International Journal of Engineering Education Vol. 33, No. 2(A), pp. 629–638, 2017
Printed in Great Britain

0949-149X/91 $3.00+0.00

A Project-Based Framework for Teaching and Assessment of Design Modules*

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In this paper, we propose a project-based framework to help teaching and assessment of Architectural design modules in an informative and fair way. The framework is based upon criteria-based assessment and uses rubrics to guide the assessment process. Using this framework, the students can fully understand the evaluation criteria by practicing peer-to-peer evaluation, and instructors can have useful feedback about weaknesses of their students and/or their teaching methodologies. By mapping students' results into required students' skills, monitoring of students over several levels of study becomes possible; this supports efficient progressive learning. The proposed approach has been evaluated by using it to assess A group of thirty students in design-1 module; then their results were compared to another group of thirty assessed heuristically without it. The initial evaluation of the approach shows its effectiveness.

Keywords: architecture design; assessment; criteria-based; rubrics; peer-to-peer evaluation; progressive learning

1. Introduction

Architectural design is at the heart of Architecture education. It is one of the major and most difficult subjects to teach or to assess. During an Architecture program in higher education, students should acquire large number of design skills through different design modules over different levels of study. However, teaching and assessment of design modules are considered difficult tasks with many challenges. Typically, teaching design modules is based upon a project-centered approach where the module is taught and assessed using a number of design projects to build design skills in a progressive way. Here assessment of projects is considered a learning tool and is known as "Assessment for Learning" [1].

Generally, assessment is an essential component in the learning process. It is responsible for measuring and monitoring the progress of students' learning. It is essential to recognize student's learning level and making decisions for next step. It is also important for instructors to check the effectiveness of their teaching methodologies and for learners to know their own weaknesses. Because of its role in Architectural design learning process; assessment method should be accurate and fair with clear evaluation criteria. These evaluation criteria should provide description of each level of performance in terms of what students are expected to do.

Evaluation criteria should be known in advance by students so that they can apply during their work. Clear criteria should be fully understood by the students from the beginning so that they can self-assess their work by applying the criteria. The feedback during assessment also plays an important role to support learning and to improve the learning process. Defining clear specific evaluation criteria in advance also has a positive impact on instruction. The instructor will focus on the most important critical components on the curriculum and the main learning outcomes of the module before start teaching. Thus, there will be integration and alignment of curriculum content, program objectives, module outcomes, instruction, and assessment that promotes meaningful learning [2]. In the absence of clear, specific criteria explained in advance to the students, assessment remains isolated from the learning process and the success of the learner is mostly incidental [2].

Rubrics can be used as a self-assessment tool to clarify the assessment criteria. A rubric is defined by Stevens & Levi [3] as "A scoring tool that lays out the specific expectations for an assignment". A carefully designed rubric helps both the instructor and the students to define precise criteria for a successful process and/or product prior to and during the completion of a task. It also offers students specific feedback for future success on a similar task [4]. The rubrics needs to be as clear and specific as possible when a multidimensional task is assigned as the challenge of the task should be in its completion, not in figuring out the task itself [2].

Cognitive learning theory promotes the use of assessment methods based on active construction of meaning rather than passive responses assessment [2]. Peer-review is a form of active construction where students evaluate the work of their colleagues based on known criteria [5]. This can help them to fully understand the criteria and to self-assess their work [6]. However, these criteria are not always available for such activities.

Developing a fair, accurate and reliable assess-

* Accepted 6 November 2016.

ment process is not an easy task for studio-based modules like Architectural Design. Designing and implementing such methods is time consuming and needs much effort. In this paper, we propose a systematic framework for the design and implementation of an assessment tool based on the required design skills for the students and on the use of rubrics. Students' skills and learning outcomes over the different design modules on the different levels are considered when designing the tool. The tool aims at simplifying the assessment process and to achieve fairness, reliability and effective progressive learning.

The remainder of the paper is structured as follows. Section 2 clarifies some terminology that will be used in the paper. Section 3 describes related work in the area. Section 4 presents the proposed framework with details. Section 5 provides an evaluation for the framework while section 6 provides conclusions.

2. Related work

In recent years, assessment in education has been moved away from traditional Curriculum-based assessment models towards outcomes—based models [7, 8]. These models are based upon the assessment of course-learning outcomes (CLOs) and/or student outcomes (SOs). The SO and CLO can be defined as follows:

Student Outcome (SO) OR Student Skill (also known as Program Learning Outcomes): Statements describe what students should know, be able to do, and value by the end of their educational program [9]. They are related to the knowledge, skills and behaviours that students acquire in their matriculation through the program. They are expressed as statements that describe what students are expected to know and be able to do by the time of graduation.

Course Learning Outcomes (CLO) OR Course Outcome: Expected learning outcome statements refer to specific knowledge, practical skills, areas of professional development, attitudes, higher-order thinking skills, etc. that faculty members expect students to develop, learn, or master during a course [10].

Academic institutions are increasingly adopting outcomes-based models because Curriculum-based models do not usually make clear statements for what students are expected to achieve upon completing a program of study. Therefore, to improve the efficiency of learning processes, academic programs focus more on assessing the expected outcomes of the educational experience rather than the quality of the offered curriculum [11]. However, the use of outcomes-based assessment for architectural design modules is still limited. Learning in design modules can be characterized as "self-directed and very free from curriculum" [12]. Orr [13] and Cannatella [14] argue that learning outcomes are inappropriate for subjects that need to allow for creativity and innovation like architectural design. However, without clear outcomes, assessment in design modules is confusing to most students and markers [15, 16].

Fair and effective assessment for design projects is essential but very difficult. Several approaches have been proposed to tackle this problem. Typically, evaluation Crits are used to evaluated design project throughout a design course. The term "Crit" includes the formative and summative feedback in small and/or large groups of students and lecturers [17]. Crits present an opportunity for discussion and evaluation of students' works. The feedback in such Crits plays an important role to support learning and to improve the learning process. Blair [18] explores the strengths and weaknesses of the Crit as a key site for providing feedback. Generally, in Crits, the grading models used in different universities can be categorized into the three following classes [19]: Holistic Models, Comparative Models, and Criteria-based Models

In holistic models, the assessment is based on the examiner background and perception. In this case the assessment is based on his point of view, preference and interest. Harpe et al. [20] analyzed the particularities of holistic assessment in art, design and architecture and identified 11 key indicators that underpin the assessment. These are product, process, person, content knowledge, hard skills, soft skills, technology, learning approaches, reflective practice, professional and innovative practice and interdisciplinary collaboration.
However, in holistic model, no formal feedback is given to students to explain their problems and weaknesses.

In comparative models, one examination committee for evaluation is selected to compare then order the different projects based on the quality. Each examiner gives grades in descending order from the best project to the worst one based on his point of view. However, this represents much load for one committee. Moreover, the comparative assessment does not provide clear explanation for the marking scheme.

In the two previous models, assessment remains an isolated and incidental activity. It does not spot the learner weaknesses or improve his skills. Success of students in these models is mostly incidental [2]. Moreover, students mostly do not understand how they are assessed and consider the assessment as an unfair process [21].

The third model is the criteria-based model. In this model, several rules or attributes are defined to

guide the assessment process [19]. These rules should reflect the course objectives and the required skills to be achieved. However, what the criteria are is left undefined [22]. Several grading approaches are developed by different universities following this model [23]. Some of these approaches adopt the grading sheet (also known as marking/evaluation form) as a simple way for criteria-based assessment. However, mostly in these approaches, the connection between program objectives, course learning outcomes and the project has broken [21]; thus, transforming students study to marks, grades or scores is very difficult.

In our framework, we adopt the grading sheet as a basis for criteria-based evaluation because of its simplicity. The work in [19] has some similarities to our work as it uses also the grading sheet and tries to connect the course learning outcomes to the evaluation criteria. However, it does not clarify how. Our work is different as it proposes a complete framework that relates the grading sheet and the evaluation criteria not only to the course learning outcomes but also to the program objectives and the required students' skills. This allows the learning process to be progressive from a design module to another over the different projects and the different levels of study in the program. By mapping the grades to the required skills over the whole program, real monitoring of students' progress from a level to level becomes possible. Another contribution of our framework is the peer-to-peer evaluation based on the grading sheet and the rubrics. This would deepen the students' understanding and improve the learning process [5].

3. A Project-based framework for teaching and assessing architectural design

Our framework adopts the problem-solving approach for teaching and learning through practicing. It aims at designing evaluation criteria that are fair, reliable in alignment with the module's learning outcomes and the required students' skills. It coordinates between the different projects and the different design modules so that the overall design skills are progressively acquired. We propose the following techniques and guidelines to improve the project-centred approach for teaching. These guidelines have been followed in designing assessment tool and in practicing the new approach. The framework consists of the following steps.

1. The general students skills (also known as students outcomes) to be achieved by the design modules are identified.
2. The skills are mapped into smaller units in the form of more specific course learning outcomes that can be evaluated directly by the different projects.
3. An evaluation form is designed based on the selected course learning outcomes. Different weights can be used to reflect the importance of the outcome and how much work is needed to achieve it. A zero-weight can be used if the outcome is not relevant to the project.
4. For each course outcome, a rubric is designed to clarify how the outcome should be evaluated.
5. Evaluation criteria in form of the evaluation form and the rubrics are handed to students so that they know exactly how they will be assessed—Other forms of feedback can also be used.
6. Peer reviewing techniques are employed, where students assess their colleagues' projects after the different phases of the project so that students can understand more their mistakes and understand the evaluation criteria.
7. Instructors evaluate the projects using the evaluation form and the rubrics, by assessing the different course outcomes and feedback is given to students based on the form.
8. Results are analysed and mapped to student skills for the different students and over the different sections and overall the course to identify weaknesses on the student level, section level and course level.
9. Students check their course outcome results and skills result so that they are aware of their main weaknesses.
10. Improvement for the course are suggested based on the analysis of results.
11. Student skills are compared over the different projects and the different semesters to monitor the progress of students.
12. Feedbacks are collected from students and from instructors to identify any missing elements. The form should be improved based on the feedback, and the process is repeated.

Details of these steps are clarified in the following subsections

3.1 Steps 1, 2: Students skills VS course learning outcomes

In these steps, the students outcomes expected to be covered by the design module are defined and linked to the course learning outcomes to be assessed by the project. Every SO is mapped to one or more CLO while each CLO is linked to one SO. An example for students' skills for a level 1 design module is shown in Table 1.

After identifying student skills, the course learning outcomes to be assessed by the project are defined. These should be selected to serve the

Table 1. Student Outcomes (SOs)

Student Outcome	Definition
1. Critical Thinking	Ability to raise clear and precise questions, use abstract ideas to interpret information, consider diverse points of view, reach well-reasoned conclusions, and test them against relevant criteria and standards.
2. Fundamental Design Skills	Ability to use basic architectural principles in the design of buildings, Understanding of the fundamentals of visual perception and the principles and systems of order that inform two- and three-dimensional design, architectural composition, and urban design interior spaces, and sites.
3. Formal Ordering Systems	Understanding of the fundamentals of visual perception and the principles and systems of order that inform two- and three-dimensional design, architectural composition, and urban design.
4. Graphics & handicraft Skills	Ability to use appropriate representational media, including freehand drawing and computer technology, to convey essential formal elements at each stage of the programming and design process.
5. Communication Skills	Ability to convey information to others effectively and efficiently.

Table 2. Course Learning Outcomes (CLOs)

Course Learning Outcomes (CLO)	Definition
1. Site analysis studies	An analysis of site conditions, and a definition of site selection and design assessment criteria to respond to natural, cultural, climate and built site characteristics.
2. Conceptual idea(s)	An abstract generative idea that expresses or leads to predicates for design; the point of beginning, or the potential basis for design exploration.
3. Landscape plan	Ability to respond to site characteristics including zoning, soil, topography, vegetation, and watershed in the development of a project design.
4. Functional relationships	The organization and resolution of the design; by shaping of parts into specific relationships to integrate concepts, formal/visual principles and techniques.
5. Integration of space, function & circulation	Demonstrate fundamental understanding and application of architectural formal + spatial principles as they relate to human experience.
6. Form &Elevations	Demonstrate fundamental understanding and application of architectural formal + spatial principles as they relate to human experience.
7. Sections	To examine the students' application level of projection and drawing.
8. Visual representation	The representation of ideas through architectural graphic standards as a component of visual communication.
9. Model craftsmanship	Craft based modes of model-making, and visualization to produce a three dimensional product created to communicate spatial aspects of the design, with attention to materials and detail.
10. Verbal presentation and dialog	Effective spoken and written communication of design ideas and the related appropriate use of design language.

students skills required. An example of course learning outcomes for a level 1 design module is shown in Table 2.

Mapping between these skills into smaller course learning outcomes that can be assessed directly by the project work is carried out. An example is shown in Table 3.

3.2 Step 3: Evaluation form/grading sheet

Based upon the selected course learning outcomes, an evaluation form has been designed with different weight for each outcome based on the project nature. If a course learning outcome is not covered by the project, then a weight of "zero" is assigned to this outcome. An example of an evaluation form is shown in Table 4.

3.3 Step 4: Rubrics

The next step is to define rubrics to guide the marking process and to ensure fair assessment. This also will be useful for students to understand their marks and their weaknesses. Rubrics should be defined for each course outcome. An example is given in Table 5.

Now the evaluation form is ready to be handed to students to understand the marking scheme, and to follow during the peer assessment process, and to be used by instructors and examiners for the fair assessment of projects. The form also can be used to give useful feedback to students in an easy way.

By integrating the results and analysing the achievements of the course outcomes, then by mapping to the associated student skills, many insights

Table 3. Mapping between student outcomes and course learning outcomes

Student Outcomes (SO)		Course Learning Outcomes (CLO)
1. Critical Thinking Ability to raise clear and precise questions, use abstract ideas to interpret information, consider diverse points of view, reach well-reasoned conclusions, and test them against relevant criteria and standards.	**1**	**1. Site analysis studies** An analysis of site conditions, and a definition of site selection and design assessment criteria to respond to natural, cultural, climate and built site characteristics.
	2	**2. Conceptual idea(s)** An abstract generative idea that expresses or leads to predicates for design; the point of beginning, or the potential basis for design exploration.
2. Fundamental Design Skills Ability to use basic architectural principles in the design of buildings, interior spaces, and sites.	**1**	**3. Landscape plan** Ability to respond to site characteristics including zoning, soil, topography, vegetation, and watershed in the development of a project design.
	2	**4. Functional relationships** The organization and resolution of the design; by shaping of parts into specific relationships to integrate concepts, formal/visual principles and techniques.
	3	**5. Integration of space, function & circulation** Demonstrate fundamental understanding and application of architectural formal + spatial principles as they relate to human experience.
3. Formal Ordering Systems. Understanding of the fundamentals of visual perception and the principles and systems of order that inform two- and three-dimensional design, architectural composition, and urban design.	**1**	**6. Form &Elevations** Emphasis on 2d and 3d mapping techniques, patterning, and graphic relationships.
	2	**7. Sections** To examine the students' application level of projection and drawing.
4. Graphics & Handicraft Skills Ability to use appropriate representational media, including freehand drawing and computer technology, to convey essential formal elements at each stage of the programming and design process.	**1**	**8. Visual representation** The representation of ideas through architectural graphic standards as a component of visual communication.
	2	**9. Model craftsmanship** Craft based modes of model-making, and visualization to produce a three dimensional product created to communicate spatial aspects of the design, with attention to materials and detail.
5. Communication Skills Ability to convey information to others effectively and efficiently.	**1**	**10. Verbal presentation and dialog** Effective spoken and written communication of design ideas and the related appropriate use of design language.

Table 4. Evaluation form

Design Project Evaluation Form

Instructure name: Dr. Ahmed Azmy

Course name: Architecture Design - 1

#	Student Name	1. Site analysis studies	2. Conceptual idea(s)	3. landscape plan	4. Functional relationships	5. Integration of space, function & circulation	6. Form &Elevations	7. Sections	8. visual representation	9. Model craftsmanship	10. Verbal presentation and dialog	TOTAL
		10	5	10	15	25	15	5	10	5	0	100
1												
2												
3												
4												
5												
6												
7												
8												

Table 5. Example of Rubrics for the first CLO "site analysis"

Course Learning outcomes	Evidences	Relative weight
1- **Site analysis studies** An analysis of site conditions, and a definition of site selection and design assessment criteria to respond to natural, cultural, climate and built site characteristics	• Site description analyzed through text, drawings and diagrams to investigate site conditions. • Analysis of climate conditions • Analysis of natural conditions • Analysis of topography conditions • Analysis of vegetation conditions	5%

0pts	1pts 2pts	3pts 4pts	5pts 6pts	7pts 8pts
F	D D+	C C+	B B+	A A+
Unacceptable	**Poor**	**Satisfactory**	**Good**	**Excellent**
None of the following: • Analysis of situation • Generation of alternatives • Rationale for project • Documentation of process	**Little of the following:** • Analysis of situation • Generation of alternatives • Rationale for project • Documentation of process • Site described • Design is not responsive to site characteristics	• Some analysis • Limited generation of alternatives • Weak rationale • Partial documentation of process	• Site described, analyzed, and designed • Design is responsive to site characteristics	• Thorough analysis • Alternatives fully generated and convincingly compared • Strong rationale • Full documentation of Process • Site described, analyzed, and designed in detail • Conclusions drawn and applied to design, which is clearly and convincingly responsive to site characteristics

about the teaching methods, the achievements of students and their weaknesses can be identified, and several improvements can be recommended.

4. Evaluation

In this section, we evaluate the proposed framework by analyzing its value, then by evaluating the proposed form and the whole framework. The evaluation process and the assessment tool are designed to be flexible and fair for students being evaluated, to promote quality teaching and students' learning, and to serve as a basis for identifying teaching and learning weaknesses.

The approach can serve the following roles:

- It serves as a fair measurement of performance for individual students.
- It serves as a teaching tool for students to know what they should focus upon and how they manage their time and their priorities while working in projects.
- It serves as a guide for instructors to reflect upon.
- It serves as a basis for teaching and learning improvements.
- It evaluates the students skills and learning outcomes.
- By mapping students' results into course outcomes and student skills, it helps to monitor students over several projects and over several semesters, thus improve progressive learning.

The evaluation form has been designed by several instructors of design modules and has been modified to fulfil their visions.

4.1 Evaluation of form & rubrics—initial results

The evaluation form and rubrics have been used for assessing a group of thirty students in design-1 module and the results are compared to another

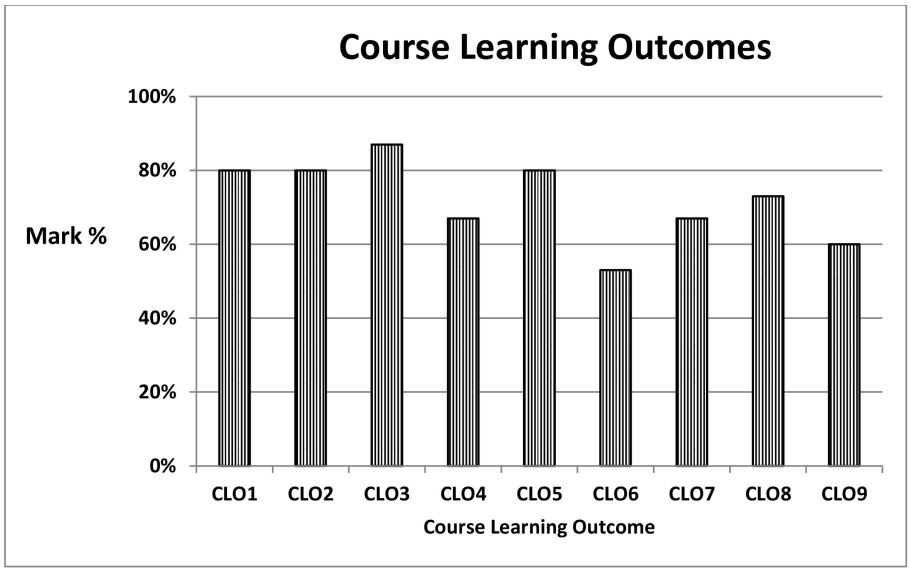

Fig. 1. An example of the average marks given by examiners to the different CLOs of a student work.

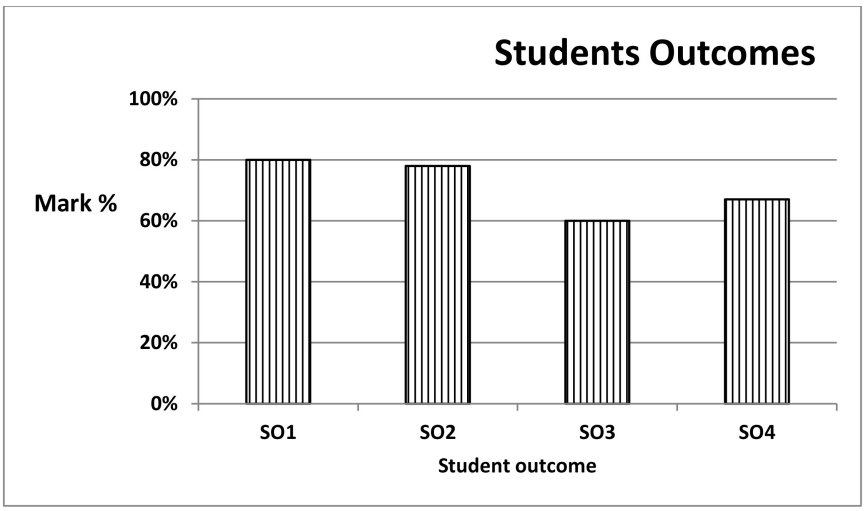

Fig. 2. An example of the different marks of the SOs of a student calculated by integrating the CLO marks.

group of thirty students that are assessed without the form. Fig. 1 shows the total marks per CLO for one student while Fig. 2 shows the marks of the student per SO. From Fig. 2, it is clear that the performance level of student is good in SO1 & SO2 (critical thinking & fundamental design skill); and weak in SO3 & SO4 (formal ordering systems & graphics and handicraft skill).

The total marks given by the examiners for a group of ten students are shown in Fig. 3. The result has been compared to another group of ten students that are assessed without the form as shown in Fig. 4. Three examiners are assessing each group and their results have been compared. The standard deviation among the three examiners is plotted in Fig. 5. Similar results have been obtained for the other twenty students.

As shown in the figure, the instructors who used the form have almost similar assessment for students; while for the other examiners the differences in marks are high (this is shown as a high standard deviation). This shows that the form helps to achieve a more fair assessment.

However, in-depth evaluation of the approach is needed to validate it. A pilot study will be carried out in the future to validate the results obtained here and to give more insight into any weaknesses or problems for the approach. The results will be reported in a future work.

To evaluate the whole framework a questionnaire has been distributed to the examiners, instructors and coordinators of design-module. The results show their overall satisfaction about the approach and its effectiveness to provide a more fair evalua-

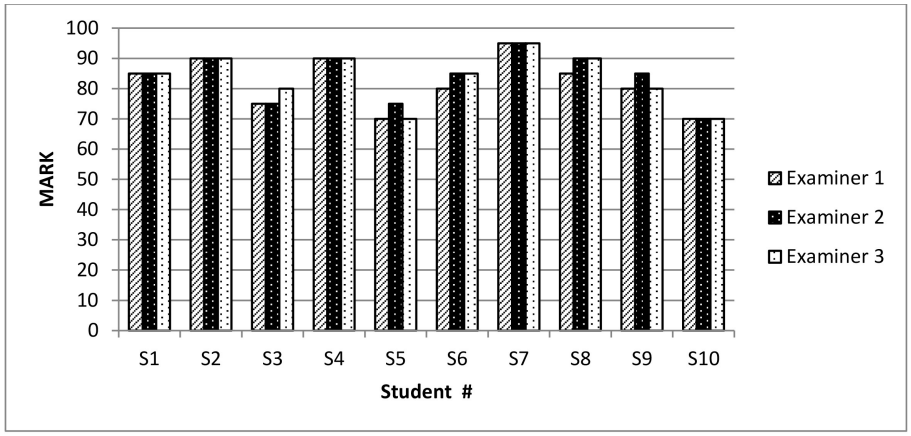

Fig. 3. Students' marks using the proposed form and rubrics—every student Si is evaluated by three examiners.

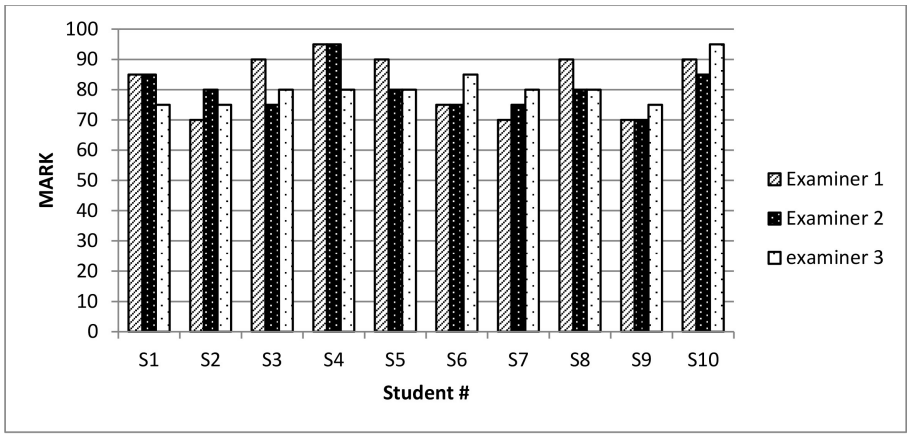

Fig. 4. Students' marks % without the form (heuristically)—every student Si is evaluated by three examiners

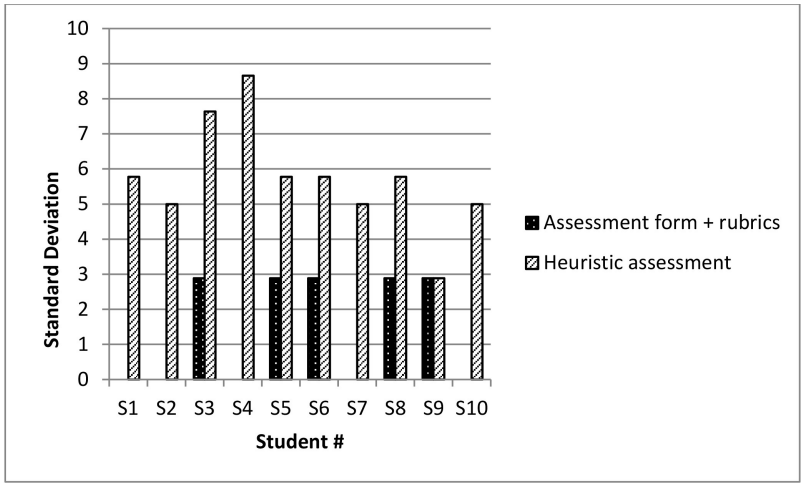

Fig. 5. Comparison of the standard deviation of the examiners' marks based on the framework assessment to the marks of heuristic assessment for different students.

tion. However, the results highlight many problems and issues:

- It is difficult to check the different Rubrics while marking the projects
- Analyzing the results, mapping the CLOs results into SOs results, and keeping results for the following instructors to check students' progress is not an easy task.

Based upon the feedback, we suggest automating the marking process and the analysis of results using

a web-based application that would simplify the whole process. This will be carried out in future work.

5. Conclusion

In this paper, we have proposed a framework for teaching and assessing project-based Architectural design modules. The framework links the student skills and the course learning outcomes for the several design modules and thus allows for efficient progressive learning and students' monitoring over the different levels in the Architecture program. We have designed a grading sheet associated with Rubrics as a form of criteria-based evaluation to guide and clarify the evaluation criteria to achieve fairness of the evaluation process. The grading sheet and the rubrics are also used as self-assessment and peer-evaluation techniques for students to improve their understanding. They also serve as an easy way to give meaningful feedback to students making the evaluation process transparent and fair. The proposed approach has been evaluated by using it to assess A group of thirty students in design-1 module; then their results were compared to another group of thirty assessed without it. The results indicate that the framework is effective in providing a fair evaluation based on comments from examiners, instructors and coordinators. The framework can be applied to other similar creative/design disciplines.

For future work, a more thorough evaluation will be carried out to validate the initial results; also, a computer system will be created to facilitate analysis of results and to improve the learning process.

Acknowledgments—This work was supported by a grant from the "Center for Excellence in Learning and Teaching", King Saud University, KSA.

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