Research and Practice on the Examination Reform of Robot Operating System and Development Practice

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Abstract. Assessment is an integral part of the processes of teaching and learning, the methods of adding usual performances to final exam scores couldn't adapt to the training requirements of next generation of talents. Taking "Robot operating system and development practice" as an example, this paper discussed the purpose of implementing curriculum examination reform, and established an assessment system of combining formative evaluations and summative evaluations. The assessment system was applied to the whole curriculum teaching processes, to explore of curriculum examination reform. The results showed the assessment methods had improved the students' self-study abilities and comprehensive abilities. 95.2% of the students agreed the curriculum assessment reform had a positive impact on improving the education qualities.

Keywords: robot operating system and development practice · examination reform · formative evaluations · summative evaluations

1 Introduction

The course of "Robot Operating System and Development Practice" is a professional basic course for the undergraduate mechanical engineering specialty of our college, which has the function of undertaking the follow-up professional background courses. Through the study of this course, the framework principles and operation mechanism of open-source robot operating system (ROS) can be summarized; the simple robot application systems based on ROS can be built, which using machine vision, speech recognition, simultaneous localization and mapping, autonomous navigation and other technologies; practical problems in relevant fields, combining professional knowledge and robot technology, can be solved.

The assessments commonly adopted in this course were to convert the scores of students such as daily homework, experiment reports, final examinations and so on into the total scores of the course according to a certain proportion, and the final examination scores accounted for a large proportion of the total scores of the course [1]. This assessment methods were mainly evaluated the learning effects of students and the teaching effects of teachers though the final examination results of students. Students couldn't

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record the data of their daily autonomous learning behaviors through this assessment methods, and it was difficult to evaluate their autonomous learning and research learning abilities. At the same time, teachers couldn't get the feedbacks of students' current learning statuses, and it was difficult to do good jobs in the continuous improvement of teaching schemes and teaching designs.

Therefore, this course is guided by the educational concept of "student-centered, output-oriented and capacity-generating", effectively strengthening the managements of students' learning processes, improving the assessment and evaluation methods of course teaching, exploring multiple, multi-agent and multi-form course assessment and evaluation methods, further improving the assessment and evaluation methods of combining formative evaluations and summative evaluations, practically establishing a scientific assessment and evaluation system, and better integrating knowledge, abilities and qualities as one of the education thoughts really through the whole processes of teaching curriculums.

2 Methods and Strategies of Curriculum Assessment Reform

2.1 Establish an Assessment System Based on the Course of the Whole-Process

Combining with the teaching objectives of the course, this course adopts the assessment methods combining formative evaluations and summative evaluations [4]. Formative evaluations run through the whole processes of project-based teaching, including quantitative evaluations and qualitative evaluations. Unit evaluations and project completions are used as the bases for quantitative evaluations and qualitative evaluations, accounting for 10% and 40% of the total scores respectively. The final evaluations replace the "traditional paper examinations" with the practical projects at the end of the course, and thoroughly examine the students' abilities to solve practical problems using robot technology, including quantitative evaluations and qualitative evaluations. The qualities of the design reports and the completions of the practical projects are taken as the assessment bases for quantitative evaluations and qualitative evaluations, accounting for 10% and 40% of the total scores respectively.

Hence, the function of the assessment methods can be defined by

$$T_i = \alpha_i F_i + \beta_i S_i \tag{1}$$

where, T_i is the final marks of the ith student, α_i is the proportional coefficient of formative evaluations and equal to 0.5, β_i is the proportional coefficient of summative evaluations and equal to 0.5.

Herewith, F_i is the ith student's formative evaluations, which can be estimated by

$$F_i = \varphi_{i1} f_{i1} + \varphi_{i2} f_{i2} \tag{2}$$

where, φ_{i1} is the corresponding coefficient of the ith student's quantitative evaluations and accounts for 20% of formative evaluations, φ_{i2} is the corresponding coefficient of qualitative evaluations and accounts for 80% of formative evaluations, f_{i1} is the scores of quantitative evaluations, and f_{i2} is the scores of qualitative evaluations.

And S_i, the ith student's summative evaluations, can be formulated by

$$S_i = \gamma_{i1} s_{i1} + \gamma_{i2} s_{i2} \tag{3}$$

where, γ_{i1} is the corresponding coefficient of the ith student's quantitative evaluations and makes up 20% of summative evaluations, γ_{i2} is the corresponding coefficient of qualitative evaluations and makes up 80% of summative evaluations, s_{i1} is the marks of quantitative evaluations, and s_{i2} is the marks of qualitative evaluations.

2.2 Design Formative Evaluation Types and Subjects

Formative evaluations include two parts: quantitative evaluations and qualitative evaluations. They mainly evaluate three aspects: independent learning, abilities and qualities development and thinking improvement. They adopt the combination of online and offline approaches, and introduce multi-agents such as "cloud class" teaching platform, teacher evaluations, student self-evaluations and student mutual evaluations.

Quantitative evaluations, namely unit evaluations, include two different forms of assessments: pre-class tests and chapter tests. The pre-class tests are "fine-grained" assessments. Before each project is taught, the students are going to carry out the pre-class tests by browsing PowerPoint files, videos and other resources provided by the teachers. The types of the pre-class tests are mainly multiple-choice questions and judgment questions, which mainly check students' grasp of the basic concepts and the key and difficult points of knowledge taught by the projects. The chapter tests are "phased" assessments, which are mainly carried out after the explanations of the corresponding knowledge units. Two phased tests are arranged during the semester, which are released regularly and completed within a limited time. According to the needs of the types of questions, in addition to multiple choice questions and judgment questions, they can also be fill-in questions, short answer questions, programming questions, etc. Students can fill in the gaps according to the formative evaluations, and teachers can also adjust the teaching schemes and teaching designs according to the students' achievements.

Accordingly, the ith student's quantitative evaluations of formative evaluations, f_{i1}, can be further expressed as

$$f_{i1} = \psi_{i1}^1 f_{i1}^1 + \psi_{i1}^2 f_{i1}^2 \tag{4}$$

where, ψ_{i1}^1 is the corresponding coefficient of the ith student's pre-class tests and accounts for 40% of quantitative evaluations, ψ_{i1}^2 is the corresponding coefficient of chapter tests and accounts for 60% of quantitative evaluations, f_{i1}^1 is the marks of pre-class tests, and f_{i1}^2 is the marks of chapter tests.

Qualitative evaluations mainly examine the completions of students' teaching projects [2–4]. The teaching projects take the practical activities in the field of transportation as the main line, and conceive the project contents at different levels including basic training projects, skill training projects and comprehensive application projects to construct a "three-stage" project-oriented learning practice system. The basic training projects include the basic knowledge of ROS, which can be set up ROS system architecture, ROS communication mechanism and ROS simulation visualization subprojects. The skill training items include the core general components of ROS, which

can be specifically set up with man machine interfaces, motion control and coordinate transformation subitems. The comprehensive application projects include ROS specific application components, which can be set up with voice processing, image processing, positioning and navigation subprojects.

Different assessment methods are adopted for different types of projects. The basic training projects are independently completed by each student. The teachers check them one by one and then score them. The skill training projects and the comprehensive application projects are completed in the form of groups. Students freely form a development team with 2–3 members in each group. It is required that members have clear divisions of labor to ensure the workloads. In the assessment and acceptance processes, each project team will demonstrate the conceptions, designs, implementations and operations of the projects through oral defense, and expound the core technology and codes. The teachers will give the project results and scores according to the demonstration effects and defense situations of each team. The project results and scores given by the teachers are based on the group as the unit, and the scores of each member are determined according to the workloads he or she undertook in the projects. The qualitative evaluation scores of each student are revised through the workloads of self-evaluations and mutual evaluations [5].

Therefore, f_{i2}, the ith student's qualitative evaluations of formative evaluations can be described by

$$f_{i2} = \zeta_{i2}^1 f_{i2}^1 + \zeta_{i2}^2 f_{i2}^2 + \zeta_{i2}^3 f_{i2}^3 \tag{5}$$

where, ζ_{i2}^1 is the corresponding coefficient of the ith student's basic training projects and makes up 30% of qualitative evaluations, ζ_{i2}^2 is the corresponding coefficient of skill training projects and makes up 35% of qualitative evaluations, ζ_{i2}^3 is the corresponding coefficient of comprehensive application projects and makes up 35% of qualitative evaluations, f_{i2}^1 is the scores of basic training projects given by teachers, f_{i2}^2 is the scores of skill training projects, f_{i2}^3 is the scores of comprehensive application projects, f_{i2}^2 and f_{i2}^3 are given by teachers(40%), self-evaluations(30%) and mutual evaluations(30%).

2.3 Determine the Final Evaluation Forms

The final evaluations adopt the practical projects methods at the end of the course. The teachers will assign several selected topic projects two weeks before the end of the course. The difficulties of each selected topic project are roughly equivalent to the comprehensive application projects of the formative evaluations. The students form a development team in the form of individuals or at most two people, and select one practical project. The selected topic projects between the groups should not be repeated as much as possible. The students will complete the final practical projects under the guidance of the teachers in their space time. According to the regulations of the college's dynamic updating of course examination questions database, 20% of the practical project topics will be updated every academic year. The final evaluations include two parts: quantitative evaluations and qualitative evaluations. The specific design is as follows:

Quantitative evaluations: the teachers evaluate the qualities of the design reports submitted by the project teams from the aspects of project scheme designs, circuit designs, software designs, test results, summary reflections, etc.

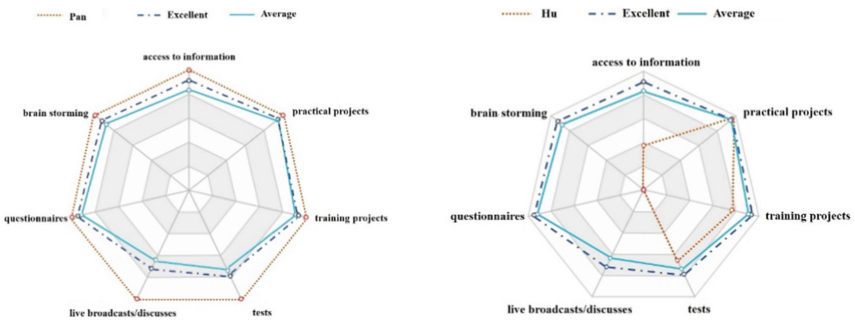

Fig. 1. Comparison of student learning (drawn by myself)

Qualitative evaluations: the teachers evaluate the achievements of the students' projects through demonstration reports, on-site defense and other links. The assessment methods of combining teacher evaluations, student self-evaluations and student mutual evaluations are adopted, which paying attention to student self-evaluations and student mutual evaluations and improving their evaluation proportion factors.

3 Analysis on the Effects of Curriculum Assessment Reform

81 students of 2019 and 2020 majoring in mechanical engineering in our college were selected as the research objects. The 2019 students were the control group (39 students) and the 2020 students were the experimental group (42 students). There were no significant differences between the two groups in terms of teachers, gender, age, etc. ($p > 0.05$).

3.1 Formative Evaluations Analysis

F_i, the ith student's formative evaluations based on the third-party teaching platform "cloud class", could accurately record the learning tracks of each student and timely feedback the learning effects to the students. At the same time, the "cloud class" platform presented the evaluation data to the teachers, which served as an important reference indicator for the teachers to adjust the teaching plans and teaching designs in time. Secondly, the formative evaluation results of each student were recorded through the platform to ensure that the results were fair and equitable.

Taking the two students in the experimental group of 2020 who were respectively excellent (Pan) and qualified (Hu) as examples, the individual scores of the students were compared with the average scores of the outstanding students (the average scores of the students whose scores exceeded 80% of the total scores) and the average scores of the class students, so that the teachers could grasp the dynamics of student learning, as shown in Fig. 1.

3.2 Total Course Scores Analysis

Statistical software SPSS 22.0 was used for the final scores (T_i) analysis. The measurement data were expressed by ($\overline{x} \pm s$), independent sample t-tests were used for

comparison, Chi-square tests were employed for the count data, and significance level was $\alpha = 0.05$.

The Q-Q diagrams of the scores of control group and experimental group, as shown in Fig. 2, were normally distributed.

The results of comparison between two groups of students showed that the scores of the experimental group were higher than those of the control group, but the difference was not statistically significant ($p > 0.05$), as shown in Table 1.

The proportion of students with over 80 scores in the experimental group (88.1%) was higher than that in the control group (76.9%) ($p < 0.05$), and there was no significant difference in the passing rates of students between the two groups ($p > 0.05$), as shown in Table 2.

This indicated that the assessment system based on the course of the whole-process improved the course performances of most students. The reason might be that in order

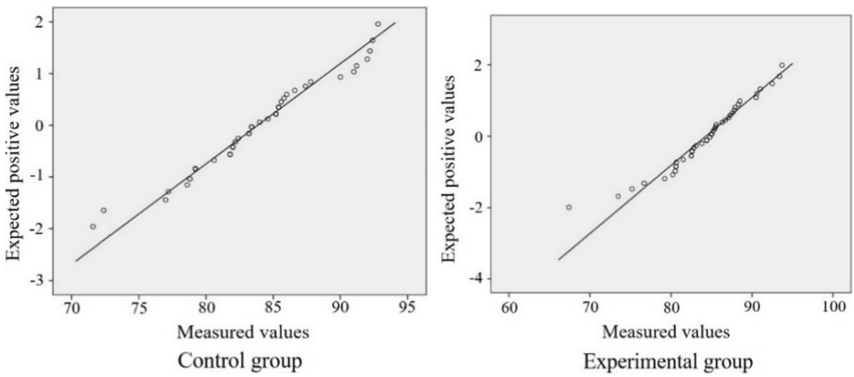

Fig. 2. The Q-Q diagrams of the scores of two groups (drawn by myself).

Table 1. The results of comparison between two groups (drawn by myself).

Groups	Scores	Levene's test	p-value	t-value	p-value
Control group	83.841 ± 0.8258	0.020	0.888	0.776	0.440
Experimental group	84.296 ± 0.8097				

Table 2. The frequency distributions of the results of two groups (drawn by myself).

Groups	Scores (%)					Total
	< 60	60–69	70–79	80–89	90–100	
Control group	0 (0.0)	0 (0.0)	9 (23.1)	23 (59.0)	7 (17.9)	39
Experimental group	0 (0.0)	1 (2.4)	4 (9.5)	31 (73.8)	6 (14.3)	42

to adapt to the curriculum examination reform, students needed to focus on the improvements of their learning consciousness. How to help students develop good learning habits will be the content that should be focused on in the next teaching reform.

At the end of the course, the course satisfaction questionnaires were given to 42 students in the experimental group, which were scored by five-point Likert scales. The questionnaires were anonymous, and 42 valid questionnaires were collected, with effective recovery rate of 100%.

The survey results showed that, as shown in Table 3, 95.2% of the students believed the curriculum assessment reform had improved their learning abilities and agreed with the methods of formative evaluations. More than 90% of the students believed that formative evaluations had promoted self-learning qualities and improved comprehensive qualities. Only 1 student thought that formative evaluations increased learning burdens, while other students did not.

Table 3. The course satisfaction questionnaires of the experimental group (drawn by myself).

No.	Items	Likert five-point scale					Ave. Scale
		5	4	3	2	1	
1	Improve autonomous learning abilities	30 (71.4)	10 (23.8)	1 (2.4)	1 (2.4)	0 (0.0)	4.64
2	Compared with traditional assessments, process-based assessments are more challenging	32 (76.2)	8 (19.0)	0 (0.0)	2 (4.8)	0 (0.0)	4.67
3	The assessment methods promote self-learning qualities	32 (76.2)	6 (14.3)	1 (2.4)	3 (7.1)	0 (0.0)	4.60
4	Through course learning, their comprehensive qualities have been improved	34 (81.0)	6 (14.3)	1 (2.4)	1 (2.4)	0 (0.0)	4.74
5	Hope other courses adopt the same formative evaluations	31 (73.8)	9 (21.4)	2 (4.8)	0 (0.0)	0 (0.0)	4.69
6	The formative evaluations do not increase learning burdens	34 (81.0)	5 (11.9)	2 (4.8)	1 (2.4)	0 (0.0)	4.72
7	Agree with the methods of formative evaluations	35 (83.3)	5 (11.9)	1 (2.4)	1 (2.4)	0 (0.0)	4.76
8	Deepen the understanding and memory of the course contents by the methods of formative evaluations	30 (71.4)	9 (21.4)	3 (7.1)	0 (0.0)	0 (0.0)	4.64

4 Conclusions

Taking the course of " Robot Operating System and Development Practice " as an example, this paper expounded the purpose and methods of implementing the curriculum assessment reform in the teaching processes, and analyzed the practical effects of formative evaluations and summative evaluations. More than 90% of the students believed the assessment system based on the course of the whole-process had promoted self-learning qualities and improved comprehensive qualities. 95.2% of the students agreed with the assessment methods combining formative evaluations and summative evaluations. But it is necessary that the assessment methods should be further improved and the teaching staffs of the course group should continue to improve teaching activities in the next curriculum examination reform.

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