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A Personal Growth System Supporting the Sustainable Development of Students Based on Intelligent Graph Element Technology

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Abstract: In recent years, the sustainable development of education has become an increasing concern, and new technology characterized by intelligence has played an important role in promoting it. However, facing the endless stream of teaching platforms, learning platforms, student management platforms and learning APPs, teachers and students are tired of coping. Meanwhile, there has been a serious lack of real information about student growth, especially in the fields of electronic graphics, and audio and video materials. At present, there is no continuous student growth system that can be used over the course of their life, which is very unfavorable to their individual development. Graphic code is a technology with the potential to solve these problems; however, the existing graphic code technology suffers from clear deficiencies in the realization of a personalized student growth system that incorporates intelligence, security and sustainability. In response to this, this paper proposes a new generation of graphic code technology, namely intelligent graph element technology (IGET). Further, a new sustainable personalized student growth system model is designed based on artificial intelligence, big data analysis and intelligent graph element technologies, and the architecture and implementation of this system platform are completed. Finally, a student growth system based on intelligent code is verified through by an analysis of the results of a questionnaire survey. The research results show that, compared with the traditional student management system, the student growth system based on an intelligent graph element code has obvious advantages in convenience, intelligence, precision, security, and sustainability.

Keywords: intelligent graph element technology; smart code; sustainability; personalized education; growth system

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1. Introduction

Sustainable development is a hot issue in the international community today. In 2015, the United Nations adopted the 2030 Agenda for Sustainable Development and proposed Sustainable Development Goals, hoping to thoroughly solve the problems of social, economic and environmental development through comprehensive governance. The macro goal of sustainable development in education has been defined as "ensuring inclusive and equitable quality education and enabling all people to enjoy lifelong learning opportunities" [1], meaning that education is both an important goal of sustainable development and an important means to successfully achieve other sustainable development goals [2].

The sustainable development of education includes two aspects. First, education serves the sustainable development of the world. Second, education itself should be sustainable. That is, education is not only an integral part of sustainable development but also

a key driver of sustainable development. The Global Action Program on Education for Sustainable Development (2015–2019) (GAP), adopted by the UNESCO General Conference, aimed to generate and expand "sustainable development education." GAP proposes two goals. One is to reorient education and learning so that everyone has access to the knowledge, skills, values and attitudes that empower them to contribute to a sustainable future. The other is to strengthen education and learning in all agendas, programs, and activities for sustainable development [3]. GAP also proposes to change the learning and training environment and integrate sustainability principles into the education and training environment. Sustainable development education involves learning content and results, pedagogy, and the learning environment [4]. It designs teaching and learning in an interactive, learner-centric way, rethinks the learning environment, inspires learners to act for sustainability, and empowers learners of any age, in any educational setting, to transform themselves and the societies in which they live [5].

New technology promotes the sustainable development of education [6]. Whether it is national governance or refined discipline governance, the fundamentals of sustainable development lie in the qualitative improvement and development of human beings, and its purpose is to realize a growth of life that is sustainable. Since the 1760s, mankind has experienced three industrial revolutions. As an important driving force of the new round of scientific and industrial revolution, artificial intelligence technology (AI) may trigger the fourth industrial revolution. Over the next 20 years and beyond, AI will be an important direction of scientific, technological, and economic development [7]. AI is penetrating into all walks of life, quietly changing every aspect of peoples' daily life. The World Economic Forum (2020) released a report titled "Schools of the Future: Defining a New Education Model for the Fourth Industrial Revolution," which emphasized the importance of personalized and autonomous learning. This fully indicates that the cultivation of personalized talents has become an important proposition and a new teaching paradigm for educational development in various countries [8].

The new technology represented by artificial intelligence plays an important role in the cultivation of personalized talents [9]. The application of artificial intelligence in education has been mainly manifested as intelligent tutor systems (expert systems), adaptive learning systems, various intelligent educational administration management systems, intelligent student management systems, etc. Integrating AI into education was first started in the 1970s. Hartley and Sleeman (1973) developed a new concept in their work, "Intelligent Tutoring System" (ITS) [10], which was a computer system that mimics a teacher's experience and methods to assist in teaching; this concept was greatly developed in the 1980s. Then, the Adaptive Educational Hypermedia System (AEHS) was developed by Brusilovsky (1996), a professor at the University of Pittsburgh, and became known as the first real adaptive learning System [11]. In recent years, "learner-centered", personalized education has become the mainstream of world education development [12]. With the continuous emergence of new technologies such as human–computer interaction, emotion analysis and big data processing, as well as the deep integration of artificial intelligence with pedagogy and psychology [13], various teaching systems, learning systems and personalized student management systems have emerged [14].

Student growth systems are indispensable in modern education. They bring convenience to school teaching. They can enable teachers to put forward targeted solutions through in-depth analyses of students' learning and growth, and they can enable students to fully understand themselves and help to promote their overall development [15]. The development of student growth systems has clearly benefited from new technologies characterized by intelligence [16]. This new technology is an important way and means to realize a student growth system [17,18]. Game learning, 3D printing, UAV, artificial intelligence and other new technologies have entered the field of education. Learning methods, learning activities, learning support and learning diagnoses are constantly innovating. In the last two years, new technologies have emerged one after another, every day, every hour, and even every minute [19].

However, everything is a double-edged sword, and new technologies bring new challenges.

Firstly, there is the issue of sustainable development. Horizontally, the data of various teaching platforms, learning platforms, student management platforms and APP software platforms are not connected. Longitudinally, the data of students in different schools and ages are not correlated, forming information islands [20]. The above is not only not conducive to the sustainable development of students but is also not conducive to data collection and learning analysis, thus affecting the intelligence of systems.

Secondly, there is the problem of inefficiency. Many teaching platforms, learning platforms, student management platforms and learning apps have emerged in an endless stream, leaving teachers and students struggling to cope. For front-line teachers, diversified teaching forms and teaching tools make them feel dazzled. A teacher has to teach dozens or even hundreds of students, so it is difficult to teach students according to their aptitude. For students, they have their own learning space, their own class schedule, course scheduling system, homework system, grade system, etc., but these heterogeneous learning data are distributed in different systems, and students cannot effectively integrate them [21].

Thirdly, there is a serious lack of real information about student growth [22], especially in electronic graphics, and audio and video materials. Therefore, there are insufficient data on the growth process and status of students, which influences accurate learning recommendation and assessment.

Fourthly, system permissions are not persistent. At present, there is hardly a student development system that can be used continuously, long-term or for life. The message of student growth is not continuous and lasting. Each stage of the student management system is disconnected and has a certain use period and data retention period. If a student graduates, some data is erased. Even for teachers, it is difficult to enter the student management system [23].

This lack of information at each stage of the growth process not only affects the objective and overall evaluation of students but is also not conducive to discovering and tapping the advantages and potential of students. Therefore, people need a safe, intelligent, reliable and convenient technology to build a system that can integrate all kinds of information and can be used for a long time so as to retain the highlights of each growth stage in their lives.

Specifically, the existing student growth system needs to solve the following four problems:

(1) How to solve the problem of resource, data, and technology tool islands and make the student growth system integrated and convenient so as to improve the efficiency of the system;
(2) How to ensure the continuity and persistence of data in each stage of students' development and promote the sustainable development of students;
(3) How to maintain the integrity and authenticity of students' information and make the system more intelligent and accurate in guiding students; and
(4) How to ensure the security of students' personal data and learning data

In this study, a new technology proposed by us, namely intelligent graphic element technology, is introduced into the field of education, and a new personalized student growth system is designed. The aim of this study is to solve the integration of information technology and platform through the system, that is, to solve the "island phenomenon" of various resources, data and technical tools, and to solve the contradiction between large class teaching and individualized teaching, so as to improve learning efficiency. In addition, this study is to solve the problem of the lack of student growth information through the complete record of the student growth process provided by the system, so as to make it replicable, continuous and durable, meet the needs of personalized talent training and promote the sustainable development of education.

2. Literature Review

2.1. Graphic Code Technology

Intelligent graphic element technology is a new generation of graph code technology that essentially belongs to the graph code technology and is developed from bar and graph codes. Graphic code technology uses graphics, instead of binary data "0" and "1", as the communication text between human and machine, machine and machine. The technology stores, spreads and displays information in an intuitive form. The development of graphic code technology has gone through the following three stages, as shown in Figure 1.

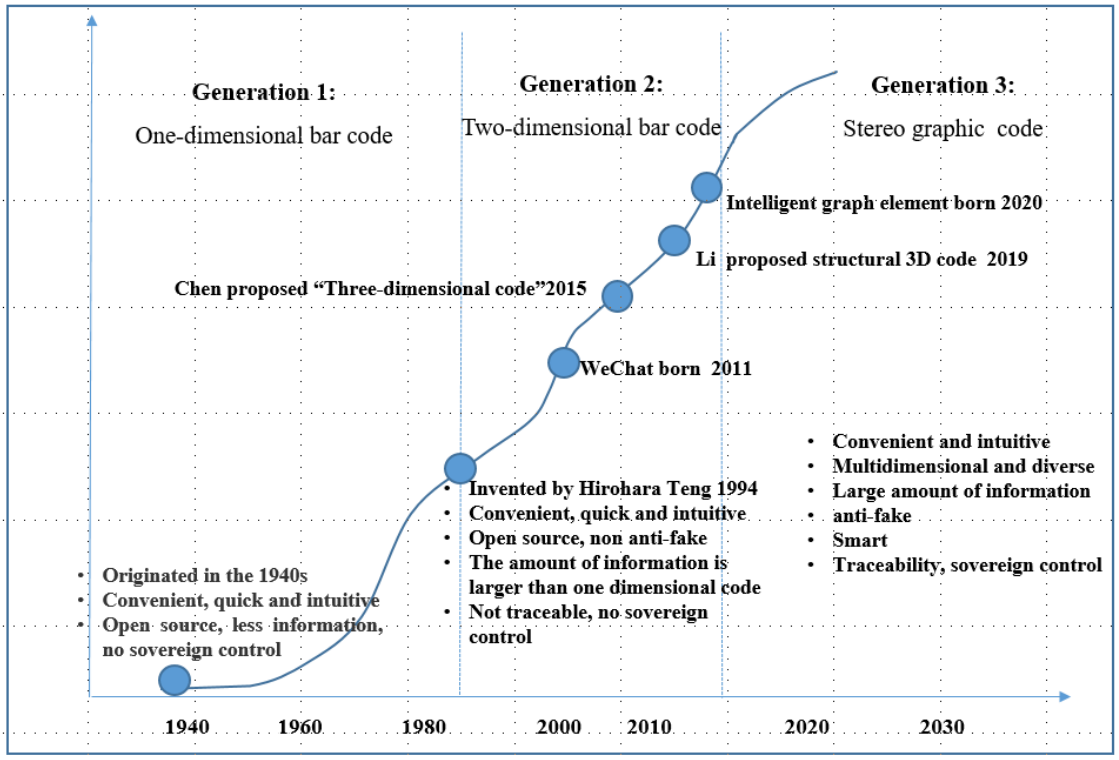

Figure 1. The development stages of graphic code.

2.1.1. The First Generation of Graphic Code Technology: One-Dimensional Bar Code

One-dimensional bar code, the earliest bar code, was born in the 1940s, studied in the 1960s, applied in the 1970s and popularized in the 1980s [24]. It is a graphic identifier that arranges multiple black bars and blanks with different widths according to certain coding rules to express a group of information.

In the 1990s, the international circulation field praised the barcode as the "identity card" for commodities to enter the international computer market [25,26]. Now the various countries and regions in the world generally use bar code technology, the application field of which is has become increasingly wide, and its use has gradually penetrated into all areas of peoples' living and production.

Bar code has the characteristics of fast speed, high reliability, convenience and low cost. However, it still has many shortcomings. First, because of the open-source nature of the bar code, there is no sovereign control ability. Secondly, barcodes can only be encoded horizontally, which is of limited length, small capacity and less information to display. Thirdly, barcodes can mark goods but less able to describe goods.

2.1.2. The Second Generation of Graphic Code Technology: Two-Dimensional Barcode

In order to solve the problem of a small amount of storage of one-dimensional bar codes, people began to study two-dimensional bar codes which can express more informa-

tion. The two-dimensional bar code was invented by Masahiro Hara of Japan [27]. It uses the principle of geometric graphics to replace binary "0" and "1" with black and white graphics to record data symbol information. The popular two-dimensional codes in China are mostly matrix type, with small black squares representing "1" and small white squares representing "0" [28].

The emergence of two-dimensional code is a milestone in the development of bar code technology. After the birth of two-dimensional code, it has not been applied in practice on a large scale. Only in the past 20 years has its use been gradually widened [29]. In 2001, China launched two-dimensional bar code plus inkjet anti-counterfeiting technology [30]. Xu, the founder of China lingkong.com (accessed on 3 June 2018) applied for the registration of a two-dimensional code scanning patent [31]. Coupled with the birth of WeChat in 2011, two-dimensional code rapidly broke out in China [32].

Compared with the one-dimensional bar code, two-dimensional code has the characteristics of large information capacity, wide coding range and strong error correction ability. However, two-dimensional code still has several shortcomings, such as low overall security, poor traceability, and single style [33].

2.1.3. The Third Generation Graphic Code Technology: Stereo-Dimensional Code

In order to solve the problems of two-dimensional code, such as linear coding, single form, and so on, people have carried out the research of graphic coding technology through different methods and ways. For example, aiming to improve the security of two-dimensional code, Chen of WeChat has carried out research on anti-counterfeiting and anti-duplication [34]. On the basis of two-dimensional code, in 2015 Chen proposed a three-dimensional code by strengthening security and increasing visual attributes [35]. Once the concept and function of this three-dimensional code were put forward, it was controversial. Li proposed the concept of structural 3D code [36]. Structural 3D code is an innovative development of two-dimensional code technology, which organically combines physical anti-counterfeiting with information technology and solves the problem of easy copying of printed "code".

However, in fact, Chen's "three-dimensional code" and Li's structural three-dimensional code are not really stereo codes.

2.2. Educational Application of Graphic Code Technology

The application of graphic code technology in the field of education has great potential [37]. In recent years, research has mainly focused on two-dimensional code teaching materials and courses, books and asset management, knowledge payment and other aspects.

2.2.1. Two-Dimensional Code Textbooks and Courses

At first, the use of two-dimensional code was limited to the book cover or back cover and used more for a publishing house's promotional means [38], as the focus on book management gradually expanded to book marketing. Later, the application of two-dimensional code in books showed a trend of deep integration with the book content. By scanning the code, readers can directly obtain various forms of learning resources [39]. It is an inevitable trend to digitize paper teaching materials and make planar teaching materials three-dimensional [40]. Two-dimensional code is printed on paper textbooks. Learners scan the code and then link to the website platform or download the app to obtain rich digital resources [41]. Such textbooks are called two-dimensional code textbooks and have become new forms of textbooks. This not only enriches the form of textbook resources and realizes the extension of learning content, but also creates a more convenient self-learning environment for learners. In addition, some researchers have proposed combining QR codes with smart phones to be used in classroom teaching [42,43].

2.2.2. University Library and Assets Management

(1) University library management.

The barcode on the International Standard Book Number (ISBN) has been used to manage books for more than half a century since 1967. This barcode management method requires manual maintenance of a Cataloguing in Publication (CIP) database. The contents of CIP need to be obtained from the publishing house or entered manually, which is time-consuming and makes it difficult to ensure the integrity of the data for management of a large number of books [44]. QR codes can contain more complex data that can be read directly, such as text, images, and web links. It can include the contents of the CIP database directly in the two-dimensional code and realize the automatic entry, scanning, processing, and identification of borrowers [45]. In China, two-dimensional code has now entered the practical application of book management.

(2) University asset management.

Two-dimensional code recognition technology can be used to complete the rapid collection, statistics, and traceability of school asset information. Relevant information such as purchase time, unit price, quantity, storage location, and the person responsible for each piece of teaching equipment and other assets are generated and pasted on the asset equipment to facilitate management. Scanning the two-dimensional code can not only track the relevant information of the equipment, but also show the assets, teaching equipment usage, precautions, and other relevant information, and is easy to use. Therefore, two-dimensional code can make asset equipment management convenient and intelligent [46].

2.2.3. Learning Record

Two-dimensional code technology can be used to record students' learning process, academic performance, and other evaluation results for a long time, and facilitate access, tracking, and verification [47]. The content of each dimension in students' learning is presented in the form of two-dimensional code. It can not only collect learning process data, but also generate students' electronic files and form a Big Data analysis model [48]. This makes it convenient for schools, teachers, parents, and students themselves to fully understand each student's unique learning trajectory [12].

2.2.4. Knowledge Payment

At present, learners can pay through QR code after receiving teaching services in China [49]. With the rise of knowledge payment platforms such as Fenaan, Zhihu Live, and Himalayan FM, it has gradually become commonplace to pay for valuable knowledge, experience, and insights [50]. WeChat and Alipay are adopted in many cases of learning consumption, and cash payment is becoming less common. After the learners scan the QR code, payment can be completed in a few steps according to the requirements of the online learning resource provider, which is simple and convenient.

In addition, QR codes are also used for student identification, intellectual property protection, and traceability [51].

Although the application of two-dimensional code is very wide, the open source, security and single form of two-dimensional code leads to its relatively weak ability in identification, traceability, personalization and anti-counterfeiting [52]. Therefore, there will be some restrictions in the application of some important scenarios of educational informationization, such as students' growth space.

2.3. Student Growth System

There is no unified connotation and definition about the student growth system in the academic circle. There are many forms of correlation, and their content often intersects. Similar to the student growth system, there are the student growth management, student growth evaluation and student growth file systems.

2.3.1. Student Growth Management System

Since the 1990s, the development of science and technology has entered a new stage. In recent years, many countries have begun to invest and develop similar information recording systems, which are used to record students or school related business data. At the same time, the emergence of electronic record systems also provides a good foundation and the necessary background [53]. The growth recording system can guide the growth of students and has great advantages in this field, and then the daily growth can also be recorded into the system [54]. A large number of application systems and research have emerged. Chen, Yang and Iloeje et al. (2010) have pointed out that the comprehensive evaluation of college students is a key issue to be solved urgently in current quality education [55]. Wei and Zhao (2015) and Zhao, Wang and Zhu (2019) adopted the B/S development mode to establish the fuzzy evaluation model and algorithm, which greatly improved the management efficiency of students [56,57].

2.3.2. Student Evaluation System

Student evaluation is a very important link in education. Correct evaluation of students can make them more fully aware of their strengths and weaknesses, so as to stimulate students' learning motivation. It is also beneficial for teachers to have a more comprehensive and in-depth understanding of the situation of students and improve their teaching. The content and means of the student evaluation system are varied. After the 1990s, American student education evaluation began a reform of student academic evaluation in the field of basic education [58]. Performance assessments and portfolio assessments were developed rapidly [59,60]. The Program for International Student Assessment (PISA) is the most famous student assessment program in the world at present, and the indicators they provide have a wide international impact [61]. Among these, PISA's multi-angle evaluation based on reading, mathematics and future perspective has a huge impact on the student evaluation system of the whole world [62]. Now the reform of student evaluation is closer to the direction of student-based evaluation [63]. In the student-centered evaluation, the content of authentic student evaluation is added. The authentic student evaluation system reflects the diversified evaluation viewpoints with student development as the core. The research results of Mehrabian, a famous psychologist, show that students' emotional expression comprises 7% words, 38% voice, and 55% facial expression [64].

2.3.3. E-Learning Portfolio

Electronic Learning Portfolio is generally shortened to Electronic Portfolio or Electronics File. Electronic Portfolio is a concepts very similar to the Student Growth Management System. People have tried to apply the research results of the portfolio to education and teaching step-by-step and have achieved very good results. Barton and Collins pointed out that when making and using a portfolio, three key elements: purpose, evaluation criteria and evidence should be considered [65]. The purpose of the portfolio determines its form and content. The evaluation criteria of the portfolio should be specific and explicit. The evidence in the portfolio should include learning outcomes, personal reflections, social practices, and evaluations of learning outcomes by teachers and students. Barton and Collins from Stanford University first used archives in teacher education and presented the teaching and learning process of teachers and students in a simple and intuitive way, so as to understand the growth experience of teachers and students [66]. Judith, Arter and Vicki et al., believed that the contents of the block bag could include students' participation, the criteria for selecting portfolio works, students' self-reflection, and so on [67]. Meyer, Abrami and Wade et al., believed that portfolio application in school teaching should be combined with the theoretical framework of self-management learning, which is mainly reflected in the improvement of learners' personal cognition, learning motivation and enthusiasm of learning participation. The research of Meyer, Abrami and Wade et al., found that teaching with the help of an electronic archive helps students to improve their learning efficiency and autonomous learning ability and has had a positive effect on the

improvement of students' learning skills [68]. Torras and Mayordomo have argued that the teaching process requires the concept of coherence to construct, execute and interpret a web-based learning environment [69].

In summary, in order to improve efficiency, the information system has been gradually introduced into the student management of the school, and the related research has been continuously deepened. However, the current student growth system or similar student growth system still has some problems, such as poor convenience, low efficiency, student information loss, limited time limit, information discontinuity, and poor system security. What is more, worldwide, there are many schools with student growth records that did not achieve information construction, or stayed in the manual stage [70,71].

3. Design of New Student Growth System Based on Intelligent Graph Element Technology

In view of the shortcomings of the current student growth system, in order to realize its intelligence, sustainability, safety, convenience, and personalized functions, we designed a new student growth system based on intelligent graph element technology.

3.1. Innovation of Graphic Code Technology: The Proposal of IGET

Different from other researchers' research methods and paths, we carried out research on the new generation of graphics code technology and proposed the concept of intelligent graphics element technology in 2020. Graph element refers to the basic graphic elements, such as the basic plane geometry, square, rectangular, trapezoidal, circular, diamond, oval, etc., or basic three-dimensional geometry, such as square, rectangle, cylindrical, and square column, and color (red, orange, yellow, green, green, blue, purple, grey, pink, black, white, brown) combination. Intelligent graphic element technology uses graphics instead of the current computer numbers "0, 1", as the communication between human and machine and machine to machine. Storage, dissemination and display of information are in an intuitive form. Different from open-source bar codes or two-dimensional codes, which store information in a linear matrix formed by interlacing straight lines horizontally and vertically, the graph element technology (see Figure 2) uses curve interlacing or straight-line interlacing with a curve, that is, using graph element encoding to store information. Its drawing rules are diverse and its drawing styles are rich. It can attach other specific information and use the geometric algorithm and structured encryption [72]. By the integration of other intelligent algorithms and technology, therefore, we call it intelligent graph element technology. The resulting graph code is called intelligent graph element code. The intelligent graph element code, referred to as intelligent code, smart code, identity code, and personality code, which retains the advantages of two-dimensional code, and adds multi-dimensional and changeable, visual recognition, accurate interpretation, high encryption, anti-counterfeiting, and anti-duplication functions. It controls information storage, transmission, and interpretation of information through the geometric algorithm and structured encryption.

Figure 2. Intelligent graph element code.

Compared with traditional two-dimensional bar code, intelligent graph element code has the following advantages.

a. More styles and more information. It can generate not only black and white code, color code, plane code, and stereo code, but also static code and dynamic code. The storage capacity is larger, about 3–5 times that of ordinary two-dimensional code.
b. High security. The encryption rules are varied and the security is high. The information in the code will not be easily changed or imitated by others. Only the owner or agent of the code can use the key to change the information in the code.
c. Traceability function. It cannot be copied or forged, and has a good traceability function, that is, the coding key has direct control and traceability ability for each code.
d. Intuitiveness. It is visible to the human eyes. Without scanning the code, the identity of the code can be recognized directly by vision. Each code has a destination and the owner is the source of the code identity.
e. Personalized customization. The style can be customized, and the code scanner, the time and duration of information reading can be set individually by the owner. The code owner can control it remotely.

In addition, for intelligent graphic code technology, scanning code is not restricted by the network, and the code can be read both online and offline.

3.2. Model of Student Growth System Based on Intelligent Graph Element Code

Based on the above intelligent pixel technology, we designed a student growth system, a model of which is shown in Figure 3. The system adheres to the student-centered development concept, takes intelligent graph element code (IGE code) as the core, integrates multiple education platforms and various education technologies, and automatically links each stage of students' growth into a continuous, safe and reliable, traceable and reproducible whole process data record. A code accompanies a person's whole life

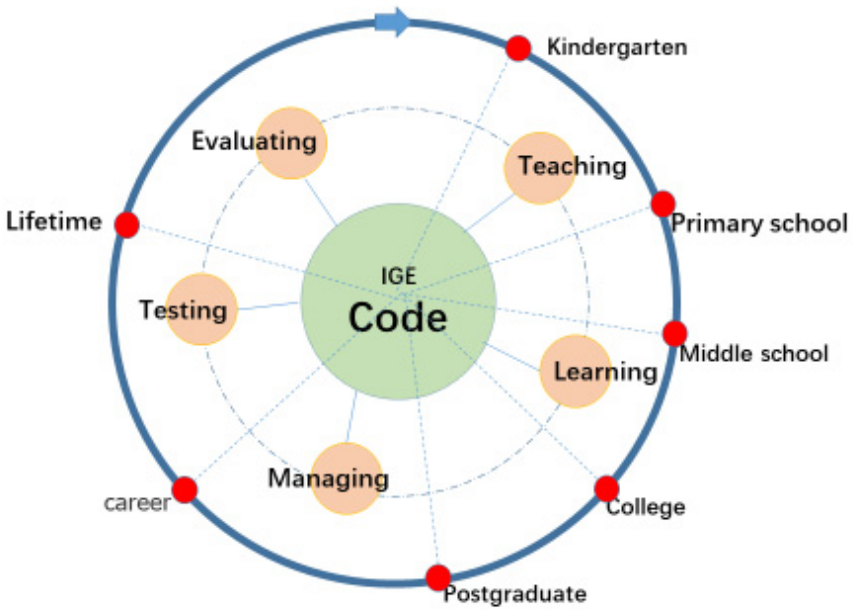

Figure 3. Model of student growth system based on IGET.

First of all, a personality code that can be used for life is customized for each student according to their own needs, becoming an IGE code. Then, with the code as the core, the system can collect information in time and link the growth information of students at all stages from kindergarten to integrate the data of teaching, learning, management, measurement, and evaluation. Finally, a complete and continuous special electronic information

growth database will be established for everyone. The system includes seven stages and five aspects from the beginning of education.

The period from kindergarten, primary school, middle school, university, and postgraduate education to the stage of work and retirement can also be summarized into five stages: pre-school education, basic education, higher education, vocational education, and lifelong community education. There is only one fixed smart code equivalent to an ID card in one's life. One code accompanies a person's whole life, which can urge people to strengthen credit management, which is of great significance to people's personalized development.

The content and service of each stage of students' growth mainly include five aspects: teaching, learning, management, measurement, and evaluation.

- Teaching. Adhere to the student-centered, teacher-led education philosophy. This is mainly manifested in the following two aspects. (1) Personalized teaching. In the aspect of lesson preparation, teachers can download a large number of high-quality teaching resources from the system and can quickly upload teaching materials or generate a new smart code for students to scan and learn. In terms of teaching methods, the system provides teachers with rich teaching tools and classroom forms and supports the full-time interaction between teachers and students. (2) Personalized guidance. Teachers and students can repeatedly interact with the smart code. Due to the unique identity of the smart code, teachers can accurately find the students and the knowledge points they need to strengthen. On the one hand, teachers can accurately seek out students' learning needs and recommend personalized learning materials. On the other hand, students can offer feedback and their individual thoughts to teachers, so that they can reflect on how to carry out education services accurately.
- Learning. The outstanding feature is individuation, which is shown in the following three points: (1) Personalized learning content. By scanning the code, students can obtain cross-platform, cross-media learning content and learning resources according to their authority, making it convenient for students to undertake independent self-learning. (2) Personalized learning process. By scanning the code, students can interact with teachers and classmates, get timely individual guidance from teachers and share knowledge with classmates. The learning growth system can automatically record students' learning track, and it allows students to actively record their learning behavior, such as uploading pictures, audio and video. (3) The design of personality code. According to the students' personality characteristics, the exclusive graphic code is generated. The personality code is generally generated by students' names, so it can be quickly and accurately identified by the naked eye.
- Management. On the one hand, smart code facilitates campus management. The system carries out analysis and decision-making according to students' learning data. On the other hand, a smart code can manage a student's information properly. For example, a student's growth information can only be viewed by users who have been granted permission. It can respect and protect personal privacy and achieve automatic, safe, orderly and efficient management.
- Measurement. On the one hand, through the smart code, students can communicate with the teacher in time and ask for the teacher's guidance, including the guidance in study and life, as well as emotional and psychological counseling, until they pass the evaluation. On the other hand, through the smart code, the system can automatically analyze and judge the learning status of students. On this basis, the system recommends related learning resources to students until they pass the evaluation. Then, the system provides the exercises of the defective knowledge points. Students can practice and consolidate around these repeatedly and get comprehensive evaluation reports.
- Evaluation. According to the real-time and multiple learning data and life data generated by the smart code, the system conducts multi-dimensional learning evaluation and comprehensive evaluation on students.

The student growth system based on IGE code provides a fast channel and personalized learning platform integrating various educational technologies for students' individual growth and provides students with targeted and optimized learning programs. The system meets the needs of school administrators to optimize the allocation of teaching resources, to improve teaching quality and teaching competitiveness, and it provides big data decision support for education authorities and education policy makers.

3.3. Architecture of Student Growth System Based on IGET

The sources of the big data of student growth are multi-faceted, multi-level and multi-dimensional. It is not enough to support multi-level and multi-scene analysis only by relying on the learning behavior data generated in the process of classroom teaching, other big data that relate to the growth of students also need to be collected through intelligent code. The architecture of the student growth system based on intelligent code is shown in Figure 4. The system architecture consists of several main parts, such as the smart code management center, user layer, data analysis layer, cloud storage layer, and technical support and connection layer.

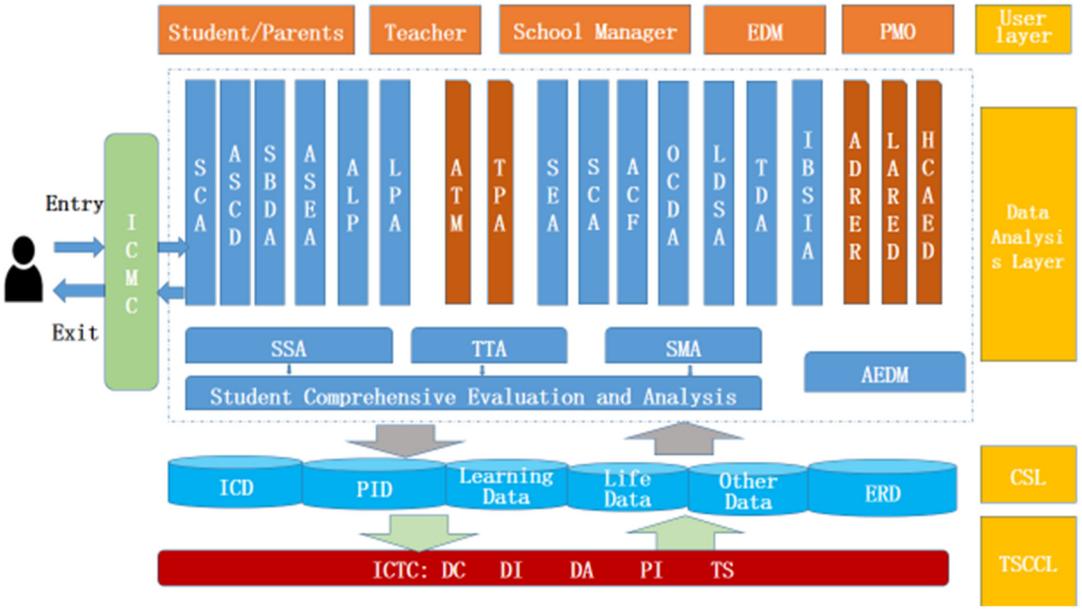

Figure 4. The architecture of the student growth system based on the intelligent code. Notes. ICMC: Intelligent Code Management Center; SCA: Student Characteristic Analysis; ASCD: Analysis of Students' Cognitive Dimension; SBDA: Student Behavior Dimension Analysis; ASEA: Analysis of Students' Emotional Attitude; ALP: Analysis of Learning Participation; LPA: Learning Performance Analysis; ATM: Analysis of Teaching Methods; TPA: Teaching Performance Analysis; SEA: Student Enrollment Analysis; ACF: Analysis of Campus Flow; OCDA: One Code through Data Analysis; LSDA: Learning Space Data Analysis; TDA: Teaching Data Analysis; IBSIA: Internet and Book Service Information Analysis; ADRER: Analysis on the Distribution of Regional Educational Resources; LARED: Longitudinal Analysis of Regional Education Development; HCAED: Horizontal Comparative Analysis of Educational Development; EDM: Educational Decision Maker; PMO: Platform Maintenance Operator; SSA: Student Study Analysis; TTA: Teacher Teaching Analysis; SMA: School Management Analysis; AEDM: Analysis of Educational Decision Making; ICD: Intelligent Code Data; PID: Personal Information Data; ERD: Educational Resources Data; CSL: Cloud Storage Layer; ICTC: Intelligent Code Technology as the Core; DC: Data Collection; DI: Data Interchange; DA: Data Analysis; PI: Platform Integration; TS: Technology Support; TSCCL: Technical Support for Convergence Connectivity Layer.

- The smart code management center mainly completes the functions of student registration, personality code design, identity authentication and system login. It is not only the entrance and exit of the student growth system but also the core of the system.
- The user layer includes students, parents, teachers, school administrators, education decision-makers and platform operation and maintenance parties, which mainly complete the data and resource interaction of teaching, learning, management, measurement and evaluation. This process is realized by smart codes representing their own identities.
- The data analysis layer mainly completes the multi-dimensional data analysis of students' growth process, such as the analysis of learners' characteristics, cognitive, behavior, emotion, participation, and learning performance. These data are collected from the registration information, the learning process, the results of learning, and the interaction data of teachers and administrators and etc., through smart code. This layer eventually forms the comprehensive evaluation of students.
- The cloud storage layer is mainly used to store related data and resources. Due to the large amount of data information in the process of everyone's growth, the special cloud storage service transfers most of the information from the smart code to the cloud storage layer, which improves the work efficiency of the smart code.
- The technical support and connection layer mainly completes the technology development of smart code, data connection, data encryption and data analysis of different information platforms.

It can be seen that the smart code can input and query information in time. This allows students, teachers and school administrators to create a variety of high-value content information interactions on the student growth platform. The system can provide students with a visual, multi-dimensional and three-dimensional comprehensive quality evaluation. Furthermore, it expands further the ability of the internet to serve students, and greatly gives play to the value of students' information.

4. Experimental Design

In order to verify the function effect of the student growth system based on intelligent code, we conducted the following experiment.

4.1. Participants

The participants were classes of 71 junior high school students who were randomly assigned to a control group with 35 students (male: female = 17:18) and an experimental group with 36 students (male: female = 18:18). All of the students were taught by the same teacher.

4.2. Research Methods

The control group adopted the traditional student management system mode, and the experimental group adopted the student personalized growth system mode based on IGET. The experiment was conducted in the second half of 2019, from September 2019 to January 2020, for a full fall semester. Generally, when students use the system, they need to go through registration, coding, scanning, interaction, query and other five processes.

- Step 1: Registration. Students submit their personal information and register on the student growth system based on IGET.
- Step 2: Coding. First, the coder of the smart code management center generates a special smart code for each student with his/her name, such as "Wang Yiming," as shown in Figure 5. The human eye can directly identify the code's attribution, and the information in the code includes the basic information (name, gender, place of origin, ID number) and other growth information. One person, one card, can be used for life. Then, the smart code is highly associated with the student growth system and encrypted to avoid personal information leakage. Finally, the smart code is printed on the student card.

- Step 3: Scanning. Code scanning is decoding, which is completed by the decoder of the smart code management center. Only the code owner has the authority to decode. When using the smart code for the first time, users need to download the growth platform APP on their mobile phones. Users can log in to the system by scanning the smart code on the student ID card through the APP.
- Step 4: Interaction. After scanning the code successfully and logging in to the growth information system, students can have instant interaction with teachers and classmates, get timely individualized guidance from teachers and help from other students, and also share knowledge with classmates. At the same time, students can easily obtain cross-platform and cross-media learning content and resources according to their rights, which is convenient for students to study independently. For example, users can upload, download, save, edit and view their information and other resources, as shown in Figure 6.

Figure 5. Smart code generated by name is printed on the student card.

Figure 6. Interacting through smart code.

- Step 5: Query. Thanks to the lifelong proprietary property of the smart code and the cross-regional and cross temporal characteristics of the student growth system, students' growth information in different ages and different schools can be recorded, saved, edited and viewed for a long time. Smart code can access and query the information about students' growth in different stages.

After the end of the semester, the academic performance of the experimental class and the control class was compared and analyzed, as shown in Table 1. SPSS24.0 was used

for statistical analysis of the data, and the mean ± standard deviation (x ± S) was used to represent the data. The t test was used between groups, and $p < 0.05$ was considered statistically significant.

At the same time, a questionnaire survey was conducted to investigate students' satisfaction. According to the purpose and questions of this study, the questionnaire items come from the expert opinions of the education system, and 13 items were selected. The questionnaire items are shown in Table 2. These items revolve around research questions regarding efficiency, security, intelligence, personalization, continuity, and so on. Seventy-one questionnaires were sent out and answered anonymously, and 71 were recovered with a recovery rate of 100%.

Through the subject examination results and satisfaction questionnaire survey, the functional effects of two system modes, namely, the student growth system based on intelligent graph element and the traditional student management system, were compared.

4.3. Research Results

4.3.1. Test Score

Table 1 shows the *t*-test results of the learning effects of the two groups of students. The control class and the experimental class adopted the same test paper. The final result shows that the score of the experimental class, which used the student growth system based on intelligent code, was 89.21 ± 5.11. The control class, i.e., the traditional class, scored 82.90 ± 3.63.

Table 1. *t*-test results of learning efficiency for experimental group and control group.

Group	*N*	Mean	SD	*t*	*p*
Experimental	36	89.21	5.11	3.43 *	0.01
Control	35	82.90	3.63		

* $p < 0.05$.

4.3.2. Questionnaire Survey

The questionnaire was prepared by soliciting expert opinions. The questionnaire results show that more than 90% of students in the experimental group believed that the new system could stimulate their interest in learning, enhance their independent learning ability, the timely interaction between teachers and students, and fast knowledge exploration, as well as reduce learning pressure, shorten homework time, increase sleep time, and facilitate the uploading of learning data. They also believed that teachers' guidance was well-targeted, evaluation methods were fair, and personal information and data were safe and reliable. All in all, students thought the new system helped to improve their academic performance. Compared with the results of the control group, the recognition degree of students in the experimental group to the student growth system based on intelligent code was significantly improved. This is shown in Table 2.

Table 2. The evaluation of the two groups of students on the student growth system.

Survey Items	Control Group (*n* = 34)		Experimental Group (*n* = 34)			
	Satisfaction *n* (%)	General Satisfaction *n* (%)	Satisfaction *n* (%)	General Satisfaction *n* (%)	Satisfaction *n* (%)	General Satisfaction *n* (%)
To stimulate your interest in learning	24 (68.57)	8 (22.86)	24 (68.57)	8 (22.86)	24 (68.57)	8 (22.86)
To enhance the ability of independent learning	24 (68.57)	6 (17.14)	24 (68.57)	6 (17.14)	24 (68.57)	6 (17.14)
Teacher-student interaction	25 (71.43)	7 (20.00)	25 (71.43)	7 (20.00)	25 (71.43)	7 (20.00)

Table 2. *Cont.*

Survey Items	Control Group (n = 34)		Experimental Group (n = 34)			
	Satisfaction n (%)	General Satisfaction n (%)	Satisfaction n (%)	General Satisfaction n (%)	Satisfaction n (%)	General Satisfaction n (%)
The convenience of querying learning resources	26 (74.29)	5 (14.29)	26 (74.29)	5 (14.29)	26 (74.29)	5 (14.29)
To shorten operating time	24 (68.57)	9 (25.71)	24 (68.57)	9 (25.71)	24 (68.57)	9 (25.71)
Less study pressure	25 (71.43)	7 (20.00)	25 (71.43)	7 (20.00)	25 (71.43)	7 (20.00)
To sleep longer	21 (60.00)	9 (25.71)	21 (60.00)	9 (25.71)	21 (60.00)	9 (25.71)
To improve the range of academic performance	23 (65.71)	10 (28.71)	23 (65.71)	10 (28.71)	23 (65.71)	10 (28.71)
The convenience of uploading growth record and content extensibility	25 (71.43)	8 (22.86)	25 (71.43)	8 (22.86)	25 (71.43)	8 (22.86)
The pertinence of teacher guidance	23 (65.71)	8 (22.86)	23 (65.71)	8 (22.86)	23 (65.71)	8 (22.86)
Process evaluation	26 (74.29)	7 (20.00)	26 (74.29)	7 (20.00)	26 (74.29)	7 (20.00)
Consequential evaluation	25 (71.43)	7 (20.00)	25 (71.43)	7 (20.00)	25 (71.43)	7 (20.00)
Security of learners' personal data	22 (62.86)	8 (22.86)	22 (62.86)	8 (22.86)	22 (62.86)	8 (22.86)

Vs. Control group, $p < 0.05$.

4.4. Discussion

4.4.1. Analysis of Final Exam Results

The final results show that the traditional class scored 82.90 ± 3.63, while the class which used the student growth system based on intelligent code scored 89.21 ± 5.11. Compared with the control class, the score of the experimental class was significantly improved. The reasons for the improvement of performance may be as follows. First, the smart code has proprietary properties, and the smart code offers one-to-one correspondence with students. Through the analysis of learning data, the system and the teacher's guidance to students was more accurate and personalized. Tang et al., believe that differentiated teaching guidance can help students complete learning tasks [73]. Secondly, through the smart code, students can acquire knowledge and upload homework and questions more easily and quickly. The teacher–student and home–school interactions are more convenient, so that students' advantages can be praised more quickly, and their weaknesses and difficulties can be helped and solved in a timelier manner. Third, the security of smart code makes students feel that they have privacy security, and their interest in learning is stimulated. Chang's research shows that students' privacy is crucial to their learning [74]. Therefore, this system is more conducive to the improvement of students' performance than the traditional system.

The standard deviation of the control class is 3.63, while the standard deviation of the experimental class is 5.11. Obviously, in terms of standard deviation, the experimental class is higher than the control class. The reason for this may be that the student growth system based on intelligent code is more conducive to the personalized development of students. The personalized difference between students is very large, and it also reflects the full play of students' independent learning ability. The standard deviation of experimental class students' scores was slightly larger, indicating that there was a large gap between high and low scores of experimental class students. Although some experimental class students had relatively low scores, their academic performance was still greatly improved. The reason for their relatively low scores is that these students have a poor foundation.

4.4.2. Analysis of Questionnaire Survey Results

Questionnaire results show that more than 90% of the students in the experimental group were satisfied with the student growth system based on the intelligent code, while the students in the control group were relatively less satisfied with the traditional system. This showed that the student growth system based on intelligent code was superior to the traditional student growth system.

The high security of intelligent graph element technology determines the security of learners' personal data in the new student growth system, and students are easy to accept it [75]. As an emerging APP, intelligent graph element code can stimulate students' curiosity, enhance their interest in learning and independent learning ability, so it can improve their academic performance. Previous studies have found that new technology, or games, can boost student interest and academic performance [76]. As the system integrates a variety of learning software and platform and makes it easy to upload and download learning materials, students and teachers can interact in time, thus helping to improve learning efficiency [77]. At the same time, it makes homework shorter, sleep longer, and reduce students' study pressure. By completely recording the growth trajectory of students, the system can maintain the integrity, authenticity and continuity of students' information, which makes teachers' guidance targeted, and enables students to get objective process evaluation and result evaluation, which is consistent with Hodgson's and Pang's findings [78]. Based on the large amount of data of students' growth, the function of the system becomes smarter and more accurate, so students' satisfaction is high.

5. Conclusions

The sustainable development of education has always been a concern, and new technology plays an important role in promoting sustainable development. At present, new technologies are emerging in an endless stream, and they are updated at a very high frequency. However, teachers and students are overwhelmed by numerous teaching platforms, learning platforms, student management platforms and numerous tools and apps. Furthermore, for a long time, there has been a serious lack of student growth information, especially of electronic graphics, video and other multimedia student information, and there is not a continuous student growth system that can serve for life. Therefore, people urgently need a safe, reliable and convenient system that can integrate various information technology platforms and technologies to support personalized lifelong education.

Graphic code technology is a very potential technology to solve the above problems, but there are still many deficiencies in the existing technology. Firstly, we innovated the graph code technology and proposed the intelligent graph element technology. Secondly, based on IGET, a new personalized student growth management system was designed, and the model and basic frame of the student growth system were constructed. Finally, the system effect was verified, analyzed and discussed.

The new system based on IGET can record students' learning process, academic performance and evaluation results for a long time, and it is convenient to access, track and verify. It can collect learning process data, generate students' electronic files, and form a big data analysis model, which is convenient for schools, teachers, parents and students to fully understand each student's unique learning track. It helps students develop in an all-round way, and reduces the workload and management pressure for teachers. The system can also be used as an effective certificate when students apply for a job after graduation, which is convenient for employers and institutions to understand and verify applicants' status. In addition, the system continuously records students' learning and growth process and wonderful moments through the application of intelligent code, which is an effective supplement to the existing paper bags. It can meet people's demand for high quality personal growth history data, image data and video data in the current media information age.

Through experimental research and performance analysis, the student growth system based on IGET can effectively solve the problems that the existing student growth system

needs to solve, such as information islands, low efficiency, lack of real information of students, information non-persistence, data security and so on. Compared with the existing student management system, the student growth system based on IGET has the following advantages.

a. Sustainability. One advantage is continuity. Intelligent code as a student's exclusive information appliance, ensure the continuity of student growth information in each platform, each learning stage. The student growth system creates a complete, continuous and exclusive electronic information database for each student, which completely solves the problem of serious lack of real information and interruption of electronic information for student growth. Another advantage is persistence. As a student's exclusive information appliance, intelligent code is unique and can ensure the life-long use.
b. Efficiency. The efficiency of the system is mainly reflected in convenience. First of all, smart code supports the integration and connection of multiple platforms and APPs, and is convenient for users to use. Secondly, the human eye can directly identify the smart code, which is convenient for students and the public to quickly identify and distinguish it. Thirdly, the smart code provides a channel for uploading and querying personal information, which is convenient for offline information to be transmitted to the network. In addition, the convenience is also reflected in the following aspects: facilitating interaction between teachers and students, being conducive to home-school education, and promoting the reform of school education.
c. Security. The core technology of the student growth system is the intelligent graph element technology, which uses structure encryption, and a variety of encryption rules. The data formed by the system during the growth of students can be traced and used but cannot be tampered with or forged, so the system is more secure.
d. Intelligence. The intelligence of student growth system benefits from continuous and persistent data accumulated during student growth. The more data, the smarter the system. The intelligence of the system is shown in many aspects, such as individualized learning analysis and recommendation, individualized teaching and diversified guidance.
e. Accuracy. The user's name is paired with the smart code, which will be recognized accurately. The information of teachers and students is stored in the students' proprietary cloud platform database for a long time, and can be edited, used and queried on demand, which improves the accuracy of the information and contributes to personalized talent training.

The innovation of this research is obvious. So far, we have not found any other continuous student growth system and practical cases that are similar to the cross-technology, cross-platform, cross-region and cross-space realized by the IGET designed by us.

First of all, we put forward the concept of intelligent graph element technology, and then the intelligent graph element technology is implemented, which is a very advanced scientific and technological innovation.

Secondly, we applied the smart code technology to the student growth system, which is an educational application innovation. So far, there has not been a student growth system, including electronic portfolio system, student management system and educational administration management system, which can realize the continuity, life-long, safety and convenience management functions of each learning and growth stage of students. The student growth system based on IGET can integrate and connect many technologies and platforms, and has the advantages of convenience, security, precision, intelligence, durability and continuity. It can solve the difficult problem of teachers and students choosing and switching from numerous APPs, solve the contradiction between large class teaching and individualized teaching, and provide continuity and reproducibility of students' growth information, as well as highlight the advantages of personalized talent cultivation, and truly realize the concept of multiple education centered on learners and sustainable development of education.

Of course, this research also has some shortcomings. For example, the system of the test time is not long enough. It would take at least three, five, or even more years to achieve the functional requirements of continuity and durability of the system. This is because there are five or six years of primary school in China, while the junior middle school stage needs three or four years, high school three years, the university stage needs four or five years (medicine), and so on. However, integration, continuity and persistence are the key differences between our designed student growth system and other traditional student growth systems. For all that, no public school or even private school is willing to carry out such a long-term experiment unless the state education administration coordinates the experiment. Therefore, this research needs to be further deepened.

Anything new to maturity requires continuous in-depth study. We hope that IGET will play a huge potential value and make great contributions to human education and economic development and sustainable development.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study and identifying information of participants was anonymous.

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