# Designing a Process Evaluation Framework for Middle School Information Technology Based on the GDINA Model

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**Abstract.** The new curriculum standard for compulsory education puts forward the proposal of reforming the teaching evaluation method, while process evaluation can provide timely feedback on students' learning status and data support for teachers' teaching strategy improvement. This study addresses the drawbacks of the current information technology course evaluation that is too general and the subject characteristics of the information technology course that is more operational, analyzes the fit between the GDINA cognitive diagnostic model and the information technology evaluation, constructs a process evaluation framework according to the characteristics of the information technology course, and finally takes the junior high school information technology course "binary and information coding" as an example of teaching evaluation practice to provide teachers with a referable The GDINA model can effectively diagnose students' mastery of information technology knowledge and provide effective data support for determining and improving information technology teaching strategies.

**Keywords:** GDINA model; Information technology teaching; Process evaluation.

## 1 Introduction

In order to further promote the development of students' comprehensive quality and the formation of core literacy, there is an urgent need for information technology teaching to improve the original single evaluation method and sound comprehensive evaluation[1]. According to Taylor, "Continuous feedback assessment can create a virtuous cycle between students and learning, enabling teaching and learning to grow and be closely linked to the development of future learning".[2] The fundamental purpose of process evaluation is to play a role in monitoring and feedback on the learning process of students, and to improve the quality of teaching by guiding teachers and students to pay attention to the teaching and learning process[3], which coincides with the current development goals of education policy. Meanwhile, cognitive diagnosis, as a newcomer in the field of measurement, has been widely researched in teaching and learning of various disciplines, providing an effective way to accurately present students' knowledge status[4].

However, most of the existing cognitive diagnostic models rely on the training of a large number of samples and the application of neural network technology, which is difficult for ordinary teachers to carry out, and the accuracy of the diagnosis needs to be improved; secondly, through the investigation and analysis of the current status of implementation of junior middle school

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information technology course evaluation, it can be found that the current evaluation of information technology teaching is based on the classical theory of measurement (CTT), and some of the feedback information from the quiz are generalized scores, which roughly cannot reflect which knowledge points or skills students are deficient in[5]. Based on this, this study discusses the fit between the GDINA model and the assessment of IT courses through the literature study of cognitive diagnostic models and the division of students' cognitive levels when learning IT courses; proposes a process evaluation framework for IT courses based on the GDINA model, which provides a methodology and a general process for teaching and learning evaluation; takes the junior high school information technology chapter Binary and Information Coding as an example for conducting teaching and evaluation research, and validate the evaluation framework from the perspectives of effectiveness, precision and applicability of teaching evaluation, respectively. By designing the general process and application practice of process evaluation of information technology courses based on the GDINA model, it can enrich the evaluation methods of information technology courses and provide theoretical and practical references for teachers to carry out actual teaching.

## 2 Related work

### 2.1 Cognitive Diagnostic Model

(1) Traditional cognitive diagnostic models

Traditional cognitive diagnostic models include DINA (Deterministic Inputs, Noisy And Gate), IRT (Item Response Theory), MIRT (Multidimensional Item Response Theory), and so on. Among them, the DINA model is a typical discrete cognitive diagnostic model, due to the simplicity of the model and the relatively good interpretability of the parameters, the prediction accuracy of the students' ability in objective questions is high, but it can not meet the needs of the application of multilevel scoring in actual teaching, and the accuracy and precision of the model's final description of the cognitive state of the students decreases when there are fewer subjects in the study[6]. IRT is a continuous cognitive diagnostic model, which is widely used in the field of psychology and educational measurement[7]. The IRT model enables multi-level scoring of students' abilities, and uses latent variables to describe the cognitive level of students, but the IRT model is more stringent in terms of the requirements of the test, and for the measurement capacity of only 40- 50 for an IT class, the distribution of subjects' abilities is not wide enough and the number of test questions is not large enough to make the accuracy of its measurement results compromised.

(2) GDINA model

The GDINA (Generalized DINA) model was obtained by de la Torre (2011) based on the traditional DINA model, which takes into account the interactions between cognitive attributes, is compensatory and saturated, and has been used in the detection of students' complex language learning abilities and the verification of whether remedial teaching in various disciplines meets expectations—been extensively studied. The specific formula of the model is shown in (1).

$$\mathrm{P}(a_{ij}^{*})=\delta_{j0} + \sum_{k=1}^{k_j^*} \delta_{jk}\, a_{lk} + \sum_{k'=k+1}^{k_j^*} \sum_{k=1}^{k_j^*-1} \delta_{jkk'}\, a_{lk} a_{ll'} \cdots + \delta_{j,1,2\ldots} k_j^* \prod_{k=1}^{k_j^*} a_{lk} \quad (1)$$

Through the analysis of existing studies, it can be found that the assumptions of GDINA in teaching practice are easier to realize, the model results are easy to interpret, compared with the DINA model, the model fit of GDINA is better, and it can also be realized through certain link function to achieve the equivalence of the transformation between the model and the other models, which is flexible[8]; compared with the IRT model, it has a lower requirement for the test, and it is not affected by the number of subjects.

### 2.2 Cognitive Level of Students in IT Programs

The learning process of information technology knowledge is the process of students understanding the basic knowledge and combining the basic concepts to practice the actual problems, it is the process of externalization of logical thinking, which is highly operational and practical. In 1956, Bloom divided the cognitive development level of the cognitive domain into six levels according to the law that people's cognitive process is from simple to complex: knowing, understanding, applying, analyzing, synthesizing, and evaluating. In the actual teaching environment, the cognitive level of students in the process of learning information technology knowledge can be judged by whether the cognitive objectives of each stage are achieved. To facilitate the course evaluation and the clustering of students' cognitive levels, the author divided the cognitive level of students' learning IT knowledge according to the characteristics of IT knowledge, as shown in Table 1.

**Table 1.** Cognitive level division of students in IT courses.

| Cognitive level | Cognitive hierarchy | Cognitive goal representation |
|---|---|---|
| Lower Cognitive Level | Realize | Understanding basic concepts and information |
| | Understand | Correctly interpret basic concepts and express them independently |
| | Realization | Achievement of results as required |
| Higher cognitive level | Evaluate | Formulation of evaluation criteria and implementation |
| | Creativity | Knowledge transfer and creation of new works |

### 2.3 The fit between the GDINA model and junior high school IT teaching

It can be found through the previous formulation that the GDINA model can not only take into account the degree of mutual influence between different cognitive attributes, but also not subject to the limitations of the amount of test data, which is easy to realize in teaching, and the cognitive diagnostic report of students' learning can not only reflect the specific cognitive attributes mastered by the students when they are learning information technology knowledge learning and operational practice, but also further predict whether the students have a higher-order cognitive level. Therefore, the combination of the GDINA model and the process evaluation of information technology teaching has certain practical significance.

# 3 Framework construction

## 3.1 Framework content

Based on the cognitive diagnostic process of knowledge content analysis, determination of cognitive attributes and hierarchical relationships, and preparation of test questions, this study builds an application framework for the process evaluation of junior middle school information technology courses based on the GDINA model by combining the relationship between the cognitive level of information technology and the characterization of the cognitive attributes, as shown in Figure 1. The evaluation framework is based on the main line of the evaluation of the course implementation process, including four parts: pre-preparation, measurement of knowledge status, characterization of knowledge level, and student analysis report.

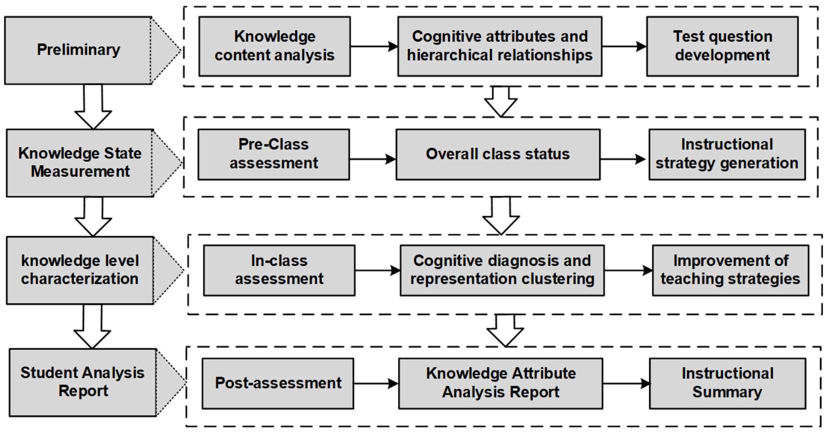


**Fig. 1.** Process evaluation framework for junior middle school information technology courses.

## 3.2 Segment Analysis

(1) preliminary

The prerequisite for cognitive diagnosis is the design of a cognitive diagnostic test instrument. Firstly, the curriculum standard, textbook content, and examination content are the basis for determining cognitive attributes and their hierarchical relationships, which can be corrected through expert interviews and students' oral reports; then the knowledge attribute accessibility matrix is derived according to the hierarchical relationships, and the extended algorithm is used to obtain the ideal response pattern of the students, which serves as the basis for compiling the test questions; lastly, after eliminating the interfering items, the test question Q matrix is obtained, and the basic knowledge test questions and operation questions test questions are compiled according to the Q matrix. Matrix to prepare the basic knowledge test questions and operational questions test questions.

(2) Knowledge State Measurement

Students do not enter the classroom with empty brains, especially in the current information society, information technology knowledge exists in all aspects of life, so the test of students' pre-existing cognitive level in the information technology classroom is a great necessity.

Teachers can point out the direction of students' learning through pre-testing, and also facilitate the development of relevant teaching strategies.

(3) Knowledge level characterization

By analyzing the cognitive level strata of students in the information technology classroom, it can be found that the cognitive level of students can be characterized according to the mastery status of cognitive attributes and goal achievement. Combined with Tomlinson's[9] theory of practical teaching KUD (Know, Understand, Do), the mastery of students' attributes is divided into shallow, medium, and deep levels, and combined with the division of students' cognitive attribute mastery clustering values, we can derive the cognitive attribute mastery and students' cognitive level of the characterization of the state of cognitive attribute mastery[10], as shown in Table 2.

**Table 2.** Division of attribute mastery.

| Tomlinson KUD theory | Cognitive goal representation | Cognitive attribute mastery |
|---|---|---|
| Realize | Understanding basic concepts and information | Not mastered |
| Understand | Correctly interpret basic concepts and express them independently | Shallow |
| Apply | Realization of the base effect according to the topic | Medium |
| Create | Evaluating and creating new work | Deep |

(4) Student analysis report

Visualization of cognitive diagnostic results can greatly improve the intuitiveness of test results and exercise students' visual literacy. Firstly, by releasing the after-school testing test questions, the student's answer situation matrix is obtained. Then, the Q matrix and the answer matrix are used as inputs for GDINA model training to get the students' score situation and attribute mastery situation respectively, and the change in students' cognitive level situation before and after teaching can be obtained by comparing the pre-test data.

## 4 Teaching experiments and analysis of results

### 4.1 Teaching experiments

The content of junior middle school information technology curriculum involves multiple modules and knowledge points, in order to test the effectiveness of the information technology process evaluation framework based on the GDINA model, this study takes the junior middle school information technology textbook "Binary and Information Coding" chapter as an example, and selects a total of 678 students in 13 classes of the seventh grade in X Middle School in Xi'an City, China, as the research object, and then takes the advantage of the informatised classroom environment to release test questions in the cloud desktop classroom environment and the online Using the advantages of the informatised classroom environment, the test questions were released on the cloud desktop classroom environment and web-based teaching platform, in which the Q-matrix based on which the test questions were written is shown in Table 3.

**Table 3.** Q-matrix for binary and information coding test questions.

| Ideal Mastery Model | A1 | A2 | A3 | A4 | A5 |
|---|---|---|---|---|---|
| Item1 | 1 | 0 | 0 | 1 | 1 |
| Item2 | 1 | 1 | 0 | 0 | 0 |
| Item3 | 1 | 0 | 1 | 0 | 0 |
| Item4 | 1 | 1 | 0 | 1 | 0 |
| Item5 | 1 | 1 | 0 | 0 | 1 |
| Item6 | 1 | 1 | 1 | 0 | 0 |
| Item7 | 1 | 1 | 1 | 1 | 0 |
| Item8 | 1 | 1 | 1 | 0 | 1 |
| Item9 | 1 | 1 | 0 | 1 | 1 |
| Item10 | 1 | 1 | 1 | 1 | 1 |

After analyzing the content of this section of the course, cognitive diagnostic tools were developed based on knowledge attributes and hierarchies, teaching experiments were carried out in stages, and finally, data were analyzed through flexCDMS and SPSS platforms. Finally, the validity of the cognitive diagnostic test results was determined by analyzing the reliability and validity of the post-teaching test papers and the results of the fit test of the GDINA model; the accuracy of the evaluation framework was reflected by analyzing the reports on the cognitive levels of the class and individual students; and the applicability of the evaluation framework was reflected by the student satisfaction survey.

### 4.2 Analysis of Results

The RMSEA index was used to fit the items to test the fit of the quiz questions. The closer the value of RMSEA is to 0, the better the fit of the item, and when the value of RMSEA is more than 0.1, the item is poorly fitted. The DINA model, GDINA model, and IRT model were used to fit and analyze the data of this practice respectively, and the final fitting results were obtained as shown in Table 4 below, and it can be found from the analysis results that the GDINA model can reflect a better fitting effect in the practice of this IT evaluation.

**Table 4**. Analytical values of quiz fitting based on different models.

| | Item1 | Item2 | Item3 | Item4 | Item5 | Item6 | Item7 | Item8 | Item9 | Item10 |
|---|---|---|---|---|---|---|---|---|---|---|
| DINA | 0.200 | 0.230 | 0.205 | 0.175 | 0.195 | 0.164 | 0.117 | 0.122 | 0.077 | 0.114 |
| IRT | 0.238 | 0.051 | 0.149 | 0.147 | 0.093 | 0.060 | 0.096 | 0.118 | 0.131 | 0.195 |
| GDINA | 0.067 | 0.032 | 0.091 | 0.021 | 0.063 | 0.075 | 0.059 | 0.68 | 0.010 | 0.033 |

At the end of the course, questionnaires were distributed to students in each class to conduct a survey on student satisfaction with the authenticity and accuracy of the evaluation methods and evaluation feedback effects during the course. A total of 643 valid questionnaires were received, and the survey was conducted on the three dimensions of difficulty of cognitive diagnostic questions, accuracy and effectiveness of test evaluation feedback, and overall satisfaction. The final level of student satisfaction is shown in Figure 2, and the results indicate that the IT evaluation framework based on the GDINA model is recognized by students, can accurately reflect the basic situation of students' knowledge mastery, and is suitable for the current junior high school IT actual teaching.

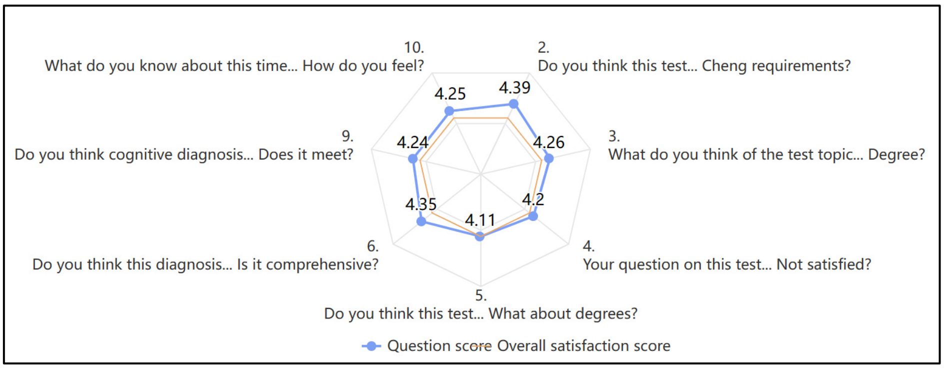


**Fig.2.** Radar chart of satisfaction survey results.

## 5 Conclusions

In this paper, based on the cognitive diagnostic theory and the assessment of students' cognitive development in the process of junior high school IT teaching, the fit between the GDINA model and the assessment of IT teaching is demonstrated, and a process evaluation framework for junior high school IT is designed. Through the analysis of the results of practical application, it can be found that the GDINA model can reliably analyze the cognitive level and attribute mastery of students in IT practice, which can intuitively get the situation of students and provide strong data support for subsequent teaching.

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