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Application of Performance Evaluation in STEM PBL-- "Alternative Energy and Wind Turbine Challenge" as an Example

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Abstract:

STEM courses and performance evaluation play an important role in the implementation of core literacy, yet related concrete practices are still relatively scarce in China. This paper takes the self-designed Alternative Energy and Wind Turbine Challenge STEM project as an example, firstly, we develop a framework for the application of performance evaluation in STEM PBL, on the basis of which we demonstrate the design and implementation of performance evaluation, and test its effectiveness, and finally, we propose corresponding improvement suggestions for the shortcomings in the application of performance evaluation, in order to provide reference for STEM educators.

Keywords*: STEM, Performance evaluation, Course case design, Core literacy, PBL.*

I. INTRODUCTION

Unit design and implementation of learning assessment based on curriculum standards is an important pathway to the implementation of core literacy and a holistic curriculum structure that frontline teachers must master [1,2]. Unit design emphasizes the design of interdisciplinary learning activities and the understanding and application of knowledge, while STEM, as a new curriculum concept, integrates science, technology, engineering, and mathematics disciplines, with a focus on disciplinary integration, attention to experiential learning and "learning by doing", emphasizing independent learning and active inquiry, cooperative learning and collaborative communication, and problem-solving skills [3], and can serve the design of units based on curriculum standards. Learning assessment needs to better depict learning outcomes that reflect higher-order thinking and complex problem-solving skills [2], and traditional paper-and-pencil tests often take the form of summative assessments that can hardly reflect these learning outcomes. Performance evaluation is a method of directly evaluating the demeanor of people who apply various knowledge and their work in a particular context [4], and is often used for complex problem-solving tasks in authentic contexts, emphasizing the alignment of assessment tasks with real-life situations as well as matching assessment results with students' authentic abilities [5], and is an

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effective assessment method for promoting the implementation of core literacies [6]. STEM courses and performance evaluation both have the characteristics of focusing on authentic learning contexts, attaching importance to the learning process, and focusing on higher-order learning outcomes, and the combination of the two provides an effective reference model for frontline teachers to design and implement core literacy-oriented curriculum. A search on China Knowledge Network using "STEM" and "performance evaluation" as keywords revealed that more and more STEM programs have been designed and implemented by educational researchers and educators in China in recent years. However, there is still a lack of teachers' practice of performance evaluation in STEM programs [7,8]. Given the similarities between STEM curriculum and performance evaluation and the important role of both in the process of core literacy implementation, this paper takes the self-designed Alternative Energy and Wind Turbine Challenge STEM project as an example to first develop a framework for the application of performance evaluation, demonstrate the design and implementation of performance evaluation on this basis, and finally examine the effectiveness of its use and make suggestions for its improvement, with a view to providing reference for STEM The project aims to provide reference cases for STEM project designers and implementers.

II. FRAMEWORK FOR THE APPLICATION OF PERFORMANCE EVALUATION IN STEM PROJECTS

The researcher designed the framework of performance evaluation application throughout the STEM program based on the three elements of performance evaluation-assessment objectives based on core literacy, disciplinary literacy, and curriculum standards as the core, performance evaluation tasks based on authentic situations, and assessment scales to assess student learning levels [9] (Fig 1). The entire design process follows the principle of centering on student thinking and assessment goals. Student thinking and assessment objectives are refined and refined at three levels: core literacy, disciplinary literacy, and curriculum standards. Based on the design of the STEM project, teachers first develop corresponding assessment objectives based on the core literacy, disciplinary literacy and the teaching objectives of the STEM project; on this basis, they select some learning tasks as expressive tasks, which are both the process for teachers to guide students to achieve the teaching objectives and the basis for developing the performance evaluation rubric; finally, they design and apply the assessment rubric to Finally, the rubric is designed and applied to assess whether students have achieved the learning objectives, and to provide feedback to teachers and students' teaching and learning based on the evaluation, so as to adjust the setting of expressive tasks and teachers' teaching methods appropriately.

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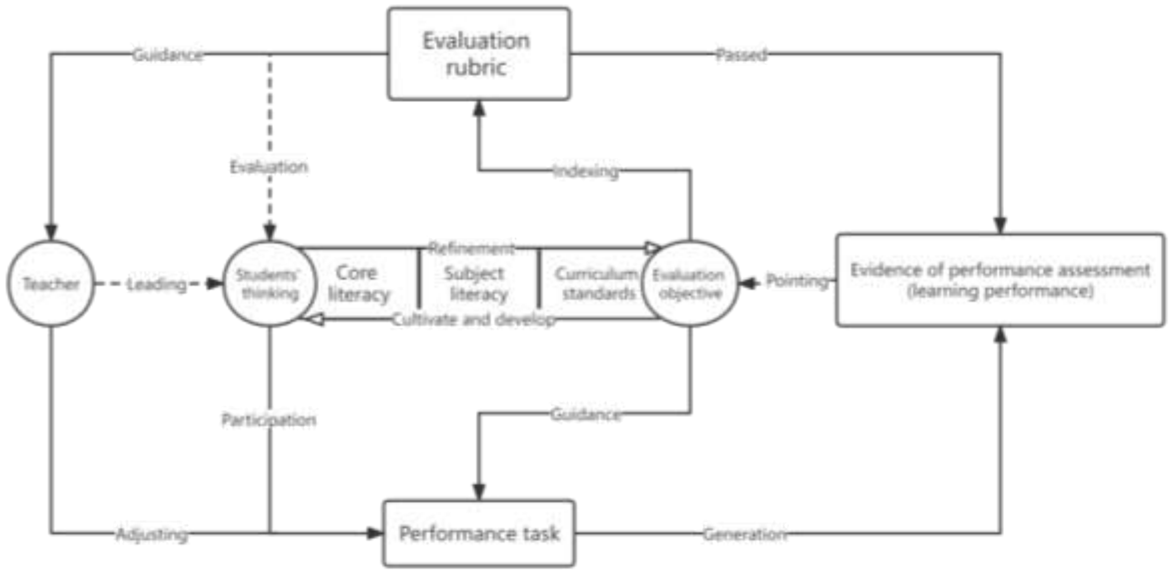

Fig 1: Framework for the application of performance evaluation in STEM project

III. OVERALL DESIGN OF STEM PROJECT

Guided by the above framework, the researcher uses the self-designed STEM project *Alternative Energy and Wind Turbine Challenge* as an example to demonstrate the design and implementation process of performance evaluation.

The *Alternative Energy and Wind Turbine Challenge* is a STEM project for 8th grade that integrates science, engineering, and math disciplines. The project is based on the context of the problems of traditional fossil energy sources and the need for alternative energy sources, and uses "solving the energy supply in the school playground" as the problem situation. Driven by the task of "using wind energy as an alternative energy source", students learn about energy sources, alternative energy sources, the principles of wind turbine power generation (Bernoulli's law, Newton's third law and electromagnetic induction) through a series of inquiry activities along the main line of the engineering task of "making a simple wind turbine". Through a series of inquiry activities, students learn about energy sources, alternative energy sources, the principles of wind turbine power generation (Bernoulli's Law, Newton's Third Law, and the principle of electromagnetic induction), and other related knowledge. In this STEM project, students learn by doing from multiple disciplines and apply that knowledge to solve complex problems in real-world situations. In addition, students continue to develop and improve their teamwork, communication and presentation skills as they participate in the project, promoting the development of core literacies.

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IV. DESIGN OF PERFORMANCE EVALUATION

4.1 Clarify Evaluation Objectives

In this project, students learn and apply science, engineering, and mathematics knowledge by engaging in scientific inquiry in a do-it-yourself manner; therefore, the researcher elaborated the STEM project evaluation objectives in terms of attitude, knowledge, and literacy based on the core literacy framework [10], disciplinary literacy [11], and science curriculum standards [12] (Table 1).

4.2 Development of Performance Tasks

Performance tasks in STEM projects need to integrate problem situations as well as the three dimensions of knowledge, attitudes, and literacy to play a role in guiding students toward specific assessment goals. Based on the science teaching model integrating engineering design proposed by Pamela S. Lottero-Perdue [13], the researcher divided this project into problem identification, investigation and research, solution design, solution making, testing and evaluation, and presentation and communication phases, with performance tasks for each phase as shown in Table I. The descriptions of these performance tasks are integrated into the problem context of the project and are compatible with the evaluation objectives.

TABLE I. Project goals and selected performance tasks for the *Alternative Energy and Wind Turbine Challenge* STEM project

TEACHING LINK	ATTITUDES AND OBJECTIVES	KNOWLEDGE OBJECTIVES	LITERACY OBJECTIVES	SOME PERFORMANCE TASKS
IDENTIFY PROBLEMS	Have a positive attitude and participate in tasks and interactions in a serious and committed manner.	1. Know the various energy sources provided by nature, understand renewable energy sources and their advantages and disadvantages, and know that wind energy is a clean, renewable energy source available in life;	1. Extract keywords, searching through multiple channels, and filtering and organizing the information obtained; 2. Determine the desired goals, determining whether the desired goals were met and determining the reasons why they were not met; 3. Select sites for wind farms based on evidence	1. Determine the fabrication requirements of the wind turbine
RESEARCH AND STUDY			1. Make reasonable conjectures about the	1. Make and test a wind turbine

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		2. Understand the working principle and structure of wind turbines and to know that wind turbines are a way of converting wind energy into electricity; 3. Understand the location of wind turbines in China and their characteristics; 4.Understand Bernoulli's principle and Newton's third law, and know how the wind drives the rotation of the windmill; 5. Know that the speed of rotation of a wind turbine is related to the shape, area, angle and number of fan blades;	factors that affect the rotation of a windmill; 2. Design a clear and complete scheme of inquiry and present the ideas for the inquiry to others; 3. Analyze the relationship between each factor and the rotation of a wind turbine based on data	2. Investigate the factors of wind turbine rotation
SCHEME DESIGN			1. Identify problem solutions with clear and actionable details; 2. Select the right tools as needed; 3. Learn to work as a team	1. Individual design of the wind turbine proposal 2. Group work together to determine the wind turbine solution
SCHEME PREPARATION			1. Learn to work as a team	1. Group work together to build a wind turbine
TEST AND EVALUATION			1. Perform appropriate operations to reduce errors and collecting valid data; 2. Analyze data and making appropriate modifications to the product; 3. Learn to work as a team	1. Test wind turbines and collect and analyze data 2. Improve wind turbines
EXHIBITION AND COMMUNICATION			1. Record and organize information and present evidence and results of the effects of wind turbine testing using scientific vocabulary, diagrams, statistical charts, etc.; 2. Express their wind turbine project learning process correctly in an appropriate manner and listen to others	1. Complete the wind turbine production, make posters and present the results

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4.3 Development of Evaluation Rubric

Evaluation rubric provides teachers with criteria for observing and evaluating students' performance in the learning process and contains three components: "evaluation indicators", "score levels", and "level descriptions" [14]. Evaluation indicators are skills or competencies based on learning activities, score levels are criteria for different levels of performance, and level descriptors are descriptions of different levels of performance.

The researcher evaluated the STEM program in the preparation, implementation, and concluding phases, and the performance evaluation was conducted mainly in the implementation and concluding phases of the program. Based on the teaching sessions in Table I, evaluation indicators for the project implementation phase were identified, including problem identification, information literacy, hypothesis building, solution design, material selection, solution making, testing and data collection, data analysis and redesign, presentation and communication, teamwork, and presentation skills. In addition, three additional indicators, "motivation", "participation" and "engagement", were added to evaluate students' attitudes and performance during the learning process. The end-of-project evaluation phase focuses on the performance, appearance, materials used, and overall effectiveness of the work. The evaluation indicators for each stage and their specific descriptions are shown in Table II.

After the evaluation indexes were determined, the researcher combined the project's problem situation and learning tasks to classify and grade each evaluation index. Since there are many evaluation indicators in Table II, the researcher took "teamwork" and "testing and collecting data" as examples to illustrate the score levels and level descriptions (Table III), where "teamwork" reflects the general core literacy, while the "testing and data collection" reflects the subject area core literacy.

TABLE II Performance evaluation indicators for each stage of the STEM project learning process

PHASE	EVALUATION CONTENT	EVALUATION INDICATORS	SPECIFIC DESCRIPTION
IMPLEMENTATION PHASE	Attitude performance	Motivation	Positive attitude performance
		Participation	Amount of tasks completed, interactive performance
		Engagement	Length and degree of concentration
	Expression of	Problem	Determine the expected goals of product creation, determine whether the expected

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	accomplishment	identification	goals are met, and determine the reasons why they are not met
		Information literacy	Retrieve, analyze and summarize information
		Hypothesis building	Initially form a solution through finding information, teacher explanation, independent study, and cooperative discussion
		Solution design	Determine the best solution to the problem and plan the details of the solution in detail
		Material selection	Select appropriate tools according to material properties and processing needs
		Solution making	Make the product according to the design plan and carry out reasonable division of labor and cooperation
		Testing and data collection	Conduct multiple tests on the product and collect valid data related to the problem
		Data analysis and redesign	Analyze the collected data and make appropriate modifications to the product according to the desired goals
		Exhibition and communication	Use scientific vocabulary, diagrams, statistical charts, etc. to record and organize information and present the process and results of the work; choose an appropriate way to express the project learning process, and be able to listen to and communicate with others' opinions
		Teamwork	Take the initiative to communicate with group members and make positive contributions to achieve common

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			cooperative goals
END PHASE	Evaluation of works	Performance	Effectiveness and stability of function implementation
		Appearance	Aesthetics, creativity
		Material	Accessibility, workability and cost of materials
		Overall effect	Degree of completion, demonstration effect

TABLE III. Evaluation rubric for performance tasks

EVALUATION RUBRIC	4	3	2	1	0
TEAMWORK	1. Be able to complete their own tasks; 2. Take the initiative to communicate with group members and make positive contributions to reach common cooperative goals.	1. Be able to complete their tasks under the supervision of the teacher; 2. Communicate with group members and make some contributions to reach common cooperative goals.	1. Not clear about their tasks; 2. Less communication with group members to make some contributions to reach common cooperative goals.	1. Not clear about their tasks. 2. Not actively communicating with group members and not making individual contributions.	Unwillingness to communicate with group members, bent on doing things their own way
TESTING AND DATA COLLECTION	Meets all of the following criteria: 1. Multiple trials were conducted or in an effective manner to reduce experimental error; 2. A large amount	Meet 2 of the following criteria: 1. Multiple trials were conducted or in an effective manner to reduce experimental error;	Meet 1 of the following criteria: 1. Multiple trials were conducted or in an effective manner to reduce experimental error; 2. A large amount	Failure to meet any 1 of the following criteria: 1. Multiple trials were conducted or in an effective manner to reduce experimental	No test or data collection

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	of relevant data is collected in a reliable manner to optimize the design; 3. The data collected meet the plan of the experimental protocol and represent the data appropriately in a variety of ways (e.g., tables, charts, graphs).	2. A large amount of relevant data is collected in a reliable manner to optimize the design; 3. The data collected meet the plan of the experimental protocol and represent the data appropriately in a variety of ways (e.g., tables, charts, graphs).	of relevant data is collected in a reliable manner to optimize the design; 3. The data collected meet the plan of the experimental protocol and represent the data appropriately in a variety of ways (e.g., tables, charts, graphs).	error; 2. A large amount of relevant data was collected in a reliable manner to optimize the design; 3. The data collected meet the plan of the experimental protocol and represent the data appropriately in a variety of ways (e.g., tables, charts, graphs).	

V. IMPLEMENTATION OF PERFORMANCE EVALUATION

In the implementation of this STEM project, to ensure the effective implementation of performance evaluation, the researcher and the teachers involved in the project used the following measures: teachers collaborated in using evaluation rubric, collecting diverse evaluation bases, identifying diverse evaluation subjects, and teachers used evaluation to improve their teaching.

5.1 Collaborative Use of Evaluation Rubric by Teachers

In the implementation of the assessment, two trained teachers were assigned to collaborate in the use of the rubric to provide peer support for teachers who were new to using performance evaluation and to ensure the accuracy of the assessment. In the implementation process, the two teachers independently scored the assessment rubric based on student performance and then used Spearman's rank correlation coefficient to test the consistency of the scores between the raters. For indicators with inconsistent ratings, the two teachers discussed the ratings with each other, explained the reasons for the ratings, and negotiated the results.

5.2 Collection of Diversified Evaluation Bases

STEM projects are conducted in complex problem contexts involving multiple learning tasks, and the students involved in them often have different learning progress and performance due to individual

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differences, so in the evaluation process of this project, teachers collect diverse evidence to support the evaluation. This evidence comes from classroom observations and classroom notes by the lead teacher or co-teacher, and from teacher-student communication, student reflections or learning journals at each stage of learning, as well as student lab reports and final design work. In the face of this diversity, teachers explore the reliability and validity of the evidence through collaborative discussions and group teaching and research.

5.3 Establishing Diversified Evaluation Subjects

The STEM program emphasizes students' active participation, and involving students in the implementation process of performance evaluation can further stimulate students' learning initiatives. In this project, the implementers of performance evaluation include teachers and students, and the forms of assessment include teacher assessment, peer assessment, and self-assessment. Teacher evaluation and peer evaluation can objectively evaluate students' performance from the perspective of multiple subjects, while self-evaluation is the students' self-reflection. It is worth noting that the choice of evaluation subjects needs to be determined according to the specific evaluation tasks, e.g., students as participants and witnesses of teamwork can more effectively evaluate the "teamwork" performance of the group members; in the evaluation of the "presentation" indicator, the teacher is better able to evaluate whether the students use scientific terms correctly and whether they reason and argue correctly about the experimental data.

5.4 Improvement of Teaching Based on Evaluation

In the STEM program, teachers were able to focus more on student performance through the implementation of performance evaluations and to reflect on and improve instruction in detail based on the gaps between students' actual performance and predetermined assessment goals. The teachers in this project identified students' poor performance at each stage of the project based on the evaluation rubric and made adjustments and improvements in subsequent stages of the project. The results of the evaluation at each stage of the project reflecting students' poor learning performance and teachers' feedback and improvement are shown in Table IV.

TABLE IV. Evaluation results and teacher feedback of each teaching phase of STEM project

PHASE	INDICATOR	EVALUATION RESULTS	TEACHER FEEDBACK AND IMPROVEMENT MEASURES
UNDERSTAND THE PROJECT	Information search	Some students were unable to collect from various aspects such as physical geographic features,	Provide students with prompts for relevant influencing factors and present them on the board to help them

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		geographical location, and weather distribution maps.	complete their data collection and initial information extraction work.
IDENTIFY PROBLEMS	Teamwork	The uneven distribution of tasks consumed time, resulting in the inability to complete the task within the allotted time.	Allow students to experience the impact that matching between developing a plan and completing it can have on completing the task, and allow more time for students to complete the task.
RESEARCH AND STUDY	Solution design	Most of the students were unable to design a detailed and specific experimental plan and had no sense of data recording.	Provide timely reminders of what parts of the plan design should be included and how to design them.
SOLUTION DESIGN	Teamwork	Most of the groups discussed intensively, got a unified opinion and started to produce, while some groups did not communicate and progressed slowly.	To facilitate groups being able to align their steps, the teacher communicates deeply with the groups to provide support and guidance.
SOLUTION MAKING, TESTING AND EVALUATION	Analyze data	Some students performed at a low level in the "Analyze Data and Redesign" indicator. When the data was relatively poor, the mood was low.	Communicate with students in a timely manner to guide them in understanding "learning from mistakes".

VI. EFFECTIVENESS OF PERFORMANCE EVALUATION IN STEM PROJECT LEARNING

In order to explore the effectiveness of performance evaluation and to inspire later improvements in the design and implementation of performance evaluation, the researcher used three sources of data: knowledge quizzes, measurement results of evaluation rubric, and teacher-student interviews to conduct a preliminary test of the effectiveness of the use of performance evaluation in this project from three perspectives: students' learning outcomes, teachers' and students' perceptions of teaching effectiveness, and teachers' and students' feelings about the use of performance evaluation.

6.1 Students' Learning Outcomes

In order to understand the students' mastery of subject knowledge, the researcher used knowledge tests to pre and post-test the students, and the test results showed that the students had good mastery of subject

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knowledge, and some difficult knowledge points (as shown in Table 5) were pre and post-tested with paper and pencil tests, and the students were also interviewed to understand the learning results of students' knowledge from both qualitative and quantitative perspectives.

TABLE V. Subject knowledge test contents and results

NO.	DISCIPLINE	KNOWLEDGE POINT	TOTAL SCORE	PRE-TEST	POST-TEST	SIGNIFICANCE (P.)
1	Science	Bernoulli's theorem	25	19.27	22.34	.000**
2	Mathematics	Linear function	25	18.60	20.45	.010*
3	Engineering	Control variable method	25	21.38	23.67	.000*
4	Science	Principle of electromagnetic induction	25	20.80	22.45	.000**

Note: **denotes p <0.01 *denotes p <0.05

By conducting paired-sample T-tests on the students' pre and post-test data, the researcher found that the students' mastery of the difficult knowledge in the program improved significantly, with a greater degree of change in students' subject knowledge in two subjects, science and engineering, and a relatively smaller degree of change in mathematics.

At the same time, the researcher conducted interviews with the students who took the test, asking them mainly about their feelings after completing the pre and post tests of the knowledge points. The results showed that most students felt that the post-test was "easier,", "clearer," and "better" than the pre-test.

In addition, to explore the changes in students' attitudes and literacy performance during the learning process, the researcher attempted to compare the average scores of the students in each item stage of the program by plotting them on a line graph according to the evaluation rubric. However, when aggregating the results of the evaluation rubric, the researcher found that some of the indicators (especially the subject core literacy indicators) only appeared in one or two project phases, and it was difficult to investigate the changes of these indicators over time; whereas the indicators of attitude performance and "teamwork" appeared throughout the project phases. Therefore, only students' attitudinal performance and "teamwork"

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performance are compared here. As shown in Fig 2, as the project progressed, students' performance in "teamwork" continued to increase, and their performance in "motivation," "participation," and "engagement" continued to increase. This indicates a positive change in students' attitudes toward learning during the project. These improvements may be related to the increasing challenge, difficulty, and interest of the tasks, but they are also related to the intervention of performance evaluation.

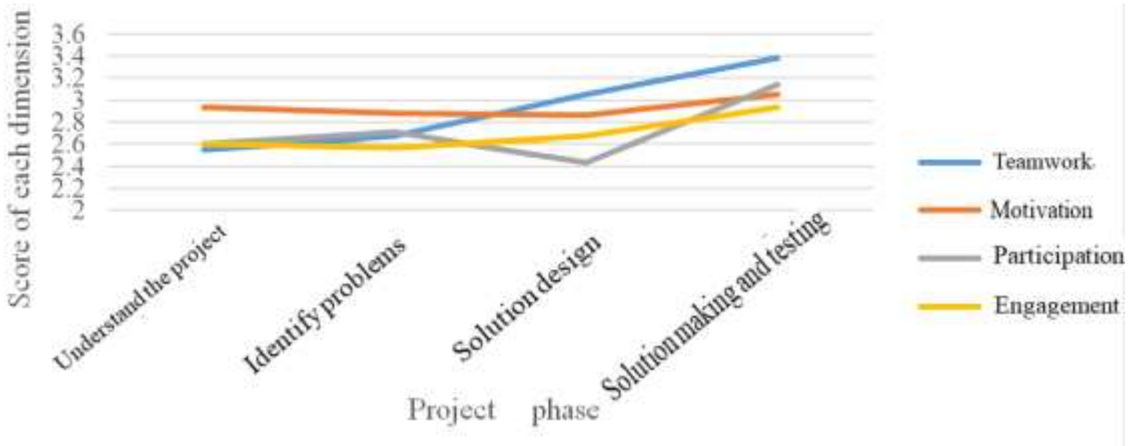

Fig 2: Changes in students' attitudes and "teamwork" performance scores in each phase of the STEM project

6.2 Teachers' and Students' Perceptions of Teaching Effectiveness

In interviews with teachers and students who participated in performance evaluation, the researchers found that both teachers and students perceived the difference between performance evaluation and traditional paper-and-pencil and summative assessment, and they believed that performance evaluation played a role in facilitating teaching and learning in STEM programs. Teachers felt that performance evaluation helped them focus on the goals of teaching and learning, making them consciously focus on the learning process and attitudes of students corresponding to the assessment indicators; it helped develop students' core competencies rather than stopping at mastering knowledge. Students believe that the indicators of performance evaluation go beyond the traditional focus of classroom assessment and make them realize the value of activity participation, active discussion, and teamwork; at the same time, they can reflect on and adjust their own learning activities through the evaluation rubric; the assessment throughout the learning process also allows students to see their own progress and think about the path of continuous improvement.

6.3 Teachers' and Students' Feelings of Use

The researcher also used interviews to understand teachers' and students' feelings about the use of performance evaluation. The results of the interviews indicated that the application of performance evaluation in STEM project learning posed a greater burden for teachers and students. For example,

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teachers need to spend a long time to familiarize themselves with the content and materials of the assessment and determine the time point to embed it in the classroom before the lesson starts; during the lesson, teachers need to pay close attention to the learning process and performance of multiple groups of students; after the lesson, teachers need to synthesize and After the lesson, teachers need to analyze the assessment results and consider improvement measures for the classroom. Students reported that the performance evaluation materials had a lot of text and were complicated to use; at the same time, the teachers' feedback on the assessment was delayed.

VII. SUMMARY AND RECOMMENDATIONS

STEM curriculum and performance evaluation play an important role in the implementation of core literacy, but there is still a lack of research on the specific application of performance evaluation in STEM curriculum in China. This paper takes the self-designed Alternative Energy and Wind Turbine Challenge STEM project as an example, and firstly develops a framework for the application of performance evaluation based on the three elements of performance evaluation, and uses this framework as a basis to demonstrate the design and implementation of performance evaluation in the project. The results of the use of performance evaluation were examined, and it was found that performance evaluation has a positive impact on students' knowledge and attitudes, and can facilitate teachers' teaching and students' learning to a certain extent; however, there are also some shortcomings in the application of performance evaluation in this STEM project, and the researcher proposes recommendations to address these challenges.

1. One way to understand students' academic progress through performance assessment is to track changes in students' scores on various indicators over time. However, the researcher found that some disciplinary literacies were present in only a single or few project phases within a single project, and the use of evaluation rubric struggled to reflect changes in students' literacy performance over the course of the project, especially in disciplinary literacy performance, such as testing and collecting evidence. Because disciplinary literacy cuts across the discipline as well as across the curriculum, teachers can combine evaluation rubric from multiple projects to assess changes in student literacy.

2. Although teachers recognize the value of performance evaluation for teaching and learning, the implementation of performance evaluation adds to the teaching load of teachers. To address this issue, the researcher identified the need for teacher training programs that would allow teachers to further understand and implement performance evaluation with the support of a professional community. In addition, information technology such as visual analytics and learning analytics have shown potential to assist teachers in collecting multiple types of assessment evidence.

3. While students agreed on the usefulness of performance evaluation, they also noted that performance evaluation is represented in a single format (mostly in textual form) and that feedback from teachers on learning lags behind. The researcher believes that information technology can be used to provide more effective feedback to students in a timely manner with a variety of representations.

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REFERENCES

[1] Zhong Qiquan. Curriculum Development Based on Core Literacy: Challenges and Topics. Global Education, 2016, 45(01): 3-25.
[2] Zhou Wenye, Chen Mingzhou, Performance Evaluation of Core Literacy. Curriculum, Teaching Material and Method, 2017, 37(09): 36-43.
[3] He Kekang. Connotation, Characteristics and Cultivation of Core Literacy. Education Sciences in China (Chinese and English), 2019, 2(03): 114-122.
[4] Matsushita Kayo. Authenticity Evaluation: Evaluating Children's Thinking and Expression. Tokyo: Standard Corporation of Japan, 2014: 6.
[5] Yang Xiangdong. Discrimination of Authenticity Evaluation. Global Education, 2015, 44(05): 36-49.
[6] Darling-Hammond L. & Adamson, F. Beyond Basic Skills: The Role of Performance Assessment in Achieving 21st Century Standards of Learning. New York: Jossey-Bass, 2014: 23-29.
[7] Wu Hongmei. Empirical Study on Performance Evaluation. Nanjing Normal University, 2007.
[8] Zhong Shihong. Preliminary Study on Design of Current Evaluation Tool of STEM Curriculum Schedule in Primary School. 2018.
[9] Zhou Wenye. Theory and Technology of Performance Evaluation in Primary and Secondary Schools. East China Normal University Press, 2014: 53-59.
[10] Core Literacy Research Group. Core Literacy Development of Chinese Students. Journal of the Chinese Society of Education, 2016(10): 1-3.
[11] The Ministry of Education of the People's Republic of China. Junior Middle School Science Curriculum Standards (2011). Beijing: Beijing Normal University Press, 2011.
[12] Guo Yuanjie. Discrimination of the Concept of "Scientific Literacy". International and Comparative Education, 2004(11): 12-15.
[13] Lottero-Perdue P S. Engineering design into science classrooms// Teaching science to every child. Routledge, 2017: 207-266.
[14] Wei Pengjuan, Xiao Longhai, Rubric Design for Appearance Evaluation. Educational Measurement and Evaluation, 2016(11): 15-20.