7-20-2021

Construct New Pattern of Evaluating and Training Youngsters’ Creativity

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Recommended Citation
DOI: https://doi.org/10.16418/j.issn.1000-3045.20210526002
Available at: https://bulletinofcas.researchcommons.org/journal/vol36/iss7/8

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Abstract
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Keywords
educational assessment reform; innovative quality training; adolescents; psychological development; cognitive ability

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Abstract: The core talents who support China’s innovative development and participate in international competition, on which the realization of the two centennial goals depends, are currently receiving basic education. Therefore, there is an urgent need to accelerate the innovative quality education for adolescents, and establish a scientific model of innovative quality training for the cultivation and selection of talents. Through the analysis of the current situation of innovative quality cultivation and assessment both in China and in the world, this study proposes a new model of innovative quality assessment and training based on the cognitive theory of brain science, combined with the quantitative assessment technology of psychology, aiming to change the traditional evaluation system and promote the innovative quality cultivation of Chinese youth. The quality assessment paradigm and tool set designed and developed according to this model have been tested in practice in the training and assessment of adolescents, and will be explored more deeply in the cultivation of innovative talents in the future. It is suggested that the evaluation and cultivation should be carried out mainly from the psychological personality (innovative personality) and cognitive ability (innovative ability) which are the core of innovative quality. DOI: 10.16418/j.issn.1000-3045.20210526002-en

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Innovation is the soul of a nation’s progress and the inexhaustible momentum for the national development. China will basically realize modernization in 2035 and become a modern socialist country that is democratic, civilized, harmonious, and beautiful in the middle of the 21st century. With the rapid development of brain science and artificial intelligence technology \cite{1}, it is an urgent task deserving much concern to actively cultivate a wealth of innovative talents with the current basic education system.

In the context of building an innovative country, it is of great urgency to boost innovative quality education for adolescents to keep in step with the global innovative education. The core talents who support China’s innovative development and participate in international competition, on which the realization of the two centennial goals depends, are currently receiving basic education. Innovative talent education should attach importance to not only the subject knowledge and skills in the exam-oriented education system but also the cultivation of innovative spirit and creative ability required in international competition. It is therefore urgently needed to design a scientific model of innovative quality training for cultivation and selection of talents out of the current basic education system.

It entails theoretical and practical explorations as for how to establish a scientific pattern of innovative quality training for adolescents that meets requirements of the times. Through the analysis of the current situation of innovative quality cultivation and assessment both in China and in the world, this study proposes a new method of innovative quality assessment and training based on the cognitive theory of brain science, combined with the quantitative assessment technology of psychology, aiming to promote the innovative quality cultivation of Chinese adolescents.

1 Current situation of innovative quality training and assessment in China and in the world

In recent years, the systematic training and assessment has been increasingly emphasized, which covers a wide range of innovation qualities like knowledge mining, knowledge processing, memory methods, fast reading, language expression, communication, digital intuition, mind mapping, logical thinking, imagination, concentration, etc. Many countries have invested abundant energy and financial resources in relevant research and practice and have accumulated some experience. Although starting late,
quality training and assessment in China has received wide attention and is expected to make breakthroughs in the near future.

1.1 Innovative quality training and assessment practice abroad

Developed countries have invested abundant energy and financial resources in innovative quality training and assessment. We take the United States, the United Kingdom, Japan, South Korea, and Singapore as examples for a brief description.

(1) The United States. The United States has always attached great importance to the quality training and improvement of adolescents, with particular emphasis on the innovative ability cultivation, and has constantly built new training and assessment systems to keep abreast of the times [2]. In May 2017, the Mastery Transcript Consortium (MTC), established by nearly 100 top private senior high schools in the United States, launched a dynamic electronic file—A New Model—as a new system for assessing senior high school students. The system, including 8 abilities and 61 sub-abilities, comprehensively evaluates students' innovative quality through a dynamic and continuous tracking electronic file. This assessment system has been supported by the Coalition for Access, Affordability, and Success (CAAS) and has become an important effort to assess students' innovative quality in American education circle [3].

(2) The United Kingdom. The United Kingdom attaches great importance to the cultivation of students' innovative quality and creative thinking and has launched the training model of project-based learning [4] in some colleges and universities, where students' innovative ability is cultivated when they are instructed to explore and solve complicated problems in practical project. At the same time, flexible and diverse evaluation methods are employed to protect students' individual development.

(3) Japan and South Korea. The enrollment systems of higher education institutions in Japan and South Korea evolved in a similar trend. Specifically, the adolescent innovative quality training shows the trend from single to multiple factors and from examination to assessment; the evaluation and selection mode presents the trend from single to classified and from unified to diversified.

(4) Singapore. In 2003, Singapore implemented the first fully school-based A-Level Project Assessment of Singapore-Cambridge General Certificate of Education (Ordinary Level) Examination, which rewrote the history of its national youth university entrance examination. This assessment system has been in use for years and accepted and appreciated by universities and employers.

Despite the unique characteristics in different countries, the innovative ability cultivation presents the general tendency of comprehensively cultivating and assessing students' innovative quality through practical projects while trying to avoid the negative impact of the exam-oriented education model.

1.2 Exploration of the innovative quality training and assessment in China

The long-term prevalence of emphasis on knowledge, diploma, and theory but neglect of ability, quality and practice in China’s traditional education system and teaching practice has affected the development of adolescents’ innovative quality [5]. The impact manifests in a strong grasp of test-taking knowledge, weak innovation, confinement to textbook knowledge and examination syllabus and poor comprehension of basic laws of things, not to mention prediction and application [6], in the majority of Chinese adolescents.

Many scholars and front-line teachers realize that changes must take place in the current student assessment system and value orientation to highlight the improvement effect of assessment on innovative quality education [7]. Unfortunately, there has not been a complete innovative quality assessment system in place for adolescents in China.

On June 30, 2020, the Overall Plan for Deepening the Reform of Educational Evaluation in the New Era was deliberated and approved in the 14th conference of Central Committee for Comprehensive Deepening Reform. It specified that we should adhere to science and effectiveness, improve result evaluation, reinforce process evaluation, explore value-added evaluation, perfect comprehensive evaluation, and take full advantage of information technology to improve the scientificticy, professionalism, and objectivity of educational evaluation. This Plan sheds great light on the innovative quality cultivation of adolescents and is expected to propel relevant work.

2 Construction of innovative quality training and assessment model for adolescents

2.1 Theoretical basis

(1) Definition of innovative quality. With different focuses, the definitions of innovative quality vary in expression. According to mainstream opinion [8], the innovative quality in this study mainly covers two aspects: innovation ability and innovation personality. ① Innovative ability. Innovative ability is the intelligent feature of innovation, which includes innovative thinking, innovative practice, and self-change and environment adaptability [9]. Innovative ability, the operating system of innovation, plays a role throughout the innovation activities. ② Innovative personality. Innovative personality is a personality characteristic of innovation, a relatively stable non-intellectual factor, which includes the consciousness, emotion, will, belief, mission, and value orientation of innovation. Specifically, it is manifested in curiosity, question consciousness, questioning spirit, enterprising spirit, pursuit of true knowledge, strong sense of mission, and perseverance. Innovative personality, which is the fuel of innovation, exerts a decisive influence at the critical moment of innovation.
(2) Innovative ability training and assessment. Cognitive ability refers to the human brain’s ability to process, store, and extract information, namely people’s grasp of structure, relationship between performance and other things, driving force of development, direction of development, and basic laws of things \(^{[10]}\). It is the paramount psychological factor for completing an activity. Meanwhile, it is a prerequisite for innovative ability. The two are reciprocal causation since cognition improves in the process of innovation and the improvement in cognition facilitates innovation in turn. Perception, memory, attention, thinking, and imagination are all regarded as cognitive abilities. Generally speaking, cognition is our thinking mode. People’s thinking mode will give birth to certain actions and naturally the predetermined results. A different perception of things will lead to a totally different direction of development and different result \(^{[7]}\). Cognitive ability is therefore the basis and determines the development of innovative quality. Assessment of cognitive ability will give us a clear picture of innovative quality; cognitive ability training will improve innovative quality \(^{[11]}\).

(3) Innovative personality training and assessment. Personality is the sum of personal dignity, value, and moral character. The cultivation of personality traits that are conducive to innovation or creativity is of great significance to the formation of innovative thinking and the development of innovative potential \(^{[12,13]}\). The cultivation of innovative personality should be addressed from six perspectives: social responsibility, passion for pursuing science and truth, academic character of concerning the reality and the frontier, insatiable appetite for knowledge and perseverance, courage to take the lead and the spirit of questioning and critical thinking, and open mind and the spirit of solidarity and cooperation \(^{[12]}\). The innovative personality assessment calls for the use of situational simulation test in assessment central technology, such as the leaderless group discussion and the role-playing simulation task.

2.2 Overview of the new pattern

In order to implement the reform measures of education evaluation in the new era and accelerate the innovative quality training and assessment of adolescents, this study proposes a new model for the innovative quality training and assessment (hereinafter referred to as the "new model"). On the basis of the cognitive theory of brain science, combined with the quantitative assessment technology of psychology, we carry out quantitative assessment of innovative ability and innovative personality, and train adolescents’ innovative quality in full accordance with the assessment results, thereby constructing a new assessment system out of the basic education that emphasizes subject examinations to realize early discovery of innovative talents.

This study constructs an innovation ability development and evaluation model that serves adolescents of different ages, which covers multi-methods and is all-round, full-process, specialized, standardized, and extensible (Figure 1). This model features a multi-dimensional assessment system on the basis of mature paradigms and scales in the cognitive science and psychology. It adopts the loop iteration model of “assessment–training–assessment–training” to achieve long-term tracking of adolescents’ cognitive growth and can realize individualized and purpose-defined potential development of adolescents. Besides, adolescents can also be awarded assessment certificates, which can highlight the training result, improve their innovative quality, and promote the all-round development \(^{[14]}\).

The new model serves to train talents with innovative quality. According to related theory, the training and assessment should be approached mainly from the psychological personality (innovative personality) and cognitive ability (innovative ability) which are the core of innovative quality. Accordingly, this study proposes a supporting training system that consists of multiple quality assessment paradigms (e.g., psychological assessment paradigm and basic cognitive ability assessment paradigm) and a tool set for the training and assessment of adolescents’ innovative quality (hereinafter referred to as the “training and assessment tool set”). In the application of quality assessment paradigms, different combinations of subjective, objective, full-process, individual, and group assessments can be designed to realize the training and assessment of different factors. In details, objective assessment means the computer-based online assessment; subjective assessment refers to expert questioning on the spot; individual assessment mainly involves personal ability evaluation combining computer and expert assessments; group assessment addresses group collaboration ability (i.e., the planning, organizing, and socializing abilities of each member), with emphasis on evaluation of innovative personality, and is carried out in a manner of on-the-spot subjective assessment.

![Figure 1: Innovation ability development and evaluation](https://example.com/figure1.png)
2.3 Training and assessment tool set

The tool set provides assessment case base, training library, assessment analysis algorithm module, personalized training module, and innovative quality improvement module to support the new model (Figure 2). Before the training, the training organization first organizes an online or on-the-spot test of the participants to obtain the primary assessment result. Afterwards, a customized training program is generated for the participants from the training library according to assessment analysis algorithm module to highlight the training advantages, make up for their deficiencies, and ultimately improve their all-round cognitive abilities. After a period of training, usually half a year, another assessment is carried out to examine the training performance. At the same time, changes in individuals’ innovative quality are continuously tracked to realize the quantitative evaluation of innovative quality.

In this study, we designed five quality assessment paradigms—fast reading, classification and comparison, digital intuition, super memory, and auditory attention. Assessment paradigm refers to experiment designed to verify a certain assumption about innovative quality. It contains the experiment purpose, specific process, and methods, which are used to evaluate and improve the seven cognitive abilities (perceptual discrimination, similarity comparison, logical reasoning, attention, memory, language comprehension and association, and digital intuition) of adolescents. At the same time, we built an assessment baseline and norm for each age group after collecting the data of 5,063 volunteers aged 5–15 (preschoolers to ninth graders) across China. The specific design ideas of the modules are elaborated as follows.

1) Assessment case base and training library modules. ① Assessment case base. This base contains objective assessment case set, subjective assessment case set, individual assessment case set, and group assessment case set, with the assessment questions including objective multiple-choice questions and subjective questions. ② Training library. The training set in this library corresponds to innovative ability and innovative personality, including reading resource, classification and comparison resource, computing ability resource, memory resource, and attention resource for all ages.

The resource in each part is composed of texts, images, and multimedia of training cases at different levels of difficulties suitable for adolescents of different ages. ③ Assessment paradigms. We referred to the classic designs in cognitive ability assessment while designing these five assessment paradigms. For example, super memory was employed to examine one’s information association ability; auditory attention is a result of referring to the famous “cocktail party effect” in attention mechanism research; digital intuition is the only computerized adaptive testing (CAT) independent of age in the five paradigms.

2) Assessment analysis algorithm module. This module makes a real-time comparison of participants’ assessment result with the basic cognitive ability assessment result of different users in the database. At the same time, the assessment benchmark is dynamically updated based on the latest assessment results. Besides, participants can be provided with personalized innovative quality training program in combination with training set cases of each element in the training library.

3) Personalized training module. In the training phase, the training and assessment tool set randomly selects a certain number of case sets from the training library as training questions. The training questions are based on the previous assessment results instead of being the same in difficulty degree and level. In addition, special offline training courses can be organized, where professional trainers can instruct adolescents theoretically and practically.

4) Innovative quality improvement module. Participants are assessed again after they complete a period of personalized training. The result can comprehensively reflect how much their certain basic cognitive ability has improved in this period, in which way the long-term tracking of adolescents’ cognitive growth is realized.

2.4 Data-driven innovative quality education

In September 2020, we carried out a validation test of the innovative quality training and assessment model through remote online assessment across China, with our self-designed tool set. A total of 7,449 volunteers participated in the assessment, with 5,063 valid results collected. Grade/age distribution of volunteers is shown in Table 1.
### Table 1 Age/grade distribution of volunteers

<table>
<thead>
<tr>
<th>Stage</th>
<th>Grade</th>
<th>Age</th>
<th>Sample size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preschool</td>
<td>1st grade</td>
<td>6–7</td>
<td>1124</td>
</tr>
<tr>
<td></td>
<td>2nd grade</td>
<td>7–8</td>
<td>965</td>
</tr>
<tr>
<td></td>
<td>3rd grade</td>
<td>8–9</td>
<td>636</td>
</tr>
<tr>
<td></td>
<td>4th grade</td>
<td>9–10</td>
<td>445</td>
</tr>
<tr>
<td>Primary school</td>
<td>5th grade</td>
<td>10–11</td>
<td>239</td>
</tr>
<tr>
<td></td>
<td>6th grade</td>
<td>11–12</td>
<td>215</td>
</tr>
<tr>
<td></td>
<td>7th grade</td>
<td>12–13</td>
<td>69</td>
</tr>
<tr>
<td>Junior high school</td>
<td>8th grade</td>
<td>13–14</td>
<td>53</td>
</tr>
<tr>
<td></td>
<td>9th grade</td>
<td>14–15</td>
<td>55</td>
</tr>
</tbody>
</table>

Summary of influence on recognition abilities developed by the proposed method is shown in Figure 3. The development of basic cognitive abilities of the participants is basically synchronized, with the digital intuition in preschoolers and primary grades notably higher than other indexes, which is associated with the early mathematics education habit in Chinese families. Perceptual discrimination, which refers to adolescents’ ability to organize and integrate sensory information in the external environment, is low among all indexes, which suggests the urgency for adolescents to master new methods of acquiring and processing knowledge. The logical reasoning shows a downward trend over age, indicating insufficient attention to logical thinking in the current education system.

![Figure 3](image)

**Figure 3** Summary of influence on recognitive abilities developed by proposed method

With the increasing accumulation of and emphasis on education data, as well as the progress of artificial intelligence and big data technology, technology has played an ever-increasing role in promoting education development. The value of data lies in better portraying basic quality profile, optimizing innovative quality assessment, and planning the improvement path of students. The efficiency of the data-driven innovative talent assessment and training will be improved. For instance, on the basis of students’ data feedback in the innovative quality assessment, students will receive assessment model-based real-time diagnosis and then a self-adaptive adjusted assessment program so that their problems or deficiencies can be pinpointed. Or, on the basis of the knowledge graph and data recommendation technique in the innovative quality training, appropriate learning content is recommended to students so that they can have access to personalized learning path and methods.

### 3 Implications and suggestions

In the era of knowledge economy, the education of innovative talents should put special emphasis on the training of qualities that distinguish talents in national and even international competitions in addition to examination-related knowledge. Moreover, a more scientific system for the training and selection of talents is eagerly expected.

Quality education is an important component of basic education, and talent assessment serves the improvement of quality education and the cultivation of innovative talents. Considering the comprehensiveness, expansibility, and procedural characteristics of innovative quality, we built an innovative quality education assessment system for all ages beyond the examination-oriented education system. The students who pass a certain test will be awarded a corresponding assessment certificate, which will help them be recognized by education and business leaders. This can be used as a reference for selection.

It is suggested that the evaluation and cultivation of Chinese innovative adolescents should be carried out based on psychological personality (innovative personality) and cognitive ability (innovative ability) which are the core of innovative quality. Accordingly, a tool set of training and assessment has been designed, and a variety of subjective, objective, whole-process, individual, and group assessment combinations are used to achieve the training and assessment of adolescents in different directions and involving different factors.

### References

Calculated from the standardized sample test result, the norm is a standard measure for comparison, i.e. the mean and standard deviation of a standardized sample. It is a reference used to compare and explain test results in talent assessment. The test score is only meaningful when it is compared with a certain standard.

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