DesignBuilder: and Sketchup
8	<i>Pubic interest/immediate use practice</i>	Project owner(s)/user(s) were incited to discuss the project and provide presentation and workshop (2 visits)
9	<i>Learning by demonstration</i>	Monthly Outside expert(s) were invited for workshop (3 workshops)
	<i>Practice by doing</i>	A) Instructors assigned homework related assignment ahead of each workshop studio
10	<i>Learning by demonstration</i>	Instructors conducted individual and small group desk critics (8 desk critics)
11	<i>Learning by visual, audio, and lecture</i>	Class instructors offered lectures about the project topics that included visuals and audios materials focusing on the low score elements from first pilot recommendation (6 Lectures)
12		Juries
	<i>Learning by demonstration</i>	A) Instructors conducted midterm juries (3 midterm juries)
	<i>Learning by teaching others</i>	B) Instructors hosted a final jury that included Bornova Municipality' president. University rector, experts, and academic members. The grade distribution was modified.

Table 2. Initial experimental of sustainable design studio grading system.

Total Class grade 100 points									
Design Process 40 Points								Final Jury 60 Points	
Site analysis & group model	class studies	Assignments & charrette work	Attendance & class performance	First midterm Jury	Second midterm Jury	Third midterm Jury	Portfolio	Sustainability checklist & energy simulation test 40%	Design evaluation 60%
(5 Points)	(5 Points)	(5 Points)	(5 Points)	(5 Points)	(5 Points)	(5 Points)	(5 Points)	(24 Points)	(36 Points)



Figure 1. The conceived sustainable concept of Culture Park by “Ece Güleç” was about creating a building like a park in a gated community-housing neighborhood that lacked green spaces. The open courtyard provided interactive atmosphere open and semi open space as well as natural light and natural ventilation into the building. The sustainable design was enhanced by the use of green roof, rainwater harvesting, and PV panels. The design offered 23% in annual energy saving and 23% in CO₂ emission reduction. The student managed to collect 19 points of the total 19 points from the sustainability checklist elements.



Figure 2. Bornova culture center by “Ezgi Çam” was exploit the idea of a center mass that included the major program spaces while it was surrounded by lower mass that included other spaces. This strategy provided good quality of natural light and natural ventilation throughout the open space created between the two masses as well as various open and semi open spaces. Furthermore, the orientation, height, and size of masses considered the natural resources such as wind, natural light, rainwater, etc. as well as the choice of sustainable materials and various shading elements. The design expected to save 25% in annual energy consumption and 30% in CO₂ emission. The project collected 19 points of the total 19 points of the sustainability checklist elements.



Figure 3. In this project, the student managed to collect 8 points of the total 19 points of the sustainability checklist elements. The project did not consider natural air ventilation, shading façade elements, sustainable material and local material, rainwater collection as well as the lack of use heat insulation. There were spaces that did not have natural light. The project did not have the correct test for energy consumption nor CO₂ emission.

5. Studio Outcome

Instructors reviewed all projects after the final jury, similar to the first experimental SADS studio. Figures 1 and 2, illustrate two successful students' final projects proposed design work of Bornova Municipality culture center that demonstrated positive integration of sustainability principles into the design starting from the project concept to the finished design as well as the energy simulation test showed the saving in energy consumption and reduction in CO₂ emission (Mohamed & Durmuş Arsan, 2016).

Meanwhile, Figures 3 illustrate an unsatisfactory students' project that neglected to include the major elements of sustainability principles such as natural light, natural ventilation, mass orientation, the use of sustainable and natural materials etc.

Table 3. Sustainability checklist elements and grading system

Main Elements / points	Points distribution	Elements	Students No.
Energy (10 Points)	6 Elements or more (10) 4 to 5 Elements (7) 2 to 3 Elements (5) One element (2) None (0)	Reducing the energy used for lighting	80% of spaces benefits from natural light
			Sky-gardens, skylights, atriums, light shelves
		Reducing the energy used for ventilation	Adjustable windows, air-holes
			Natural ventilation by channels (wind catcher)
		Reducing energy used for heating and cooling	Reduce heating loads (high insulation glass system (low-e glass), double-wall application, double skin
			Reduce cooling loads (sunshades, movable blinds between glass layers, etc.)
			Passive recovery to reduce heating and cooling loads (thermal mass, etc.)

Table 3 continued

		Use of renewable energy sources	Low emission but non-renewable energy sources
			Renewable energy sources like sun, and wind
Materials (5 Points)	2 to 3 Elements (5)	Flexible design of interior space and interior furniture	
	One element (2)		Use of eco-friendly material and equipment
	None (0)		Reducing waste
Water (5 Points)	2 to 3 Elements (5)	Recollection and reuse of water: grey water and rail water	
	One element (2)		The use of rain water in interior and exterior space to reduce the cooling load during summer
	None (0)		The use of water in landscape to enhance the natural light in the building
Health (5 Points)	4 Elements (5)	Natural light and fresh air for working area	
	2 to 3 Elements (4)		Indoor glare effect control by using facade's solar shading
	One element (2)		Eco friendly tian spoliation to the site (bicycles, electric cars, etc.)
	None (0)		Selection of noil-harmful materials
Total 25 Points		Total Elements 19	
Energy Simulation Tests (15 Points)	(5 Points)	Base case result	
	(6 Points)	Modified case with selected materials and shading elements. Reduction of 10% or less in Energy and cdeission	
	(10 Points)	Modified case with selected materials and shading elements. Reduction of more than 10% in Energy and cbemission	

6. Evaluation and Assessment

Evaluation of the level of sustainability principles into students' projects were done by the studio's instructors while the students assessed the studio structure method and teaching tools.

6.1. Evaluation by the instructors

The sustainability principles checklist of first experimental SADS studio (Mohamed & Elias-Ozkan, 2017) were explained to the students as well as the demonstration of the integration of each element in the design project. All projects were evaluated against the sustainability checklist (40% of the final project evaluation grades). Table 3 illustrates the checklist elements.

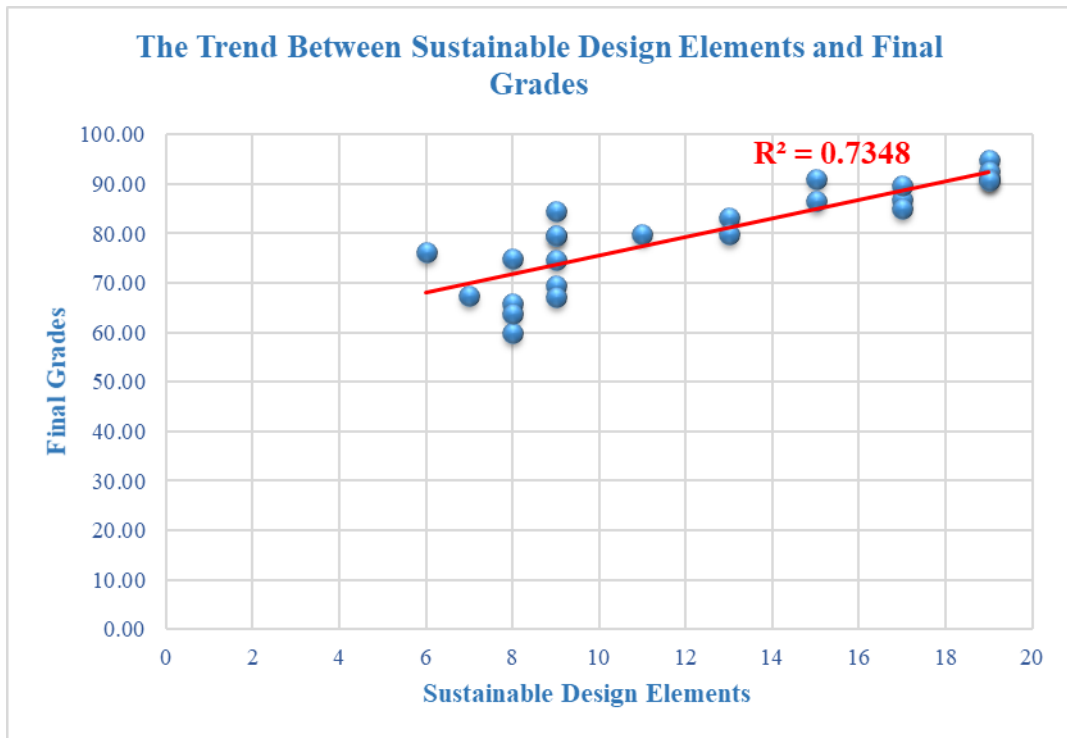


Figure 4. The correlation between the number of sustainable elements each student used in his/her project and the final SADS's grades.

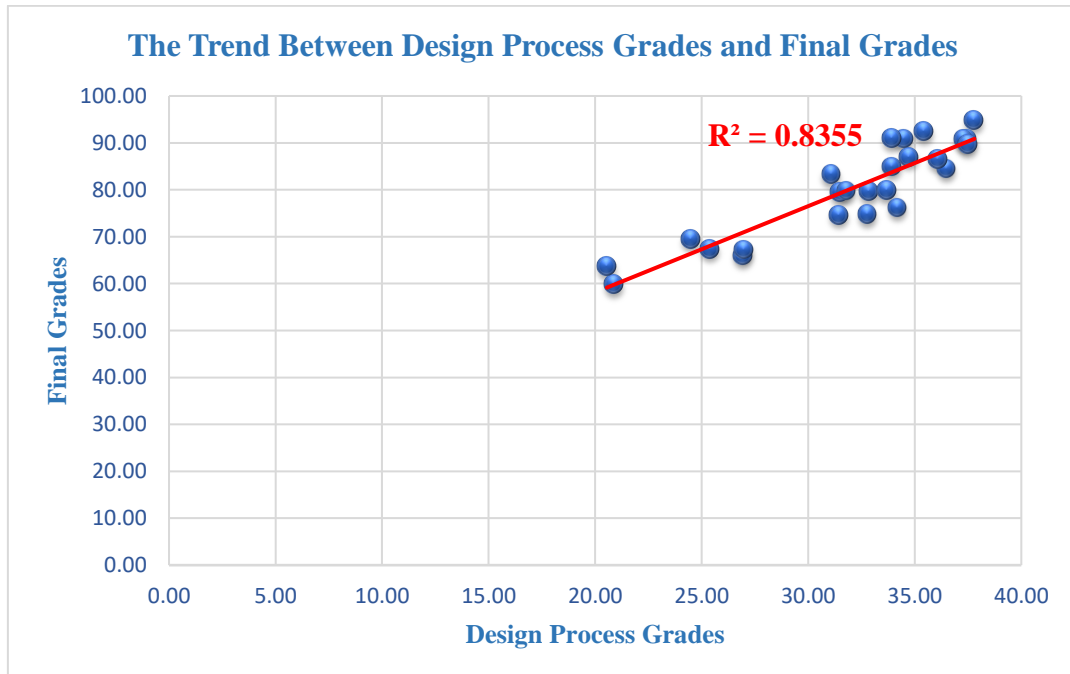


Figure 5. The trend result between design process grades and final SADS studio grades

6.2. Assessment by the students

After the final jury, the grades were announced. Instructors invited the students for an open colloquium. Students were handed out a questionnaire form that had various questions regarding studio structure and format, jury style and format, sustainability issues, as well as their own comments about studio aspects. Before attending the studio, 70% of the students had no knowledge about sustainable design where 30% attended the first SADS studio. 95% of the students confirmed practice sustainable design in their professional life as well as it will be their preference for graduate education study subject.

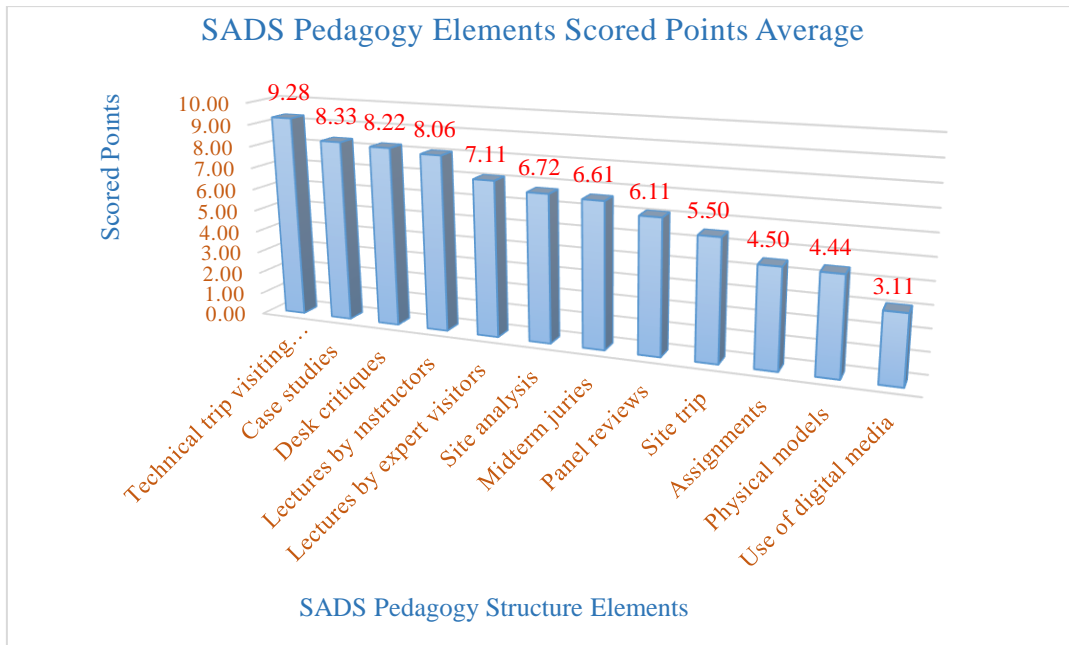


Figure 6. Pedagogy structure elements average scored points.

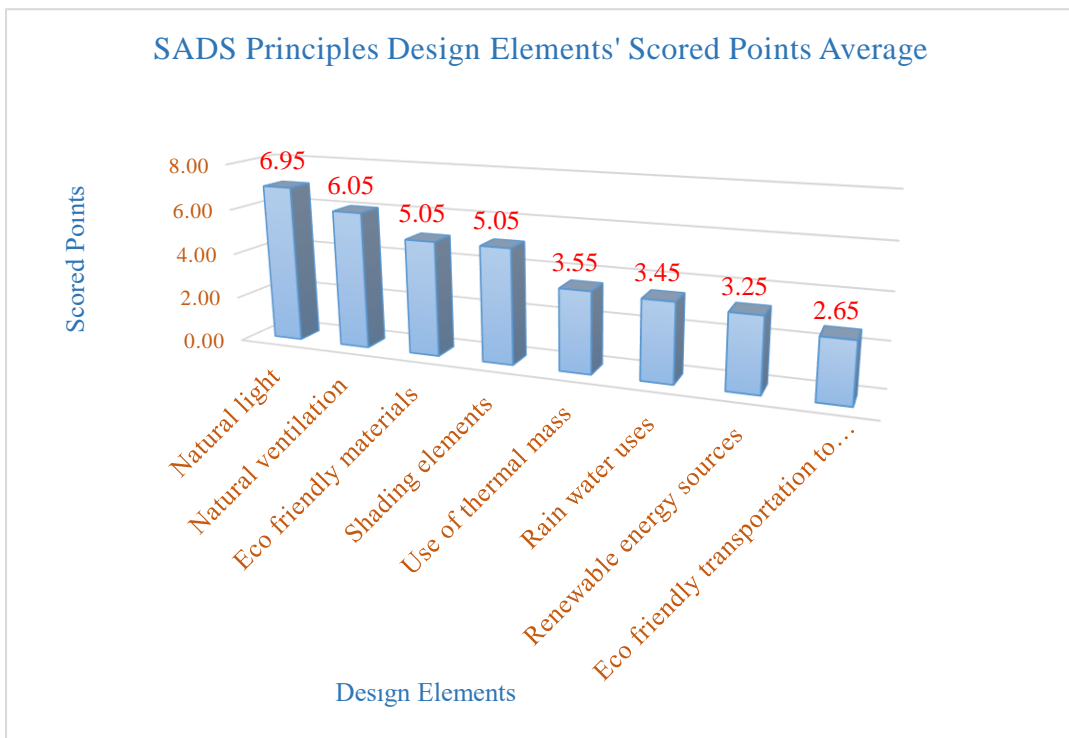


Figure 7. The average scored points of principles design elements of the initial experimental studio.

Figure 6 illustrated that the technical trip scored the highest points among the studio tasks (pedagogy elements) while the use of digital media in benefitting the students design scored the least points.

On the other hand, Figure 7 showed that natural light scored the highest points among the sustainable design elements and the eco transportation was least within the students' consideration.

The few students who had the SADS in previous semester were comfortable working in the project. Some students said that instructors were organized and helpful in coaching us to produce the project that we want. One student comment was that the class content has been organized efficiently. Other said that the studio were fruitful. Another said, "The instructors were well qualified. I am thankful to them, it was very good studio".

7. Conclusions and Recommendations

The improved method along with the modified pedagogy structure and teaching method introduced new grade distribution system of sustainable checklist elements and simulation energy test Table 3. This grade system reflected positively on the integration of sustainability principles into the final project results as well as it did better evaluation work accuracy. The use of one software program (Revit) reflected positively to achieve the energy simulation test of the project. Only two students were not able to complete the simulation test due to their slow design progress.

There was a parallel trend result between students design process grades and final SADS grades Figure 4 with R-squared value of (0.7348) represented strong data that were fitted to the regression line, which was stronger than the pilot experimental studio. There was positive correlation between the numbers of sustainable design elements each student use in his/her project and final SADS grades Figure 5 with strong R-squared value of (0.8355).

There was no major change of order of the pedagogy elements by the students from first experimental. However, the standard deviation score among the elements was less scoring 1.85, which referred to the extra effort that was given to the elements on the bottom list by instructors Figure 6.

Natural light and natural ventilation had the top score among students choice for SADS design principles elements while eco-friendly transportation scored the least points. However, the standard deviation between the elements was 1.51, which reflected that the gap was less between the top and lower elements Figure 7.

Afterwards, the conclusions led to a number of recommendations that had been applied to change or modify the SADS pedagogy structure of the third and final SADS experimental studio (AR 302 SADS-spring of 2016). These recommendations were:

The grade distribution points of sustainability design shall emphasize more on the energy consumption saving and CO₂ emission reduction. Moreover, attention could be given to the low scores elements of SADS pedagogy structure as well as the sustainable design principles elements by providing more lectures and inviting outside experts.

The project size (meter square) shall be reduced in order for the students to focus more in the sustainable design issues. In addition, the students would present all case studies within the first five weeks of the design process to get the most benefits of it.

Simulation shall be used not only for energy test but also for the evaluation of natural light quality of the space. In additional, instructors shall invite more outside experts for midterm juries, presentations, and workshops. There should be design consideration of all sustainability aspects; environmental, economical, and social.

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The author would like to thank the students of sustainable design studio class AR 301 of fall 2015 at Izmir Institute of Technology Figure 8.



Figure 8. The Students of SADS class of AR 301 fall of 2015

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