10.18686/neet.v2i4.4372

Research on the Advancement and Application of the Experimental Evaluation Scale Within the Primary School Science Classroom

Yuqian Zhang

Yifu Primary School, Guanchenghui District, Zhengzhou City, Henan Province 450052

Abstract: This paper develops an evaluation scale specifically for science experiments in primary schools based on research and practice. Its goals are to measure students' real performance in the experiments, bridge the gaps in related domains, and exert an effective influence on the teaching and learning of classroom experiments. During the development of the scale, the evaluation scale is constantly updated and refined through practical research to attain the anticipated evaluation outcome. The scale centers on the six aspects of students' experimental purpose: equipment selection, practical operation, observation record, equipment arrangement, and attitude responsibility, and conducts a comprehensive evaluation of students' experimental literacy in the forms of self-evaluation, group evaluation, and teacher evaluation.

Keywords: Primary School Science; Classroom Experiment; Evaluation Scale; Teaching Effect

1. Introduction

Currently, numerous issues exist in the evaluation of classroom experiments in elementary school science, including lags and incompleteness. Frontline science teachers typically adopt the traditional method for classroom experiment evaluation during teaching practices, which solely relies on the subjective judgment of teachers and lacks objectivity and standardization. Consequently, it is challenging to offer effective teaching feedback and improvement guidance for teachers. Hence, it is an urgent task to develop a set of pragmatic and effective evaluation scales for classroom experiments. In the course of implementing the evaluation in the primary school science experiment classroom, the primary consideration is what kind of development we anticipate promoting through evaluation? Which capabilities have been developed? What habits have been cultivated? In the experimental class, what do students "understand" and "be capable of doing". Based on the curriculum objectives and academic quality standards, a comprehensive evaluation scale based on literacy is constructed to reflect students' learning status comprehensively and fully.

2. The development process of primary school science classroom experiment evaluation scale

The development of the primary school science classroom experiment evaluation scale is grounded on the 2022 edition of the Compulsory Education Science Curriculum Standards and the core literacy of science. The evaluation scale results are presented in the form of grades, featuring three grades: "excellent", "good" and "poor". The main evaluators are self-evaluation, group evaluation and teacher evaluation. The development process comprises three stages: the preliminary development stage, the supplementary modification stage and the improvement stage.

2.1 Initial development stage

In the initial stage of development, the key points of the research lie in: (1) The evaluation project permeates the four scientific core qualities namely scientific concept, scientific thinking, inquiry practice, and attitude responsibility; (2) The specific contents of the evaluation items encompass: experimental purpose, experimental equipment, experimental method, experimental process, and experimental record. Thus, the prototype of the evaluation scale for primary school science classroom experiments was formed. (Table 1)

2.2 Supplemental revision stage

The preliminary developed first version of the evaluation scale was discussed in the activities of the district's teaching and research base, and the teachers raised several problems: (1) It is irrational to adopt the form of evaluation in the group evaluation and teacher evaluation since the teaching time is insufficient, and the group leader and the teacher have no time to write remarks; (2) There are excessive words in the evaluation criteria for students to comprehend.

Table 1

Evaluation Scale of Primary School Science Classroom Experiments		
School:	Class:	Name:
Experimental name:		
Evaluation item	**Evaluation criteria**	**Rating classification (Please check the mark "√")**
		self-evaluation
Experimental objective	Capable of articulating the purpose of the experiment with utmost clarity.	
	Capable of presenting the purpose of the experiment extremely clearly.	
	Incapable of clearly articulating the objective of the experiment.	
Experimental apparatus	Be capable of clearly ascertaining or selecting the equipment utilized in the experiment.	
	Capable of selecting the majority of the equipment utilized in the experiment.	
	Only a small number of the instruments employed in the experiments could be identified or chosen.	
Experimental approach	Be capable of elaborating on the method employed in the experiment.	
	Had knowledge of the experimental method but was unable to express it clearly.	
	The experimental method utilized in this experiment is perplexing.	
Experimental procedure	Be capable of actively engaging in the group division of labor, conduct scientific operations in accordance with the design steps of the experimental plan, adhere to the discipline of the experimental classroom, and maintain a high level of interest throughout the entire experiment.	
	There existed disparities in the division of labor within the group, and the operation couldn't be conducted in accordance with the design steps of the experimental scheme. Classroom discipline needs to be prompted by the teacher for compliance, and the interest in inquiry during the experiment cannot be sustained.	
	Disregard the group within the division of labor, fail to follow the design steps of the experiment scheme, neglect the discipline of the experimental classroom, display no interest in or participate in clinical trials briefly.	
Experimental documentation	The recording content is comprehensive, the writing is tidy, the content is succinct and accurate, and the phenomena in the experiment can be recorded in a timely manner.	
	The recording content is relatively comprehensive, the writing is mediocre, the content is abundant yet correct, and the experimental record is relatively complete.	
	The recorded content is incomplete, the writing is unrefined, the content contains errors, and the record of the experimental rules is absent.	
Comprehensive grade point	Excellent :Obtain at least three A's and not fewer than one.	
	Good:Obtain at least two A's and not fewer than one	
	Poor:Obtain at least one A's or none at all.	
Evaluation of Group Leaders		
Evaluation of Teacher		

To enhance the aforementioned two issues, (1) the evaluation items were transformed into 6: the purpose of the experiment, the selection of equipment, experimental operation, observation and record, equipment returning, and attitude and responsibility; (2) The evaluation content was augmented and 7 items were defined: clear purpose, accurate selection, orderly operation, control of variables, meticulous observation and timely recording, organizing equipment, cooperation and communication; (3) The evaluation criteria were streamlined to enable students to readily understand and operate; (4) Group assessment and teacher assessment were set as grade evaluation to economize teaching time. It should be noted that the implementation of the evaluation does not require conducting a special assessment independent of the teaching process, and the performance of students can be observed and recorded at any time during the learning process. (Table 2)

(1) Mark "√" after the item fulfilling the requirement; (2) Each evaluation item corresponds to three evaluation criteria. By default, the first is "A", the second is "B", and the third is "C"; (3) The column of "Total" is required to count the number of "A" obtained from "self-evaluation", "group evaluation" and "teacher evaluation" respectively, and only the number of "A" should be filled in this column. The number of "A" in "self-evaluation" is filled by the evaluated person, the number of "A" in "group evaluation" is filled by the group leader, and the number of "A" in "teacher evaluation" is filled by the teacher; (4) "Overall assessment" requires teachers to calculate the total number of "A"

Table 2

Evaluation Scale of Primary School Science Classroom Experiments					
School:		Class:	Name:		
Experimental name:					
Evaluation item	Evaluation content	Evaluation criteria	Rating classification (Please check the mark "√")		
			self-evaluation	Group leader evaluation	Teacher evaluation
Experimental objective	Definite purpose	Specify the purpose of the experiment.			
		The objective of the experiment is much clearer.			
		The objective of the experiment remains ambiguous.			
Select equipment	Precise selection	All the experimental equipment can be selected.			
		Some experimental equipment can be selected.			
		No equipment will be selected.			
Experimental procedure	Operational procedure	All the experiments were conducted in a systematic and orderly manner.			
		It was conducted in an orderly fashion in accordance with the experimental procedures.			
		Confusion regarding the experimental procedure.			
	Controlled variable	It can precisely control variables and effectively eliminate experimental interference.			
		Can accurately control variables, yet cannot eliminate experimental interferences.			
		Variables cannot be precisely regulated and experimental interferences cannot be ruled out.			
Observation recordation	Observe meticulously Real-time recording	Be capable of observing meticulously, timely and accurately recording phenomena or data.			
		One can observe carefully, but fail to record phenomena or data timely and accurately.			
		Failure to observe carefully and unable to record phenomena or data timely and accurately.			
Equipment homing operation	Completion equipment	Arrange the equipment and maintain a clean desk.			
		Arranging the equipment orderly and not maintaining the desk clean.			
		Failure in organizing equipment and failure in maintaining a clean desk.			
Attitude and responsibility	Collaborative interaction and exchange	Be highly engaged and attentively listen to other people's viewpoints.			
		Not highly engaged, and listen to others' points of view.			
		Reluctant to undertake communication.			
Aggregate					
Overall evaluation					

in "total" based on the numbers of "self-assessment", "group assessment" and "teacher assessment", and then determine the final grades of "excellent", "good" and "poor" according to the total number and fill in the specific determination method: 9 "A" or more is "excellent", and 6 - 8 "A" is "good". A score of 5 "A" or less is considered "poor".

2.3 Optimal stage

The second edition of the supplementary and revised Evaluation Scale for Primary School Science Classroom Experiments has been initially applied in the teachers' demonstration class activities in the teaching and research base of the district. However, some new problems were raised by the teachers: teachers are unable to grasp the situation of each student in the classroom and cannot grade every evaluation content, yet teacher evaluation is indispensable.

Aiming at the aforementioned issues, the evaluation scale of the primary school science classroom experiment was enhanced, without any alterations to the evaluation items, evaluation contents and evaluation criteria. "Teacher Evaluation" was designated as the final rating approach and positioned in the last column. After the improvement, it was re-applied in the teaching and research activities for teachers organized by the District Teaching and Research Office. The evaluation scales submitted by the students yielded favorable outcomes, and the teachers approved of the modified evaluation scale. (Table 3)

Table 3

Evaluation Scale of Primary School Science Classroom Experiments				
School:		Class:	Name:	
Experimental name:				
Evaluation item	Evaluation content	Evaluation criteria	Rating classification (Please check the mark "√")	
			self-evaluation	Group leader evaluation
Experimental objective	Definite purpose	Specify the purpose of the experiment.		
		The objective of the experiment is much clearer.		
		The objective of the experiment remains ambiguous.		
Select equipment	Precise selection	All the experimental equipment can be selected.		
		Some experimental equipment can be selected.		
		No equipment will be selected.		
Experimental procedure	Operational procedure	All the experiments were conducted in a systematic and orderly manner.		
		It was conducted in an orderly fashion in accordance with the experimental procedures.		
		Confusion regarding the experimental procedure.		
	Controlled variable	It can precisely control variables and effectively eliminate experimental interference.		
		Can accurately control variables, yet cannot eliminate experimental interferences.		
		Variables cannot be precisely regulated and experimental interferences cannot be ruled out.		
Observation recordation	Observe meticulously Real-time recording	Be capable of observing meticulously, timely and accurately recording phenomena or data.		
		One can observe carefully, but fail to record phenomena or data timely and accurately.		
		Failure to observe carefully and unable to record phenomena or data timely and accurately.		
Equipment homing operation	Completion equipment	Arrange the equipment and maintain a clean desk.		
		Arranging the equipment orderly and not maintaining the desk clean.		
		Failure in organizing equipment and failure in maintaining a clean desk.		
Attitude and responsibility	Collaborative interaction and exchange	Be highly engaged and attentively listen to other people's viewpoints.		
		Not highly engaged, and listen to others' points of view.		
		Reluctant to undertake communication.		
Aggregate				
Teacher evaluation				

The specific utilization approach will not be reiterated, and is essentially identical to the method stipulated in 2.2. The areas requiring special attention are as follows: "Teacher evaluation" merely represents the ultimate rating level. A total of six or more "A's" is considered "excellent", four or five "A's" is "good", while three "A's" or fewer is regarded as "poor".

3. Research Findings and Prospects

The primary school science classroom experiment evaluation scale compiled by this research has, to a certain extent, functioned as a measurement tool for primary school science teachers to evaluate students' attainment of learning goals, further enhancing teaching quality

and cultivating students' core science literacy. However, certain issues do exist.

3.1 The issues existing in the research procedur

Owing to the restriction of research circumstances, the quantity of students in the ultimate study is also extremely limited, and the variances of students' abilities in various genders, grades, and levels of schools are required to be further analyzed. Additionally, only the fundamental version of the evaluation scale has been developed. However, there are numerous categories of primary school science experiments, and there exist differences among each type of experiments. Consequently, the reference and promotion of the fundamental version of the evaluation scale possess certain limitations and cannot fully meet the assessment requirements of primary school experiment classrooms.

3.2 A vision for the future

For any scientific research endeavor, attaining perfection is out of the question. Only through continuous revision, enhancement, and refinement in future practice and application can the evaluation scale of primary school science classroom experiments become more scientific and practical. In the future, the research objects will be expanded to conduct further studies and analyses on the level differences among students of different genders, grades, and school levels in terms of problem awareness, cooperation ability, exploration ability, practical operation ability, and expression ability, thereby enriching the evaluation indicators and elements in the evaluation scale and expanding the scope of its application. Additionally, representative use cases of the evaluation scale for each type of experiment are developed, and excellent cases designed by teachers are constantly collected, with the hope of developing a set of representative and classic evaluation scale use case databases for primary school science experiments in the future. This can also serve as a reference for classroom experiment evaluations of physics, chemistry, and biology in middle school.

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