2006-2277: DEVELOPING AN ASSESSMENT REGIME FOR PAN-MENTORING IN CREATIVE ENGINEERING DESIGN

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Developing an Assessment Regime for Pan-Mentoring in Creative Engineering Design

Abstract

Pan-mentoring (from the Greek *pan* meaning *all*, to indicate a mentoring relationship with a team of students) is a pedagogical approach to creative engineering design education establishing a close relationship with and within design teams of students. The role of the pan-mentor consists of: helping students to effectively tap into their creativity as individuals and as teams; guiding them through the design process at both the individual and team level; and encouraging self-reflection and assessment. This paper develops and discusses an assessment regime for the three elements of pan-mentoring in creative engineering design. In the regime, student assessment, course assessment, and pan-mentor assessment are utilized. In this paper, the only data discussed is from a questionnaire (course assessment) completed by freshmen students. The results from this part of the assessment regime were favorable.

1. Introduction

Pan-mentoring (from the Greek *pan* meaning *all*, to indicate a mentoring relationship with a team of students) is a pedagogical approach to creative engineering design education establishing a close relationship with and within design teams of students. The term "pan-mentor" was coined by Ekwaro-Osire[1] in the context of capstone design course, presenting the concept of a close relationship with teams (3-5 students) of students to compensate for the special challenges of creative engineering design.[2] In this context, the role of the pan-mentor consists of: helping students to effectively tap into their creativity as individuals and as teams; guiding them through the design process at both the individual and team level; and encouraging self-reflection and assessment.[3]

This paper develops and discusses an assessment regime for the three elements of pan-mentoring in creative engineering design, namely, (1) the students' learning process (student assessment), (2) course development, and (3) pan-mentor. Figure 1 shows the three elements of pan-mentoring and their individual assessments, namely: student assessment, course assessment, and pan-mentor assessment. The assessment tools used for student assessment include: design notebooks, peer evaluations, examinations, and product evaluation. The assessment tools used for course assessment include: pan-mentor questionnaire, student questionnaire, and industrial client questionnaire. The nature of the pan-mentor requires that the instructor should not be in the spotlight but rather a facilitator.[3] Therefore, the assessment of the pan-mentor is partly implied in the student questionnaire and industrial client questionnaire used in the course assessment. An additional tool is a separate questionnaire pertaining to the pan-mentor. It is noted that some of the assessment tools discussed yield quantitative results, which often provide little account of human perceptions or motivations.[4] To address such deficiency Leydens *et al.*[4] recommend the usage of some qualitative methods to provide better information about human perspectives through a detailed description of an event.

In assessment of the student reflection, the emphasis is on the students' articulation of the connections between the design process and learning, and the students' awareness of what has been learned. The assessment regime proposed here is currently being implemented in a freshman engineering design course and a Capstone design course at three different universities. Hence, the target groups are both senior engineering students enrolled in capstone courses and freshmen enrolled in introduction to engineering courses. In this paper, the only data discussed is from a questionnaire (course assessment) completed by freshmen students.

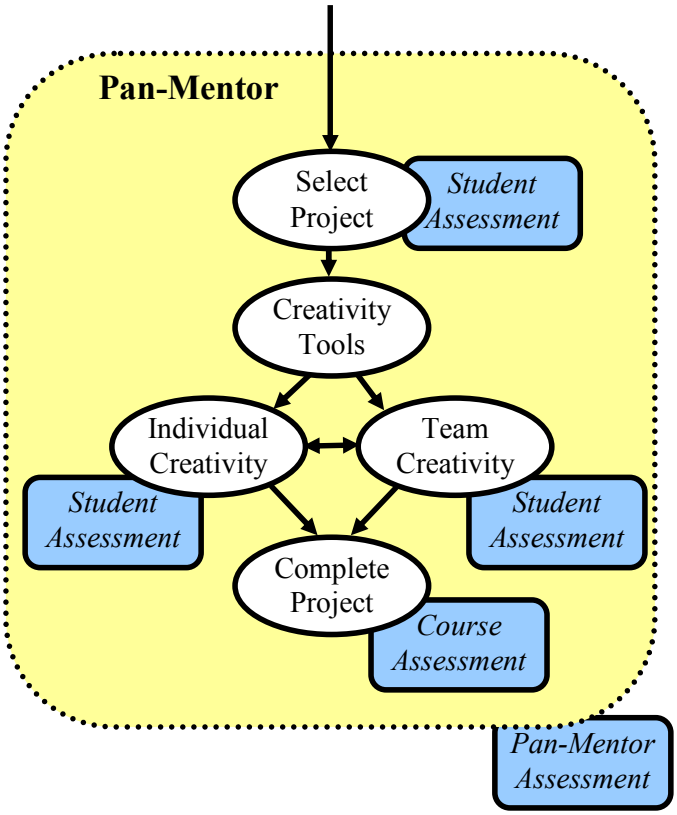

Figure 1 Assessment regime for pan-mentoring in creative design.

2. Student Assessment

How does one assess someone's thinking *process*, including the mistakes involved in this? This is the central question when facing the inevitable (?) request to assign grades for learners in engineering design classes and especially to assess their learning process. Students still adhere to traditional teaching models, where the instructor has the knowledge and the students absorb it and reproduce it for assessment. Left to generate knowledge for themselves, students often express frustration about not knowing what they are "supposed to do." Prettyman *et al.*[5], for example, cite from student journals that learners want to be given specific instructions and assume that "professors want something in particular … they are not disclosing." The pan-mentor needs to make expectations about assessments very clear in order to create a "safe place for learning."

The first tool in student evaluation, therefore, is a documentation of the learning process – in this study called the design notebook. The pan-mentor has to assure the students that the assessment of the design notebook will be based on the quality of their reflections of the learning process. Each student will keep an ongoing record of activities, questions, and comments in a design notebook. The book will have weekly entries depending on how often the groups meet and when assignments are given by the pan-mentor. The students will also enter their reflections on what has been learned or experienced, especially concerning areas of possible improvement. This notebook should contain the entire documentation of the creative engineering design process, from the earliest phases of brainstorming, to minutes of team meetings. It should also contain hand sketches, research information, and thoughts on design improvements to demonstrate individual responsibilities for the team project. The pan-mentor should point out the importance of including date and time spent on each task (e.g., time spent on internet research). While such design notebook could be conducted as a weblog, as suggested by Chen *et al.*[6], the advantage of paper design notebooks is that entries can be made anywhere, anytime, and that they allow for spontaneous concept sketches. The design notebook as an expression of reflective thinking – so important in engineering education[7] – is particularly important in the middle phase of the design process. Sobek[8] calls the phase between the basic concept and detail design the transition, commenting that it has received little attention. This is the area where reflective thinking is most required and where assessment *must* be kept to a minimum. Assessment should be limited here to acknowledgement of design notebook entries, even if they are occasionally limited to a date and a statement of frustration.

Peer evaluation is also part of the student assessment. In regard to teamwork as practiced in Industry, the team members should also rate each other's efforts. These peer evaluations should be based on a questionnaire provided by the pan-mentor, which includes ratings of team members' attendance of meetings and contributions to creative productivity, information gathering, and reflective thinking. To rate the latter, the pan-mentor should give students guidelines. Such a guideline could be: each team member needs to state the (in his or her opinion) strongest and weakest aspect of the point discussed. To rate contributions, the team needs to late each member voice at least one constructive comment (besides "Let's all get coffee"). Here, the instructor just has to act in good faith and on the assumption that students are sincere about and interested in their learning process.

The remaining last two tools are examinations and, of course, product evaluation. The examinations should not make up a large percentage of the overall grade but still reflect an understanding of the learning *process*. They should include questions about the creative design process (such as a demonstration of knowledge of the various brainstorming techniques), hand sketching techniques, research techniques and design process documentation and communication. The product evaluation, obviously, carries greater importance. While at the freshman level the assessment of the learning process is more critical, for the capstone design class the final product is imperative. Both the pan-mentor and the industrial client will conduct the product evaluation.

3. Course Assessment

The pan-mentor, the students, and industrial clients at the end of project will assess the course. For each, the assessment tool will be a questionnaire developed by the pan-mentor. For

the industrial clients, the questionnaire will ask for input regarding the relevance of the course to their company, including areas of improvements, as well as the strong points of the course. Most design projects, for example capstone design projects, will be industry sponsored. However, since the course is process oriented, the main contribution will come from the pan-mentor's introspection and from the students. Most instructors of engineering design would agree that "because design process knowledge is less concrete than most of engineering, assessing if students are learning it is very difficult."[9] Bailey and Szabo's[9] study to create an assessment tool represents a promising contribution, the continuation of which will be of interest. The student survey will address the students' attitudes concerning the design process: 'Did you feel comfortable with just stepping back and reflecting?' 'Do you feel that considerable time spent on problem definition is time well spent?' Questions like these re-enforce the importance of reflective practice in creative engineering design, both at the individual and team level.[10] When analyzing questionnaires, the pan-mentor needs to be aware of the possible draw back of such tool as listed by Olds *et al*.[11] (e.g., that the accuracy depends on the honesty of the subject). The feedback from the design notebooks on student learning simultaneously provides feedback on the course. In this paper, the only data discussed is from a questionnaire (course assessment) completed by the students.

4. Pan-Mentor Assessment

Since the pan-mentor is an essential element in the creative design education, answers to the questions mentioned above will automatically reflect on the pan-mentor. For example, how comfortable a student feels about making revisions, both during individual and teamwork, is influenced strongly by the pan-mentor's encouragement and reassurance. Still, the questionnaire could include questions like 'Did the instructor relieve some of your anxiety?' 'Did the instructor give equal attention to all team members?' Since accessibility is an important characteristic of the pan-mentor, the questionnaire should include a feed back on accessibility.[12]

Another function of the pan-mentor is her/his influence on team building. While Bannerot's study on the "characteristics of good teams"[13] found almost no correlation between team performance and individual member characteristics and that practical factors, such as setting up times for meetings, were more influential, Leonard *et al.*[14] emphasize the instructor's influence on functional roles on student teams. They stress that, unlike in industry, student teams should be offered a breadth of learning experiences rather than a narrowing down into specializations. Particularly at the freshman level of engineering design classes, the pan-mentor can and should continually monitor heterogeneous composition of teams (after all, evidence of, for example, gender specific behavior, such as communication patterns, does exist) and the rotation of roles. The pan-mentor needs to find a way of letting students practice unfamiliar skills without their risking a lower grade for the team. A questionnaire should consequently include questions concerning the pan-mentor's effectiveness in this regard. Program objectives and course syllabi are also appropriate documents to give a feed back on the pan-mentor.[4]

5. Application

For the last three years the concept of pan-mentoring has been practiced at a university, in the context of capstone design course. Its application is currently being explored in freshman engineering at another university. A sample questionnaire for a freshman class is shown in

Figure 2. This questionnaire was completed by two different freshman classes in the fall of 2005. The first class used weed-trimmers as design projects, while the second group used robots (BOE-BOT). The data presented in Figure 3 and Figure 4 was that of the group that used the weed trimmer as class project. This class consisted of 32 freshmen, three of whom were part-time students. The class had seven teams with 4-5 members, and these projects were conducted for a period of five weeks. The questionnaire analysis of this group is shown in Figure 3 (questions 1 through 14) and Figure 4 (questions 15 through 27).

The robot projects had 11 design teams consisting of 2-3 students. The projects only lasted a period of two weeks. This class met once to receive instruction from the instructor. The students also had a wealth of information from the robot website. The tasks the robots performed at the end of the project were determined by each group utilizing as many capabilities of the robot as possible. The analysis of the questions 1 through 14 of the questionnaire is shown in Figure 5. The analysis of the questions 15-27 of the questionnaire is shown in Figure 6.

The distinction between the full-time and part-time students was made to see if there were significant differences in their appraisal of the course and the approach of pan-mentoring. For the weed-trimmer project, a distinction between part- and full-time students reflects more confidence in part-time students to work on their on (responses to items 9 and 26) – possibly because of their perception of team member attendance (responses to item 1). For the robot project, where part-time students rated team member attendance very high, item 9 ("learning to work in teams is important") is rated high too. Generally, the part-time students rated the items in the questionnaire slightly higher than the full-time students. With the number of part-time students being so small the results of such comparison may not be statistically significant. Additional data will be collected and analyzed to see if the distinction should be upheld.

All together, the course ratings were positive. Some of the items are particularly reflective of the goals of pan-mentoring, such as: design as process, importance of brain storming as reflection, teamwork, independent work. show an average of 3.8 on a scale of 1 to 5. The items particularly relevant to pan-mentoring were items 5, 7, 8, 12, 18, 19, 20, and 27. Other items relate to the aspects to an engineering design course.

It should be noted that this questionnaire relates to the course assessment of the assessment regime as shown in Figure 1. It is not part of the comprehensive student assessment and comprehensive pan-mentor assessment as discussed in section 2 and section 4. As discussed in section 4, a separate questionnaire pertaining to the pan-mentor's effectiveness will be constructed.[1, 3] Also, another course evaluation, if not expressed in numbers is the feedback from the design notebooks on student learning.

Criteria for Assessing Freshmen's Design Project

Team number or Name :
Work experience (effective years) :
Engineering related work experience (years) :
Equivalent full time college experience :
(years or approximate hours completed) :
Estimated college gpa :
Academic Major :

Please respond to the following statements indicating the degree to which you agree or disagree with each.

		Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	NA
1	My team members attended most of team meetings.						
2	My role as a team member was clearly defined						
3	We had enough time to work out of class						
4	I feel that the team meetings were effective						
5	We gathered sufficient info. before moving on to the next step						
6	My teammates were reflective with their ideas						
7	Considerable time was spent brainstorming, problem defining						
8	We had enough time to step back and reflect						
9	Learning to work in teams is important						
10	Members of the team being part time had problems meeting for the project outside the classroom						
11	If everyone in the team lived close to each other, we would have been able to complete a more effective project.						
12	Everyone contributed his or her talents						
13	I liked working in a team						
14	I liked working in MY team						
15	I would change teams if I could						
16	I think my team worked effectively						
17	I enjoyed this class						
18	I learned a lot by myself						
19	I learned a lot from my team members						
20	I learned a lot from my instructor						
21	I have experience with hand and power tools						
22	Working with a senior level student is helpful						
23	The time allocated to complete the project was enough						
24	The learning goals of the project have been met						
25	This project helped me learn new skills						
26	I would have been able to complete this project by myself.						
27	By the end of the project I felt I would be comfortable in working with a more complicated project.						
	Overall Rating	**5**	**4**	**3**	**2**	**1**	

The effectiveness of my team was reduced because of……
___ our inability to establish a team leader
___ one (or more) disruptive team members
___ personality conflicts among team members
___ long travel distances for meetings
___ one (or more) disinterested team members
___ conflicting work/class schedules
___ too many team leaders

(fill in any other reason)

List 3 strong points on the course:
1
2
3

Do you think the project needs improvement, if so, what?

Figure 2 Sample questionnaire for a freshman class.

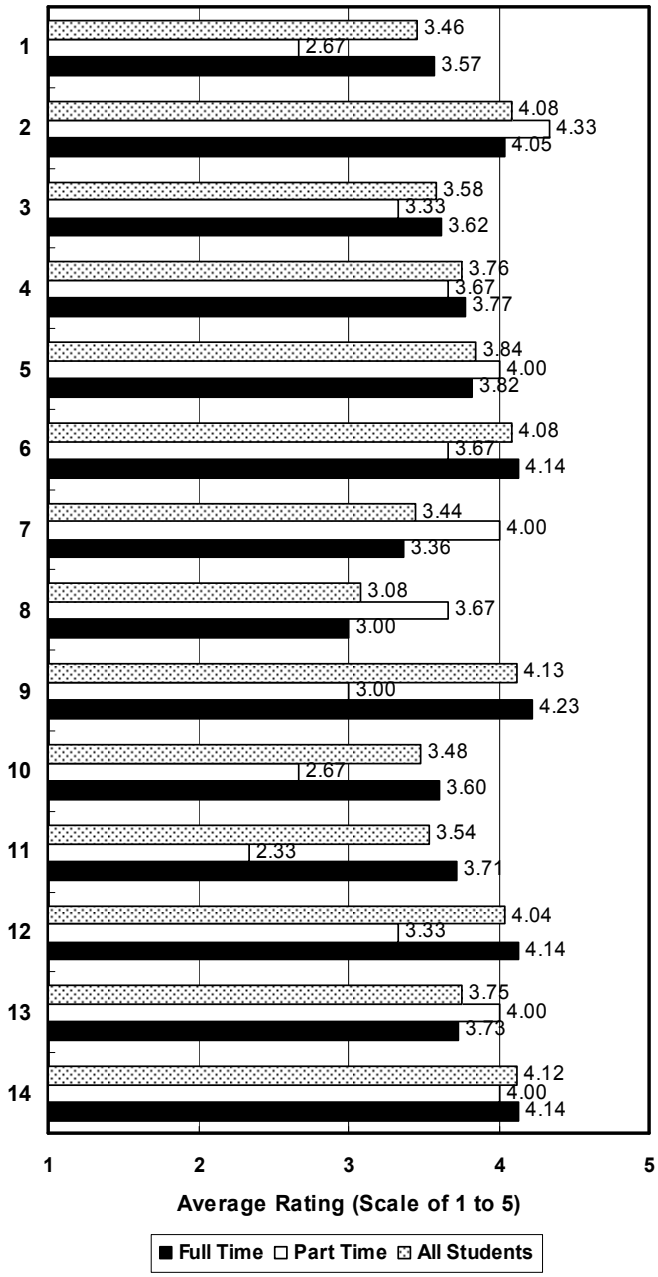

Figure 3 Analysis of Question 1 thru 14 (Weed-Trimmer Projects).

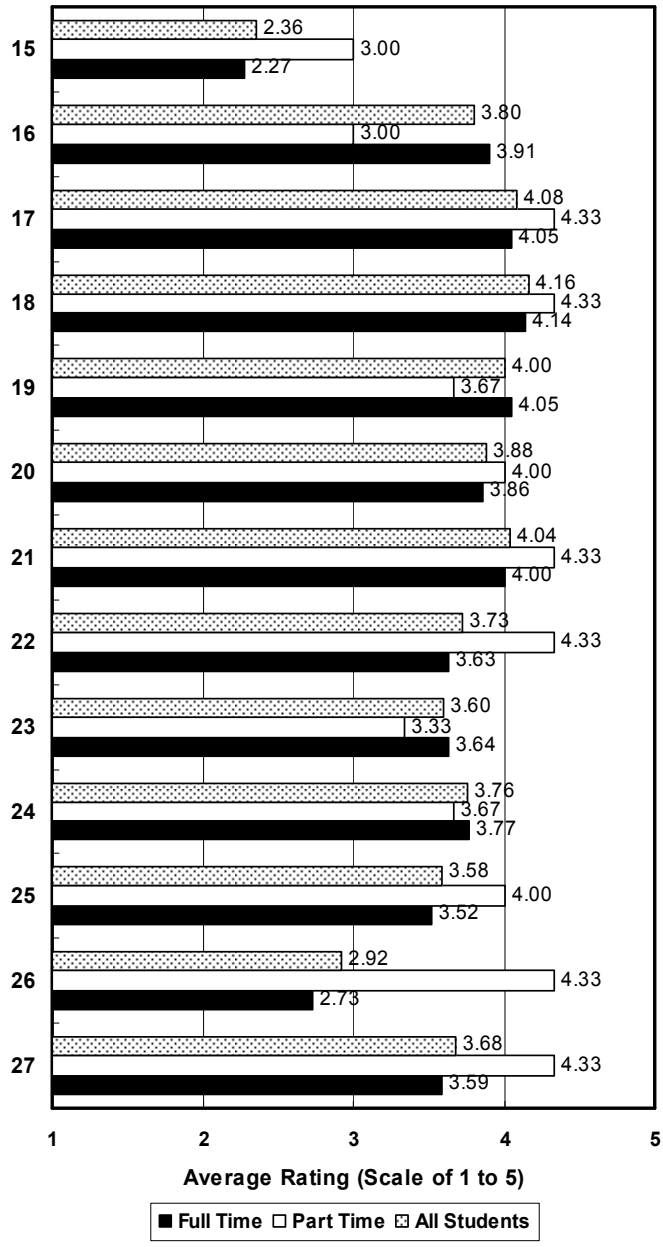

Figure 4 Analysis of Question 15 thru 27 (Weed-Trimmer Projects).

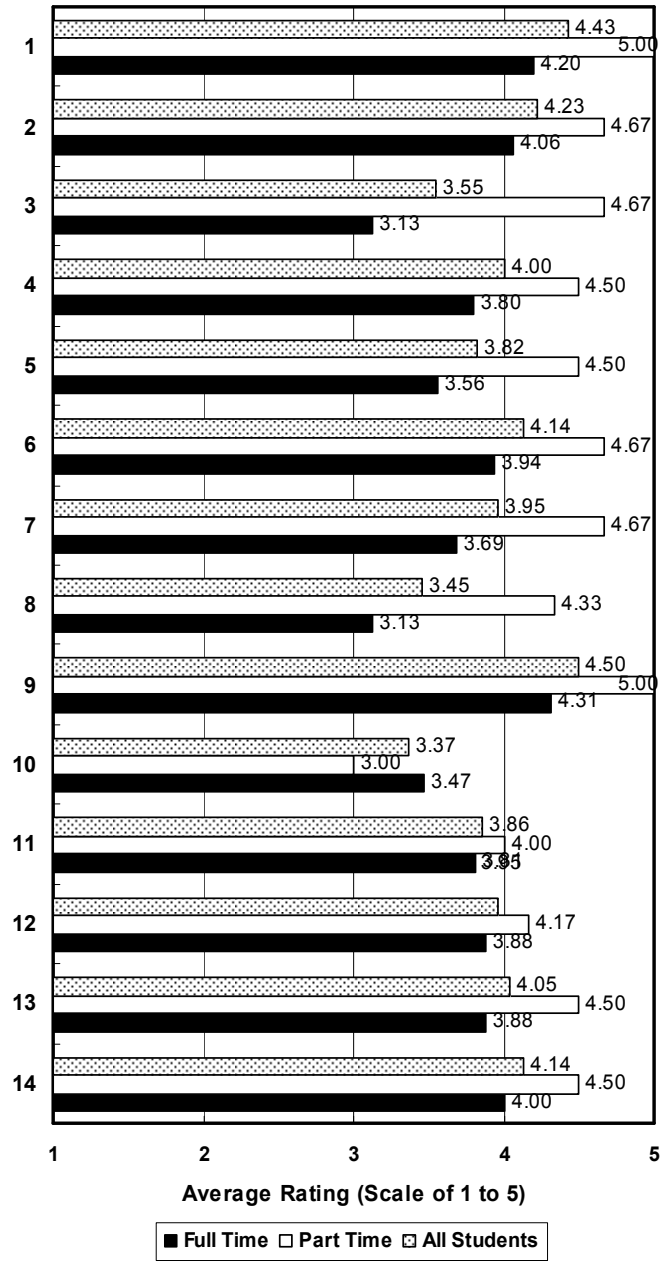

Figure 5 Analysis of Question 1 thru 14 (Robot Projects).

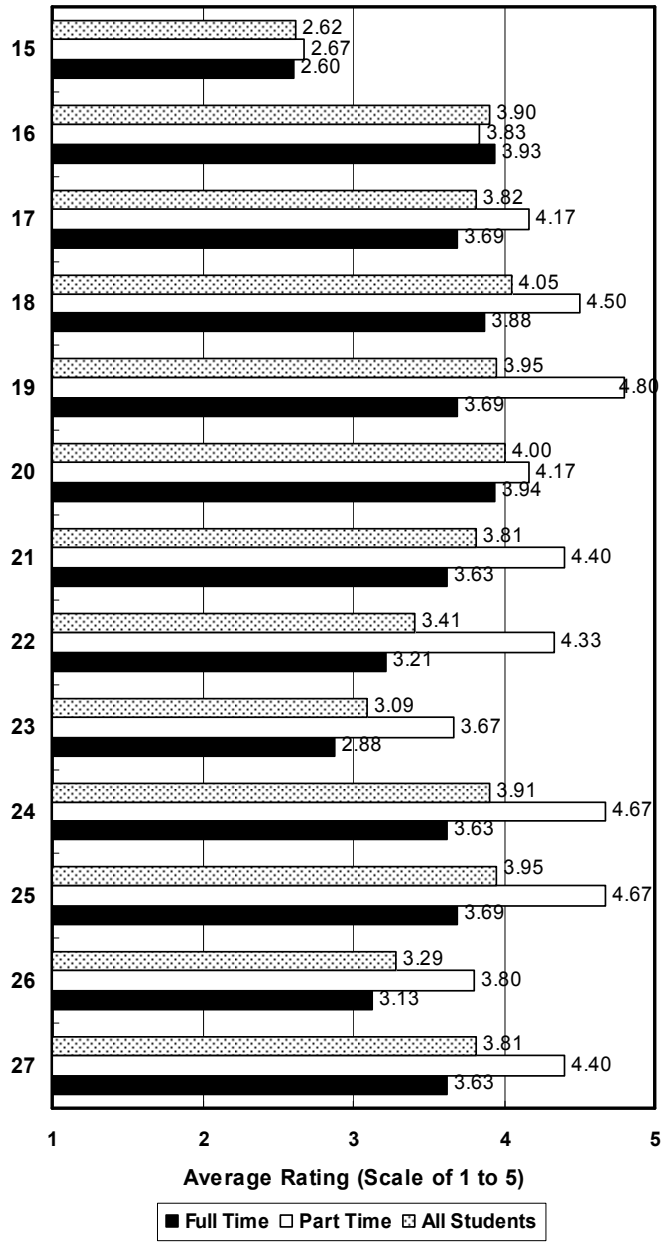

Figure 6 Analysis of Question 15 thru 27 (Robot Projects).

6. Conclusion

In this paper, an assessment regime was developed and discussed for the three elements of pan-mentoring in creative engineering design, namely, (1) the students' learning process (student assessment), (2) course development, and (3) pan-mentor. It describes the various assessment tools for each of the elements, for example the design notebooks (for student assessment). In this paper, the only data discussed is from a questionnaire for course assessment completed by a statistically small sample of students. The results from this part of the assessment regime were favorable; however, these student questionnaires have to be applied in further iterations. Additional, a separate questionnaire pertaining to the pan-mentor's effectiveness will also be constructed.

7. Acknowledgements

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