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Big Data in Education and Organizational Change: Evidence from Private K12 Schools in China

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Doctor of Management

Supervisors:
Professor Nelson Antonio, Management,
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I declare that this thesis does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any university and that to the best of my knowledge it does not contain any material previously published or written by another person except where due reference is made in the text.

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作者申明

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# Abstract

China is a time-honored civilization with a long history of private education. In China, private education has played an important role in preserving Chinese civilization.

At the end of the 20th century, private education in China began to develop thanks to government support. As such, remarkable progress was made during the past decade. Due to specific conditions within the education industry, however, the administration of private education - and basic education, in particular - has remained rudimentary compared with other more mature service industries. To address the many problems in basic education, such as rigid teaching methods, heavy teacher workloads and long, repetitive working hours, it is imperative in this information era to conduct innovative explorations with the help of the "internet of things" (IoT), big data and other scientific and technological means to carry out organizational reform in schools and to establish contemporary organizational structures and management modes. Doing so will comprehensively improve the administration of basic education, which will in turn promote the quality of education and teaching.

This thesis examines Tianli Education Group, a typical example of private, basic education in China. By adopting experimental research methods, the behavior of students and teachers in Tianli's schools were experimentally analyzed. IoT technology was employed to collect data about student behavior at school. Likewise, after collecting and analyzing big data on the behavior of teachers at school, the content and processes of their work were analyzed.

Based on these experiments, this thesis explores a new 5G era-appropriate mode of student selection and training that makes use of big data technology. It outlines the standard work scenario for teachers and improves both their work efficiency and salaries by "trimming staff and streamlining administration," thus rekindling enthusiasm among teachers for their work. Finally, as a part of this thesis, a series of organizational changes were implemented at Tianli Education Group and its schools to boost organizational vitality, improve overall levels of education, teaching and operational efficiency, raise teachers' salaries and enhance student happiness.

Keywords: Organizational Change; Big Data Applications; Educational Innovation; Private K12 Education in China; Experimental Research Methods.

JEL: M1, I21

# Resumo

A China é uma civilização muito antiga, com uma longa história de educação privada. A educação privada desempenhou um papel importante na preservação da civilização chinesa. No final do século 20, a educação privada na China começou a desenvolver-se com o apoio do governo. Nos últimos dez anos, devido ao apoio concedido temos assistido a um grande progresso. Contudo e em virtude das condições específicas da indústria da educação, a administração da educação privada – a educação básica em particular – permaneceu rudimentar quando comparada com outras indústrias de serviços. Para resolver os muitos problemas da educação básica, tais como os métodos rígidos de ensino, as cargas de trabalho pesadas e horas de trabalho repetitivas, torna-se imperativo nesta era da informação realizar pesquisas inovadoras com a ajuda da "Internet das Coisas", do "Big Data" e meios científicos e tecnológicos que nos permitam realizar a reforma nas escolas e estabelecer estruturas organizacionais e métodos de gestão adaptados aos tempos em que vivemos. Os resultados destas pesquisas irão contribuir para melhorar de uma forma abrangente a administração da educação básica, o que por sua vez promoverá a qualidade da educação e do ensino.

Esta tese estuda o Tianli Education Group, que consideramos um bom exemplo do ensino privado na educação básica na China. Adoptando métodos experimentais de pesquisa, o comportamento dos estudantes e professores das escolas Tianli foram analisados. Aplicamos a tecnologia da "Internet das Coisas" para recolher informações sobre comportamento dos alunos na escola. Da mesma forma, após a recolha e análise dos dados sobre o comportamento dos professores na escola, efetuamos a análise do conteúdo e dos processos do seu trabalho. Tendo por base estas experiências, esta tese explora na nova era 5G, um modo apropriado para seleção e formação dos alunos. Esta tese descreve o cenário padrão de trabalho para professores e melhora não somente a eficiência do trabalho como também os seus salários ao "reduzir o pessoal e simplificar a administração", reacendendo assim o entusiasmo dos professores pelo seu trabalho.

Finalmente, como parte desta tese, uma série de mudanças organizacionais foram implementadas nas escolas do grupo Tianli Education Group com a finalidade de impulsionar a vitalidade organizacional, melhorar todos os níveis gerais de educação, aumentar a

eficiência operacional e de ensino, aumentar os salários dos professores e aumentar a felicidade dos alunos.

Palavras-chave: Mudança Organizacional; Aplicações Big Data; Inovação Educacional; Educação K12 Privada na China; Métodos de Pesquisa Experimentais

JEL: M1, I21

# 摘要

中国是历史悠久的文明古国，私立教育源远流长，在传承中华文明方面发挥了重要作用。

二十世纪末期，中国的民办教育因为得到政府支持而开始发展，近十年发展尤其快速。但由于教育行业的特殊性，相较于其他成熟的服务行业，其管理还处于较低水平，特别是基础教育阶段。在信息时代，要改变教学模式"千人一面"，教师工作负担重，重复性劳动时间占比大等一系列基础教育的难题，就应该借助物联网、大数据分析等科技手段进行创新性探索，对现有学校组织进行变革，建立更适合智能时代的学校组织架构与管理模式，全面提升基础教育阶段的管理水平，用高水平的管理带动教育教学质量的提升。

本文选择中国民办基础教育的代表之一--天立教育集团下属学校作为实验对象，采用实验研究法对天立学校学生和教师的在校行为进行实验、分析。其中，利用物联网技术较为全面地采集学生在校行为数据，同时通过对教师在校期间的行为大数据采集与分析，全面梳理教师工作流程和内容。

在上述实验的基础上，本文通过大数据技术加以分析，探索了"5G时代"新的学生选拔与培养模式；创新性地勾画教师工作的标准场景，通过"精兵简政"提升教师工作效率与薪酬，激发教师工作热情。最后，在天立教育集团和各学校进行了一系列的组织变革，以期激活集团化办学的组织活力，提升整体教育教学水平和经营效益，提高教师待遇，增强学生幸福感。

关键词：组织变革，大数据应用，教育创新，中国民营基础教育，实验研究法

JEL 分类号: M1, I21

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# Chapter 1: Introduction

## 1.1 Research background

### 1.1.1 Contextual background

In recent years, a new generation of parents who have benefited from higher education is increasingly willing to invest in its children's education, and this is especially true for education focusing on personal growth. Obviously, the existing basic public education system cannot meet the various needs of parents. In this context, the demand for high-quality private education is becoming stronger, allowing more entrepreneurs with an enthusiasm for and devotion to education to participate in the development of basic education.

Since reform and opening up, private education in China has risen again. This is closely related to the country's great background of social change: the legal status of schools run by the private economy with societal backing was officially recognized in the *Amendment to the Constitution of the People's Republic of China* in 1982, after which increasingly many private schools began to emerge. The country's regulation of the private economy, however, has had a direct impact on the scope, scale and status of the society-led allocation of capital for education in China. According to the *Amendment to the Constitution of the People's Republic of China* in 1988, the state will protect the legitimate rights and interests of the private economy, which is regarded as a supplement to the public economy; however, the private economy is limited to its designated scope and must be guided, supervised and managed by the state. Moreover, China's educational system reform has been relatively moderate, slow and conservative, making education the "last bastion of the planned economy." Indeed, the country's educational reforms have been exactly modeled after its economic reforms without any understanding of the development characteristics and laws of education.

The development of private education has not been smooth. The government's efforts to encourage and support the development of private education were insufficient before 1992, and even today, the common development between private and public education has not yet been realized. The concept of schools being run individually (privately) through the power of society itself has appeared sporadically in official documents, reflecting the government's ambivalence toward encouraging and supporting private school administration.

In 1992, Deng Xiaoping's "Three Benefits" became a new criterion for measuring the gains and losses of reform in various fields. As the dominant position of the market economy became more well recognized, education system reform was accelerated, and private education gradually eliminated its timid and cautious mode of development.

In the Outline of China's Educational Reform and Development (1993), a goal of "gradually establishing a system for administering schools based on the government and supported by all sectors of society" was put forward. The participation of all sectors of society in the administration of higher education was permitted for the first time, marking the moment when social forces could participate in almost all fields of education. The state's policy of "actively encouraging, strongly supporting, correctly guiding and strengthening management" for social organizations and individual citizens to run schools in accordance with the law, as mentioned in the outline, continued to be used in all the state's relevant important documents.

The Teacher Law of the People's Republic of China (1993), the Education Law of the People's Republic of China (1995) and the Vocational Education Law of the People's Republic of China (1996) all had special provisions for private education, which showed that private education became an indispensable part of China's legislation on education.

With the rapid development of private education, the first administrative regulation on private education - Regulations on Privately Running Schools - was issued in 1997. Since then, there was a law for the development of private education to abide by. These regulations were relatively mature and reconfirmed that privately run schools were an integral part of socialist education. In addition, they required people's governments at all levels to incorporate such schools into their national economic and social development plans.

In 2002, the first law on private education - Non-state Education Promotion Law of the People's Republic of China - was officially passed. This law inherited the basic spirit of the 1997 regulations and made breakthroughs on many issues such as "how should private education organizers earn reasonable returns," which allowed the education industry to see a steady increase in private investment, thus forming a healthy and rapid path for private education to develop.

This vigorous development of private education in general has played an irreplaceable role in alleviating public education fund shortages, in improving the education levels of all citizens, in promoting democracy and equal opportunity of education, and in realizing the prosperity of the country.

Private education in China has a relatively short history of development. Indeed, private basic education has only grown rapidly in the last thirty years. Compared with other mature

industries, the administration of private education is still scarce in China due to backward management concepts, a lack of excellent management talent, imperfect internal management systems and incomplete teacher management.

The "attributes" of education remain the first priority of most administrators of private education. Undoubtedly, the core of private education, especially private basic education, as an important supplement and optimization to public education, is education itself. We should, however, also realize that private schools need to be operated, a concept absent to most private education administrators. It is thus necessary for each private education administrator to clearly realize that a private school has neither the government's financial allocations nor large social donations, and thus all the funds for running the school come from investment by shareholders and operating income. Generally, shareholder funds are used as an initial investment to establish the school, whereas operational funds come, naturally, from operating income. In addition, a private school's operating profit is used to reward its shareholders and for its sustainable development. Therefore, private schools are more like enterprises because of their business-like attributes, namely the pursuit of profit through school administration. This, however, is often the most neglected point of private education administrators in China.

According to stakeholder theory, "stakeholders" refer to any group or individual related to a specific organization who can affect its development and the achievement of its goals or who are affected by its development(Freeman, 2010). Stakeholder theory closely examines these relationships and looks for various factors that can affect or be affected by the achievement of an organization's goals from both within and without. According to stakeholder theory, stakeholders in the management of a private school include sponsors, shareholders, the government, teachers, students and their parents, among other parties. Private education itself is the vehicle for stakeholders to express their demand for interest. This expression affects the overall trend of private education, whereas the overall development of private education also affects the vital interests of all stakeholders. Hence, stakeholders must be taken into consideration during the management of private education to satisfy their demands fully and evenly throughout the development of private education.

At present, most of the main managers of Chinese private schools are expert teachers with an abundance of educational experience and outstanding teaching achievements. Because of their long-term teaching experience, they often focus on teaching quality throughout their daily school management. They lack, however, experience of and attention to the operation and management of private schools. In addition to excellent teaching management skills, an excellent private school manager also needs strong human resource management skills, financial

management skills, marketing and other skills. But such acumen is also the common short-coming of private education administrators in China. Therefore, such administrators in China are ultimately bound to transform from teaching-centric expert principals to professional principals with comprehensive management abilities.

The internal management systems of most of China's existing institutions of private education continuously use or copy those of public education, resulting in many private schools managing themselves in "public" rather than "private" ways. In this new era for the development of private education, it is particularly important to comprehensively improve the internal management of private schools along with their systems in a way more suitable for developing their own characteristics. Private education systems require innovation, the core of which should create a deeper understanding of the function and positioning of private schools. This will improve the breadth and depth of their internal management systems, and it will facilitate the improvement and institutionalization of private education management, finally laying a system-based foundation for the overall improvement of the internal management of private schools.

Teacher management, the core of private school management, is directly related to the overall quality of private schools. Thus, improving teacher management is indispensable for private schools that want to improve. For now, although a number of good results have been achieved by Chinese private schools regarding teacher management, there are still many deficiencies in their systems, employment, training and school-based studies, among other aspects, thus requiring further improvement(Xu, 2012). Specifically, from the perspective of the hiring of private school teachers, without a standardized and complete teacher recruitment system, unfair teacher recruitment still exists in some of China's private schools. On the one hand, this seriously affect society's recognition of and trust in private schools; on the other hand, low-quality teachers seriously hinder the development of such schools. Second, from the perspective of the management of daily teacher activities, without scientific, reasonable and systematic rules and regulations on teacher management, teacher evaluations are partial and unscientific, the evaluation results of which cannot truly reflect actual teaching abilities. Moreover, although it has been clearly pointed out in China's applicable laws that teachers in private schools have the same rights as teachers in public schools, some private school teachers lag behind their public-school peers in terms of salaries, benefits, learning opportunities, social status and staffing issues. These problems not only severely affect whether excellent, highly educated teachers choose to work in private schools; they also dampen the work enthusiasm of existing teachers in private schools, resulting in a dereliction of responsibility, high job

mobility, brain drain and other common issues. Such issues seriously hinder teacher improvement and private school development. Likewise, all these problems of teacher management are unfavorable to private school development and even Chinese education as a whole. It is thus necessary for the state, especially China's private schools, to pay more attention to teacher management in private schools and to craft solutions as soon as possible.

In addition to these problems, private education administrators should profoundly rethink the influence of many other adverse factors, such as low public recognition, weak national policy support, incomplete legislation, a lack of competent authorities and uneven private education quality. In so doing, they should comprehensively improve management levels.

At present, education administration in China is evolving from informatization to smart transformation. Although real results in the construction of big data platforms for education administration have been achieved, universal problems remain to be solved, such as uneven information development and a lack of understanding and attention for big data and cloud computing technologies among administrators. In this era of big data, whoever grasps the right opportunities at the right time will occupy competitive high ground. Private businesses, which are comparatively flexible in the ways they operate and allocate resources, should make more efforts regarding top-level design, their system mechanisms and technology R&D, as well as promotion and exploration. In addition, they should adhere to "people-oriented" and "green science and technology" principles while promoting co-development, sharing and the common use of data. Their aim should be to make big data technology their edge for promoting the comprehensive development of students, intelligent education administration and the meaningful development of private business.

Mayer-Schonberger and Cukier (2013) believes that big data is a source for learning more about the world and creating value, as well as a way to change markets, organizations and the relationship between governments and their citizens. Big data changes management - not because it provides data services and support but because big data-based thinking and methodologies change the ideas, methods, structures, boundaries and objects of management. In addition, they make significant improvements to management efficiency. The application of big data technology and the provision of big data services will fully innovate public management, enterprise management, business management, education management, health management and other kinds of management, all while realizing the transformation from "governed by authority" to "governed by data."

First, big data is spurring management structures to open up. In traditional management, power is in the hands of managers. As such, information, resource allocation and decision-

making strategies exist behind closed doors in the hands of management. This creates doubt, distrust and an inclination to fall into the "Tacitus trap." In this era of big data, information, decision-making strategies and resource allocation on the internet and cloud platforms can be accessed at different levels. The natural openness of big data is thus conducive to eliminating public distrust for management. Openness is not only the mother of transparency and trust but also an effective anti-corruption strategy.

Second, big data is driving management structures to transform from hierarchical ones to non-hierarchical ones. The traditional management hierarchy is a kind of "pyramid" structure that results in an inverted "pyramid" of resource allocation. Its lack of procedural fairness in resource allocation hurts morale among those being managed. But this traditional linear, top-down decision-making mode has been upended in this era of big data. A bottom-up, nonlinear decision-making mode driven by big data will generate group wisdom to replace traditional decision-making by the elite. Management in this era of big data no longer relies on individual, subjective decision making but instead emphasizes rational decision-making based on facts and data. Big data management is conducive to making the full use of collective wisdom and strength while also fostering a democratic and equal management culture.

Third, big data is shifting the focus of management from people to data. In the traditional management framework, people are the object and goal of management, whereas in the era of big data, data has become the primary focus, whether it be talent evaluations or performance appraisals. From market analysis to development strategy formulation, there are massive sets of data that can form the basis for decision-making, thus heralding a new era of comprehensive, digital management. Management has changed from the traditional, direct management of people to the management of data and people-oriented services. This is, in turn, improving service efficiency and quality, which is the most fundamental change caused by big data.

Finally, big data is promoting management efficiency in its change from "emergency response" to making warnings in advance. Traditional management is a kind of "post crisis management," that is, it acts only after a certain phenomenon or crisis appears. Before this kind of management can resolve a conflict, a price has to be paid. The support of big data means, however, that management can have access to warnings and characteristic information in advance, thus avoiding the tragedy of waiting for problems to occur before solving them.

The new generation of education platforms and management models based on big data are strongly competitive and have triggered fundamental changes in education. First, adaptive online learning platforms based on the special needs of individuals have broken through the limitations of space, time and resources and completely changed traditional education modes.

As a result, learner-centric, intelligent learning, large-scale learning, fragmented learning, learning for free, personalized learning and lifelong learning have become a reality. Second, the presentation of course content has become more diverse, visualized and people friendly. Students can now learn remotely or through resources such as video and audio. Likewise, teachers can manage their classes with multiple database tools, remote teaching platforms and multimedia teaching equipment. Interactive network classrooms represented by the "flipped classroom" have become an emerging teaching form. Third, educational resource networks have formed a positive circulation of high-quality educational resources that can now play an increasingly effective role. By consequence, learning communities based on exchange, sharing and common development have appeared. Fourth, big data collection and analysis technology introduced into traditional modes of education now provide an informational basis for decision making in education, thus effectively improving teaching, enhancing the effect of teaching and helping students improve their academic performance. The head of Online Education at Harvard University once compared online education to the most significant change in education after the invention of the printing press.

Na (2006) says, "The ultimate good of management is to change others' lives." This statement has important implications for the management of off-campus education. "Benefitting from management" is not only a business slogan but also a concept applicable to school education administration. The ultimate good of school administration is to improve each facet of school administration, as well as their combination, with the aim of serving the fostering general talent to have full spirits, noble morals, the capacity for independent thinking and strong faith. School administration is an important method and means to efficiently achieve the goals of running a school by coordinating the relationships between internal elements, as well as between internal and external elements, and by allocating limited resources reasonably in ways better suited to the environment. The quality of school administration is a criterion by which the degree of education modernization can be measured, as it directly affects the level and quality of a school's education and teaching on offer, thus realizing school administration goals. School administration consists of teaching management, student management, scientific research management, teacher management, material management, financial management and service management, of which teaching management, scientific research management and student management are the focus of this study.

Obtaining feedback in traditional education management is a matter of regular inspections, examinations and evaluations. But such feedback is not timely. In the era of information tech-

nology, big data management cloud platforms are a good way to solve low resource usage rates.

Big data education management, an objective requirement of education modernization, is scientific, timely, interactive, differentiated and adaptable, all of which are advantages that traditional education management lacks. There is a fundamental difference between the big data applied in education management and that of business management: correlation rather than causation is emphasized in business management, whereas the big data in schools consider correlation but ultimately search for causation.

China's curriculum reform of basic education for the new century starting in 2001 represents a more systematic and comprehensive change. In the construction of the overall curriculum system, the school needs to systematically plan how to better carry out the construction of the curriculum system from the organizational level. Thus, we must systematically plan how to better develop a curriculum system from the organizational level. School organization must adjust to such a system. By solving issues such as "who will develop the curriculum," "who will plan the curriculum" and "who will guarantee the implementation of the curriculum," effective divisions of work and cooperation within organizations can be achieved to realize the systematic reform of school curricula.

The new form of curriculum reform emphasizes the implementation of a three-level management system that has changed the decades-long, highly unified curriculum management from the founding of the People's Republic of China. Schools are entitled to carry out curriculum management and development, which changes the role of schools and allows them to exercise the national curriculum in the center of their curriculum development, as well as in their teaching material research and development. Which institutions are responsible for the planning, research, development, design, implementation, support, guarantee, evaluation and improvement of curricula, as well as their supervision? Which are responsible for setting up new departments or for designating the functions related to curriculum establishment and implementation in existing departments? How should the effective integration of functions in each organizational department be realized, and what are the responsibilities of each department? All of these questions should be considered at the organizational level.

This new curriculum reform requires "putting the development of students at the center of overall curriculum design and teaching design," thus breaking long-standing, subject-based curricula. Curriculum integration has thus become inevitable, a fact that means schools, as organizations, must change. Take teaching and research groups for instance. When a school decides to implement an interdisciplinary, integrated curriculum, any previous system in

which teaching and research is conducted by teachers from a single discipline will no longer suffice. Traditional methods of teaching and research will hinder interaction and communication between different subjects, and the integration of curricula is not a matter of roughly combining subjects but, instead, interactively integrating them. Thus, teaching and research should change. Organizations should encourage teachers from various disciplines to carry out teaching and research together to realize the full integration of disciplines via exchange and collaboration instead of superficial change. Thus, the real integration of curricula can in this way be guaranteed. Moreover, with the deepening of curriculum reform, teachers' academic competence is expected to meet higher requirements. Relying on the efforts of individual teachers is far from sufficient, so teachers should be supported by organizations.

At present, there are a small number of schools that are carrying out organizational change in China, most of which are in the initial stage. But there are many schools that still have not made extensive changes. According to the development needs of the times, organizational changes in schools is an inevitable trend. Implementing effective organizational change is a challenge of school development at present. Previous research on organizational reforms in schools either viewed schools as special social organizations or as independent social organizations when investigating changes to "school organization" or when exploring theoretically how to change a specific type of organizational component. Such research thus lacked any systematic discussion or practical implications for the organizational change of schools.

From the perspective of the overall development of education, there remain various internal problems within China's schools. Although the Ministry of Education has reiterated the need to abandon the extreme pursuit of high enrollment rates, to comprehensively implement the national education policy and to avoid "one size fits all" approaches, most schools in China have failed to follow this guidance. They continue to lecture and regard the rote imparting of knowledge as the main purpose of school education. Now that we have developed an information-based society, the social environment has become increasingly complex and diverse. Everyone now faces a society full of opportunities and challenges. Society urgently needs "new talent." The "modern" school with the primary goal of training people with the proactive awareness, capability and motivation to develop their own creative potential will become a mainstay of educational development (Lan, 2002).

A school's organization is a collection of different groups of people within the school. The way they contact and work with each other directly determines the future development of the school. Also, the quality of school education and teaching is directly affected by whether this organizational structure of the school is reasonable, how the members of the school work,

whether the relationships between members are good, whether the school's organizational system is sound, whether its cultural atmosphere is harmonious and whether different types of organizational divisions cooperate organically. Therefore, changes to a school's organization lead to school transformation, and thus the organizational members of a school are the main force for school transformation. The effectiveness of organizational change directly determines the smooth transformation of schools.

We are in a period of social transformation amid the macro, knowledge-based context of globalization and informatization. With the rapid development of economies, people's values and behaviors are changing dramatically, and the demand for individualized development is becoming increasingly obvious, as people are paying more attention to individual happiness. The status-quo in education is, however, unsatisfactory. Students typically do not have enough leeway in choosing courses. They tend to tire of learning, drop out of school and suffer school bullying. For example, in 2016, one researcher conducted a survey of 104,825 teenagers in 29 counties across China and found that more than a quarter of them confessed that they had been bullied; 4.7% of them were regular victims of bullying. There was also an astonishing global survey on school bullying in which the annual average number of children who are bullied around the world is 216 million(Yao, 2017). The school is the main place for student growth and development. To some extent, the development of students depends on the atmosphere created by the school, the quality of education and teaching they receive, and other factors. As the vehicle for in-school education and teaching activities, as well as management activities, school organizations and their structures directly reflect and affect the quality of in-school education and teaching. Therefore, the organizational systems of schools should be efficient. In fact, the ultimate goal of all schools is to promote student development, so it is important to build a school organization system with student development at the core.

With the development of the internet, information technology and artificial intelligence, the combination of the big data era and management is not only a trend but also an inevitability. The value distribution of big data is inherently coupled with the resource allocation of management. Big data is dynamic, shared, predictable and differentiated, and it is bound to have a critical influence on organizational reform.

### 1.1.2 Theoretical background

At present, modern curriculum theory established by Tyler (1949) plays a leading role in China's basic education system; that is, by considering the suggestions and demands of society, students and subject experts, curriculum designers work out blueprints containing all aspects

of their education objectives based on prior experience. Under the guidance of such blueprints, experts and educators carefully select learning materials and combine these materials with applicable teaching methods so that students can easily understand and master knowledge and skills. After students complete these learning objectives, fully reliable and valid tests are applied to verify whether the learning process satisfied the educational objectives. Test results are fed back to managers who evaluate the students' mid-term and final exam scores and make plans for the following semester.

Dewey (1916) points out that education is personal and intimate, and through education, children must be guided to explore the real world and learn what they will encounter in society as adults. To transfer real life experiences into the academic environment, Dewey (1948) emphasizes that subject knowledge selection and organization should be adapted to the learning characteristics of different students. In general, Dewey's progressive teaching theory focuses on students' personal growth and school democracy. He encourages Socratic seminars, in which teachers and students can pursue the same learning goals together.

Reformative teaching theory is regarded as the successor and reformative version of Dewey's progressive teaching theory. Unlike some of the views of progressive teaching theories, reformative teaching theory holds that giving students full freedom to choose courses based on their own interests is like providing a buffet: a diner's first choices always suits his or her own appetite but does not necessarily provide balanced nutrition. Thus, the ideal curriculum would be tailored by a professional teacher to a single student, just as a doctor prescribes prescriptions to his or her patients. This metaphor highlights the role of the teacher in shaping students' personal identities and helping them achieve their personal long-term growth goals by designing personalized routes of development for each of them. Throughout this process, teachers and students use dialogue, storytelling and hands-on activities to achieve teaching goals(Jackson, 1986).

Based on this theory, educators have proposed that courses should be tailored to each student's learning rhythms and proclivities to ensure fully personalized development. Generally, costs and benefits should be considered to decide whether to implement a learning or management method. Although the concept of individually customized courses has existed for a long time, due to its high cost of implementation, it was only used for nobility in the past. If we want to popularize and use this education idea in society today, the power of science and technology should be introduced to reduce its costs.

The informatization of education represents not only a profound reform of educational concepts and teaching modes but also an effective means to promote educational equity and to

improve educational quality. Taking "three links and two platforms" as its core goal and landmark project, the informatization of education in China's "12th Five-Year Plan" period has used the "Banbantong" resource platform and has relied on cloud service platforms to introduce an abundance of high-quality teaching resources and diverse teaching applications into classrooms. According to the 13th Five-Year Plan of Educational Informatization issued by the Ministry of Education on June 7, 2016, the informatization of education should continue to adhere to the core concept of promoting the integration of information technology, education and teaching. It should also adhere to the basic principle of application-driven and mechanism-based innovation in addition to the strengthening of top-level design and multi-party cooperation. "The use of big data technology should be encouraged throughout collection, analysis and feedback of student behavior data during education and teaching activities to provide support for the promotion of personalized learning and targeted teaching." For both basic and higher education, the application of big data in promoting personalized management and scientific decision-making should be the emphasis of future work.

On April 13, 2018, the Ministry of Education issued the Action Plan of Educational Informatization 2.0, which clearly defines the specific actions to implement educational informatization 2.0 across eight aspects, including standard digital campus development and innovation-driven development for intelligent education. The main tasks are "to continuously promote the in-depth integration between information technology and education, to facilitate the evolution of educational informatization from integrated applications to innovation-driven development, to facilitate the in-depth integration of information technology and intelligent technology into the whole education process, to drive the improvement of teaching, management and performance, to comprehensively improve the information literacy of both teachers and students, and to strengthen the systematic deployment, in-depth promotion and sustainable development of educational informatization from research to application."

Considered as the future development direction of internet education technology, personalized learning can assist each child in fulfilling his or her own growth goals by replacing teachers with computer algorithms to integrate and optimize learning resources, analyze each student's learning characteristics, and customize applicable personalized courses. Hence, the development of big data technology is the premise of artificial intelligence (AI).

Educational technology inventors are joining hands with computer scientists and network engineers to integrate AI and big data technology into education design. Some advanced and avant-garde projects are actively exploring a form of open education called "micro-schooling." The most popular "micro school" in California is Altschool, which has received 33 million

US dollars in capital from several famous venture capital companies(Horn, 2016a, 2016b). Altschool intends to use AI software designed by teachers and technicians to develop a dynamic, personal course of learning after collecting data on a large number of students(Barros & Osório, 2017; Horn, 2016b). On independent online learning platforms, teachers guide cooperative students to obtain Dewey's "ideal learning experience." In addition, the use of big data and time-tested teaching software can cut down on traditional expenses such as teachers' salaries and venue rent, thus promoting financial equity and personalized education nationwide.

In summary, education reform today is guided by advanced education theory. And by introducing internet education technology to reduce operating costs, to improve the quality of teaching and to restructure management forms, it is revolutionizing education.

The purpose of education is to socialize people and train citizens who are well-adapted to society. This socialized training mainly focuses on the development of similarities between people, and it typically ignores any exploration of individuality. Advocating individualized education can thus make up for the flaws of socialized education. In fact, supporting individualized education does not deny the development of our commonality; instead, cultivating commonality should be regarded as a foundation for developing individuality. In other words, individuality consists of the individual differences that derive from social engagement.

With the increasing emphasis on education, individualized education has become a hot topic. The concept of "individualized education" is not new and has achieved a high standing in various countries around the world. Research on individualized education is developing all over the world. The idea of individualized education derives from the humanism of 20th century education philosophy. This trend of thinking values individualized education above all else and argues that education should give full play to students' individuality. Therefore, based on this theory, individualized education has been advocated from various perspectives. In the 1970s, J. W. Keefe established a complete model for individualized education. He held that individualized education was an effective practice employed at school based on students' individuality(Keefe, 1979).

Individualized education respects the unique value of the individual, explores the potential of individual lives, cultivates students' independence and unique personalities, and promotes the free and harmonious development of life(Liu, 2012). It represents the process by which educators give appropriate feedback regarding each student's knowledge, awareness and emotional maturity. As China grows stronger, its investment in education will continue to increase. A such, the contemporary trend toward individualization is obvious, and the person-

alized demand for knowledge is on the rise. Many students not only hope to better acquire knowledge but also to discover and develop their potential. Based on accepting a general education, they aspire to achieve comprehensive development. But to achieve individualized education, we must understand the relationship between student behavior and learning. Thus, understanding the relationship between their behavior patterns and their academic performance remains key to individualized education.

In addition to individuality, people have much in common, which is what it means to be "human." Commonality can be understood as "group" characteristics. No matter how distinct individuality is and how diverse its manifestations are, people share common and universal psychological and physical characteristics. Considering these common traits, mankind has taught classes with large numbers of students since ancient times. This mode of education gathers students together, which is suitable for the development of their common traits. Throughout this process, educators seek to train excellent students to make outstanding grades, which serve as evidence for effective teaching. But in fact, this kind of teaching is not suitable for the current times, as it is not conducive to developing individuality. It fails to allow every individual to develop his or her own potential. Similarly, it does not train and empower creative talent. Given the obvious downsides of large class sizes, individualized education thus came into being. What, then, is individualized education?

First, individualized education is not about emphasizing individuality. Scholars have different understandings of individualized education. In Feng Jianjun's paper on the concept, Feng illustrates the difference between "individualized education" and "education emphasizing individuality"(Feng, 2004). Feng believes that education emphasizing individuality originally focused on helping students develop their individuality. There are, indeed, differences between people from the moment they are born. Thus, a singular emphasis on cultivating personalities poses limits on teaching. By contrast, individualized education simply distinguishes itself from modes of education that undervalue individuality; in other words, it accepts that students must develop common characteristics while respecting their unique, individual traits. Teaching should be adapted to the development of various students' individuality by using diverse teaching strategies. Ultimately, such teaching can train talent that not only fit into society but also retain their individuality.

Second, individualized education is represented by small classes or one-to-one tutoring. Ancient Chinese royalty attended schools with private tutors who taught one or several students, and this mode of teaching has been passed on to the present day. Indeed, many educational institutions in the market have been recruiting students with such promises. These edu-

cational institutions make up for the shortcomings of large classes and offer tailor-made educations. But this is not "individualized education," as its purpose is to improve students' academic performance without valuing the development of their individuality.

Third, teaching students in accordance with their aptitudes also does not represent "individualized education." Confucius, the great educator of ancient China, put forward the idea of "teaching students in accordance with their aptitudes," which has been upheld by many teachers in modern times. This idea focuses, however, on "aptitude," which refers to how, during the teaching process, content of various levels should be taught according to students' understanding and cognitive abilities. It is fair to say that this mode of teaching is the exploratory predecessor of individualized education, but it does not represent individualized education because it results in fast and slow classes, as well as assignments at different levels, and it requires additional tasks (usually difficult tasks) to be performed in school examinations. The idea of "teaching students in accordance with their aptitudes" mainly focuses on achieving certain teaching objectives that come far from encompassing all of what individualized education is. Individualized education emphasizes the development and fostering of student individuality while achieving teaching tasks such that students comprehensively develop their knowledge, skills, abilities and specific traits.

In summary, individualized education is a refutation of traditional education, which produces standardized teaching results. As such, it is a new educational paradigm or mode. It respects the development of students' individuality, prevents students from passively adapting to the way they are taught and serves them. Education should discover students' individual potential and better develop them. To put it simply, individualized education is an educational approach that aims to develop the unique qualities of students. It allows educators to carry out education with individualized goals. As American scholar Arch Carroll put it, individualized education is a balance between the learner's individuality and the learning environment. Everyone is unique. Their unique environments and backgrounds shape their lives. They are obliged to maintain and realize specific forms of existence. Education is for people. Thus, throughout the process of education, educators must offer conditions for the unique development of life and enable education to serve individual development to thereby create individualized education suitable for the development of the unique lives of individuals.

Children undergoing basic education are in a period during which individual characteristics are developed. Compared with adults, their characteristics are malleable, as this stage of life is unstable. There are obvious differences in their interests and hobbies, which provide ample space for the development of their personalities. Considering these individual differ-

ences, educators should seize this key period of education to carry out individualized education by choosing effective teaching strategies, recognizing each student's unique characteristics, employing years of teaching experience to deeply tap into each student's potential, and helping students to leverage their own strengths or unique talents. Their ultimate goal should be to make each individual unique so that his or her personality, interests, hobbies and emotions can be developed fully in a free and harmonious manner. In this sense, everyone's strengths can be brought into play, and students can become talented individuals with a diversity of strengths throughout all walks of life.

## 1.2 Research problems

### 1.2.1 Big data on student behavior based on IoT-empowered intelligent campus perception

Internet of Things (IoT)-empowered intelligent campus perception is a product of the deep integration of education informatization and IoT technology. It is also an important aspect of the basic network development of "Banbantong" in this era of IoT. It can integrate and improve the informatization of education, and it can further improve its efficiency, thus promoting innovation of education mechanisms and realizing the in-depth reform of education modes and concepts.

College entrance examination reform in China was first put forward in the Opinions on the Implementation of the General Senior High School Academic Performance Test issued by China's Ministry of Education on December 16, 2014. Beijing's reform plans for a new senior high school entrance examination and a new college entrance examination were implemented in 2018 and 2020, respectively, causing a series of changes in how junior and senior high schools teach. Likewise, mobile learning has become a trend of teaching reform. "Mobile teaching" satisfies students' interests and gives full play to their freedom to choose and their enthusiasm for learning. Work concerning students' attendance, however, has subsequently become a knotty issue. IoT-empowered intelligent campus perception makes smart attendance-taking possible via wearable technology. It also allows for the compilation of attendance statistics and the management over mobile teaching attendance. This saves time that would otherwise be spent on taking attendance in class, effectively solving mobile teaching attendance problems.

According to the requirements of the National Outline for Medium and Long-Term Education Reform and Development (2010-2020) and the Notice of the General Office of the State Council Transmitting Opinions of the Ministry of Education and Other Departments on Further Strengthening Physical Education (GBF [2012] No. 53) on improving students' physique and strengthening physical education, the Ministry of Education promulgated three normative documents on April 21, 2014: Measures for the Monitoring and Evaluation of Students' Physical Health, Measures for Physical Education Evaluation in Primary and Secondary Schools and Measures for the Annual Report on Physical Education. Thereafter, the monitoring and evaluation of students' physical health was incorporated into China's index system of educational modernization and is now regarded as an important part of the development and reform of China's examination system. The aim is to gradually form a scientific and standardized monitoring and evaluation system of students' physical health while offering clear guidance, credibility, reliability and strong guarantees. In 2016, the revised edition of China's National Student Physical Fitness Standards was issued, which not only offers basic guidance over national education and basic standards for education quality but also offers an important basis for evaluating students' comprehensive abilities and relevant achievements, as well as the development of education in various regions. IoT-empowered intelligent campus perception monitors and collects students' exercise and sports habits, as well as sleep and heart rate data, through intelligent perception terminals. It compiles statistics and analyses of students' daily health, exercise habits and sports performance, and it establishes files on healthy development, carries out health evaluations, manages students' daily health, conducts physical monitoring, provides physical education, and finally completes the state's goal of improving students' physiques while strengthening physical education reform.

With the development of the IoT, IoT-empowered intelligent campus perception will further promote informatization in education. Research on big campus data encompassing student behavior data, as well as education and teaching data, based on such IoT networks, will deepen education reform, integration and innovation. In addition, it will further the informatization of education and increase innovation, ultimately realizing intelligent and personalized education by serving all aspects of education and teaching.

This thesis sought to build IoT-empowered intelligent campus perception in Tianli's schools to collect in-school student behavior data (such as daily step counts and attendance data) by means of smart bracelets. With this data, this thesis attempts to find correlations between student behavior in school and their academic achievements via data mining and analy-

sis. The expectation is to replace traditional experience-based methods in student selection and management with new measures and methods based on big data analysis.

### 1.2.2 Big data on teacher behavior based on daily work logs

For private schools, teachers are undoubtedly the cornerstone and key driving force for their development. Thus, the informatization and scientific management of their human resources is imperative. First, a large number of original data must be collected for information-based personnel management, which necessitates big data analysis technology for integrating data and mining potential value. Second, teachers and their needs have changed substantially. For example, young teachers pay more attention to independent learning, academic advancement, information acquisition, real-time communication, recognition and incentives, which necessitates the effective activation of teachers' internal motivation and the improvement of human efficiency. Third, with the large-scale development of schools run by commercial conglomerates, internal talent markets have gradually become saturated with reserves of human resources, thus necessitating the optimized allocation of human resources among institutions or the selection of desperately needed, excellent experts and talent from other institutions. To solve these problems, we must effectively support HR management decision-making platforms based on big data analysis to thereby improve the efficiency and benefits of HR management.

For this thesis, studies were conducted at a number of TL schools. Teacher's daily work logs were collected via information technology, after which the types, duration and intensity of teachers' daily tasks were analyzed with big data technology. Based on this, this thesis seeks to find scientific methods to improve human efficiency and to effectively reduce teachers' work intensity. This is done by turning the focus of teachers' jobs to the key links of education and teaching, as well as by stimulating their work enthusiasm and creativity, thus ultimately promoting school innovation and development.

### 1.2.3 The organizational change of private schools in the big data era

Each organization has its own life cycle and will face aging and death one day. Facing a competitive market, an organization either changes to get a new lease on life, or it slowly heads toward its demise. Private schools that ignore the importance of organizational change and blindly focus on teaching quality will gradually lose to those with more vitality and more efficient teaching management.

With the rapid advancement of information technology, competition among private schools is becoming increasingly fierce. Continuous adjustments and refinements are indispensable for improving service, quality, operations, management and the like. Organizational change has also become a topic frequently discussed by the management of private schools. But it is not enough to merely recognize the need to change, as knowing what kind of change can make an organization successful is more important. In today's "3C" business environment (of customers, change and competition), armchair theorizing is woefully insufficient - we must consider actual circumstances on the ground at organizations and analyze the actual operational data that they generate to render decisions about organizational change more scientific and instructive, thus ensuring that the direction and methods of change are appropriate.

We have deeply realized that, driven by modern information technology represented by big data and AI, the meaning and impact of private school governance have changed profoundly, which has resulted in changes in governance systems, organizational forms, mechanism design and institutional arrangements. Consequently, in adhering to the technical and social logic of this era of intelligence, conventional private education management is making strides toward intelligent, dynamic governance, as well as comprehensive, collaborative modes of governance.

Starting with specific measures, this study will attempt to create a way for private schools to change in this era of intelligence. It will do so from two aspects: (1) student selection, evaluations and modes of education, as well as (2) the organizational form of schools. As such, it will promote the organizational innovation and development of private education to provide new ideas for the practice of private education management by building a new governance framework of private education and by creating a new governance ecology.

### 1.2.4 The leadership of private schools in the big data era

With the advancement of internet technology and the advent of the big data era, enterprise managers must efficiently complete their tasks via the skillful application of internet technology, make accurate decisions based on big data and solve all kinds of security problems and unpredictable challenges at all times. The IT trend led by the internet represents not only a technological revolution but also a revolution in organizational culture, leadership and behavior. Nowadays, all students in K12 schools are "digital natives" that have grown up with information technology. Training them to better adapt to future competition and helping them become the best versions of themselves is placing higher requirements on school leadership, and this is especially true in terms of information.

As a leader and decision-maker of a private education institution, the author of this study has a deep understanding of and urgent expectations for the improvement of information-based leadership. Therefore, based on the three studies mentioned above (1.2.1-1.2.3), the author has also consciously analyzed and drawn conclusions about the role he plays throughout this entire process. And in this thesis, he expresses his own ideas for how to improve the information-based leadership of commercial schools.

## 1.3 Research goals

For managers of private schools, it is extremely important for them to be able to use information technology and systems to achieve enterprise goals, especially given how information technology changes so frequently. We should fully realize that information systems are an important tool for managers, as they enable private schools to operate well, provide high-quality services, improve decision-making and gain competitive advantages.

In fact, many educational reformers have begun trying to apply cutting-edge information technologies such as big data to teaching. Most of these applications have been limited, however, to trials in small numbers of classes or grades by using ready-made products from education technology companies. Similarly, school administrators lack an awareness for the in-depth impact of educational technology on organizational change, and few relevant research reports or academic papers have been published.

As the founder of a well-known Chinese private education group, the author of this study manages more than 10,000 staff and 70,000 students in more than 40 K12 schools. These schools were established based on traditional teaching concepts and have the same organizational structure and curricula. The group's vision of "being an innovator and leader of China's private education" has been apparent ever since the group's inception. Facing today's high-tech tools such as big data and AI, it is necessary to vigorously introduce advanced technologies into daily teaching scenarios, where students can come into close contact with them, become interested in them and develop an appreciation for advanced technologies. In so doing, teachers will also further improve their scientific and technological literacy while becoming more knowledgeable about the latest education modes. On the other hand, it is also necessary to invest great energy in studying how to apply advanced technologies. All of these efforts will have a profound impact on the organizational change of entire schools. Only in this way can we ensure the vitality and innovation of private schools while also remaining impervious to market competition. As a private school manager, the author conducted research on the ap-

plied innovation and organizational change brought about by big data on campus. And in this thesis, he deeply analyzes the positioning and focal points of decision makers in this era of ever-changing information technology. Likewise, he provides new thinking and a path for the training and promotion of the group's principals.

Based on this thinking, this study was designed to introduce big data technology to quantify the behavior of students and teachers in Tianli schools. Advanced information technology provides teachers and managers with valuable information to serve the development of students and the schools. By mining the behavioral data of students and teachers in these schools, this study explores possible changes in student selection and training, as well as changes in teaching modes and personnel management. It also analyzes the benefits of such changes to business operation. Finally, this study seeks to draw conclusions about the role of the schools' core managers throughout the whole process of big data application and organizational change.

## 1.4 Research innovations and contribution

1. This thesis systematically studies the development of information-based education around the globe and highlights the far-reaching influence of big data technology on educational change.

2. It systematically studies the current application of big data technology in the education industry. This includes the big data-based prediction of student academic performance and mental health at school, as well as the big data-based development of a school personnel system regarding teachers' conduct at school.

3. To do so, this study established IoT-empowered intelligent campus perception to collect student behavior data in TL schools. Such data included daily steps, movement tracking and weekly attendance data. By collecting and processing such data, a correlation analysis considering behavioral data and academic performance is produced.

4. This study then establishes an intelligent, big data analysis platform for human resources. The platform is based on in-school teacher behavioral analysis using data including working hours and work content each day. As a part of this analysis, work intensity and the reasonableness of teacher task distributions are analyzed.

5. Based on these two aspects of work, the organizational structure of TL schools and the group headquarters were adjusted by setting up an independent IT Department as well as a science and technology company to strengthen the application of science and technology in

the education industry, to restructure the schools' educational administration centers and to reformulate student evaluation criteria. This was done in an attempt to help students improve their learning efficiency and academic performance. In addition, these efforts promoted the work efficiency of teachers, reduced unnecessary workloads and comprehensively enhanced teacher happiness at work.

## 1.5 Research framework

In the first chapter, it mainly introduces the research background, problems and purpose of this thesis, and briefly summarizes the research innovation and contribution of this thesis.

Chapter 2, a literature review, contains two aspects: (1) the application of big data in the education sector and (2) relevant theories of organizational change along with organizational change in the field of education.

Chapter 3, which consists of the research methods and experimental design of this thesis, demonstrates the research strategy. This includes the experimental methods and the site of the experiments, Tianli schools, a model of privately-run basic education in China. Data collection and processing are also illustrated.

Chapter 4 introduces the field research of this thesis. The subjects of the experiments at Tianli schools were students and teachers. Student behavioral data at school were collected by establishing IoT-empowered intelligent campus perception, and behavioral data of teachers at work were collected via an information-based approach. In this chapter, the author carries out a big data analysis of the students' and teachers' behavioral data.

Chapter 5 starts with conclusions regarding the big data-based organizational change of schools. This is followed by comments on directions for future research.

# Chapter 2: Literature Review

Data mining technology emerged to extract in-depth and effective information from data to discover valuable knowledge and content, and to enable people to use data more reasonably when carrying out research and crafting policy. Data mining technology is a process of mining effective rules and patterns hidden in big, incomplete or noisy data sets(Han, 2005). Unlike machine learning, which focuses on algorithms, data mining technology often starts from an actual application scenario to meet the needs of a practical problem. It compiles data statistics, conducts analyses, synthesizes and reasons from multiple dimensions; it then constructs models related to the problem, finds the connections among data points, conducts further analyses and finally solves the problems at hand. At present, this method has been widely used in financial markets(Helbing & Balietti, 2011), IoT application(Tsai et al., 2014), network security(Liu et al., 2003), health care(Cios & Moore, 2002) and other fields as a new driving force. As such, it has profoundly changed lives and work styles.

The application of big data technology in education has had a late start and is still in the early stages of exploration. As such, it is relatively immature. Based on its strong performance in other fields, however, we have no doubt that big data technology will soon bring changes to education and greatly improve the existing state of education and teaching management.

As early as the 1960s, the potential value of data has attracted the attention of American educators. With the strong support of the U.S. Department of Education, American education researchers established the National Center for Education Statistics (NCES), which is committed to discovering the potential value of data and promoting the application of data in education. After more than 30 years of research and exploration, the center put forward a complete set of research and application programs for education data at the beginning of the 21st century. It then established the core position of data in education decision making by issuing the Education Sciences Reform Act, which states that any education program must be formulated or implemented on the basis of relevant data, thus initiating the development of education driven by data(Du et al., 2016)

With the advent of the big data era, big data has become a vogue topic and is a high-frequency tech word in mainstream media. Technological and industrial advancements, as

well as national security, have become closely related to research and development involving big data. Education is no exception. One American research institute came to the following conclusion: "Big data will bring significant changes to education. The introduction of big data enables the dynamic acquisition of information about students' daily performance and learning on campus, replacing the regular tests of the past. Educators can grasp the real-time dynamics of students and guide them in a timely manner using big data analysis."(J. Lu, 2013)

Also, to better adapt to the development trends of the big data era in the future, the cultivation of data literacy has begun to attract people's attention. Data literacy refers to the integrated capabilities of data awareness, collection, management and application. The cultivation of data literacy encourages people to better adapt to future data-driven industries and to improve their competitiveness(Gao, 2015). The American Data Literacy Program sponsored by the Institute of Museum and Library Services was implemented in 2012 with the aim of training a new force for the big data era by improving the data literacy of students, teachers and even researchers. In October of the same year, the U.S. Department of Education issued a report entitled "Enhancing Teaching and Learning Through Educational Data Mining and Learning Analytics," specifying the fields and cases of big data application in education as well as the challenges faced during their implementations in the United States. Aiming to promote the research and application of data mining technology in education, the report also provides official guidance for K12 schools, colleges and universities in the application of data mining in education(Chen & Zhang, 2014). "Enhancing Teaching and Learning Through Educational Data Mining and Learning Analytics" interprets the application of data mining in education from five perspectives. First is personalized education: data mining technology can subdivide education, turning what used to be standardized teaching management into one-on-one targeted teaching management, as well as realizing individualized teaching. Second is the in-depth analysis of learning: in the past, student progress evaluations were often limited to scoring or rating, whereas data mining technology can analyze a large number of more complicated factors, depict students from a more comprehensive perspective and provide more accurate student information. Third is the introduction of adaptive learning systems (namely, learning systems that can automatically adjust the learning progress and its intensity for students according to their learning needs) into data mining applications. Fourth is the introduction of data mining and learning analytics applications, including interviews with data mining R&D personnel from more than ten companies engaging in the R&D of education systems, as well as successful applications of education data mining in real life. Finally, the report analyzes the challenges faced during the application of education data mining in the US, gives

some suggestions on how big data in education should develop and puts forward expected goals and prospects.

Additionally, the report summarizes four research targets on the future development of data mining in education. First is the integration of existing knowledge, motivations for learning, learning attitudes, learning habits and other student characteristics. This facilitates the establishment of a data mining model from which student learning and development can be predicted. Second is the exploration of new education and teaching modes, as well as reforms of existing education systems, to find the best teaching materials, improve their quality and discover the best courses of learning to effectively improve learning efficiency. Third is the development of a set of new evaluation systems using data mining algorithms. This will help evaluate the effectiveness and rationality of existing education software and services. Fourth is the comprehensive use of data calculation models, including student models, the latest education systems and education software, to improve the management and decision-making of educational institutions, as well as to promote the learning efficiency of students(Jia, 2015).

In addition to the strong support and guidance of governmental departments, the private online university education platform Coursera was put into service in 2012 and has since signed agreements with 83 top, international universities in the US to provide online courses. It has taken this opportunity to carry out data mining applications in online education(Severance & Charles, 2012). Yale University, Harvard University, Stanford University and other famous American universities have also carried out research on data mining applications in education. Moreover, the American Association of School Administrators (AASA), together with the Consortium for School Networking (CoSN) and international information technology research consulting firm Gartner, jointly implemented a project called "Closing the Gap: Turning Data into Action," with the aim of promoting research in schools on the data in student information management systems and educational administration information systems.

To seize the unique strengths of the IT industry, Japan's Ministry of Internal Affairs and Communications issued a comprehensive strategy covering information, communications, network technology and other fields - the "ICT Comprehensive Strategy for 2020" - in 2012. The strategy clearly proposes that Japan should attach great importance to the research and application of digital content strategies, communication strategies and safe and high-trust ICT strategies. It also proposes further increases to investments in big data applications, digital content development and infrastructure and information security. In 2014, the UK invested GBP 73 million for the development of big data technology by establishing big data research

centers in cooperation with colleges and universities. Its aim is to drive well-known institutions of higher education to set up majors in big data. In addition, Singapore also lists big data as a key technology. As such, it supports colleges and universities in establishing data mining and analysis platforms, and it organizes specialized talent training(G. Q. Wang, 2017).

China's research on education data mining started relatively late. Its earliest research started in 2012, when the US government raised big data to the top of its national strategy. As such, data mining technology attracted once again the attention of researchers in China. By interpreting American policies, some researchers in China began to focus on the research of education through data mining. With the rapid development of big data research and the great advancement of the informatization of education in China, IT became more widely used in education, bringing profound changes to China's education sector. With the deepening of education reform in China, IT will become a driving force for education reform and a catalyst for innovation-driven development, a fact that has been unanimously recognized by the education sector.

China's first "year of big data" was 2013. Since then, education in China has seen a wave of research on education-oriented data mining technology, along with plenty of high-quality papers related to data mining in education. According to the Key Points of Education Informatization 2014 issued by the General Office of the Ministry of Education at the beginning of 2014, the development of education in China should keep pace with the times, rely on IT and big data, closely integrate with data mining technology, strengthen the integration of real-time monitoring, data-based decision making and education prediction, and provide educators with complete data mining services to help them make decisions quickly, accurately and efficiently(China, 2014). In addition, data mining technology should be fully used to improve the process of data collection, data integration and data analysis, among other aspects of data handling, and it should be used to realize the nationwide sharing of basic data in education. Thus, education-oriented data mining has become an important part of the informatization of education in China. The close integration of education, teaching and data mining technology is an inevitable trend for education in China.

The report to the 19th CPC National Congress (2017) pointed out that China should make full use of advanced technologies such as the internet, big data and deep learning to create new areas of growth in the real economy and to promote the rapid development of the national economy. This lays out the path for the future development of information technology and the real economy in China. The deep integration between modern IT and the real economy

will encourage mass entrepreneurship and eventually result in a new wave of mass innovation, thus promoting the implementation of China's innovation-driven development strategy.

The use of information systems provides a precondition for data collection throughout each stage of life. The "big data" era was first proposed by the world-famous consulting company McKinsey, which alleged that data has penetrated into every area of today's industry and business functions and has become an important factor in production. McKinsey held that the mining and application of big data is preceding the arrival of a new wave of productivity growth and consumer surpluses. In China, Taobao, with a B2C market share of 57.6% and a C2C market share of 96.5%, is one of the first internet enterprises to engage in big data commercialization. Its experience in big data and e-commerce model innovation driven by big data provide useful references for other e-commerce enterprises. Also, with the continuous growth of e-commerce on Taobao, the massive data it has generated has attracted the attention of scholars in many fields. Chen et al. (2015) elaborate on Taobao's development and the important processes within its big data-based strategic layout. They also discuss its big data applications and follow-up e-commerce innovation, analyzing Taobao's big data e-commerce model from the perspectives of products and services, the basic structure of its e-commerce network, and its core resource capabilities and profit model. In addition, they look into future research. Based on Taobao's online cellphone transaction platform data from June to December of 2011, Ye et al. (2019) quantify the scope and sources of China's urban online transactions using a big data approach and a gravity-based model, and they discuss the underlying driving forces. Based on big data from Taobao's intelligent information systems between 2007 to 2016, Ye et al. (2018) construct an evolutionary analysis framework for "Taobao village" entrepreneurship networks. Wang and Deng (2018) mine user characteristics, merchant characteristics and user-merchant characteristics from big shopping behavior data obtained from the Alibaba Competition in 2017. From this, they study predictions of the future purchasing behavior of new users in a particular store under normal circumstances. Social networks represented by Weibo and Facebook also provide a friendly environment for big data applications:Zeng and Wu (2016), through technical means, collect and analyze Weibo data, construct a user portrait model and describe the behavior features of enterprise users, thus enabling precision marketing. Wang et al. (2017) study the characteristics of tourism flows in Lanzhou from the perspective of time and space based on LBS sign-in data from Weibo as well as a nuclear density estimation analysis method, from which they find an obvious rhythm in the time dimension of tourism flows. In an article by Straton et al. (2016), the authors try to understand how users share sports information on social media (Facebook) and then complete

a big data analysis of public health. With a large number of users' travel and tourism information collected by tourism websites such as Ctrip and Feizhu, Xu and Xiao (2019) use machine learning technology to predict the retention of users, as well as to better understand the reasons for user loss, after which they give suggestions on improving the user experience and website services. The China-EU Tourism Big Data Report 2018, jointly released by China Tourism Academy and Ctrip's HCG Travel Group, reports on comprehensive research and analysis on the market scale and growth of tourism in Europe. In it, the popularity, consumer characteristics and preferences of provinces and cities from which tourists depart, as well as destination countries, are noted. Similarly, an in-depth analysis of independent European travel, travel in tour groups, and customized itineraries is conducted, including an analysis of ticketing and amusement, visas, other products and users themselves. Such analyses are combined with big booking data from Ctrip on outbound Chinese tourists, all of which provide valuable conclusions(Shang, 2019). An abundance of user data has been recorded in a great variety of information systems and business systems. Online, clicks, browser data and other behavior can be analyzed to learn about users' interests and needs, and offline, hot spots and group behavior patterns can be obtained through behavior tracking data to benefit urban public security. On the other hand, during the early stage of the development of internet technology, both e-commerce websites and traditional information systems sought to improve work efficiency and increase revenues.

Big data in education is an organic whole composed of data itself, that which the data describes, educational activity and education data. The transformation of big data research in education in China can be clearly demonstrated by the number of articles in the CNKI database. Typing the keywords "big data" and "education" into the search bar, 10,580 search results (as of December 5, 2019) are obtained, among which only eight were published in 2012 or prior. The numbers of studies published in the following years are shown in the Figure 2.1 below.
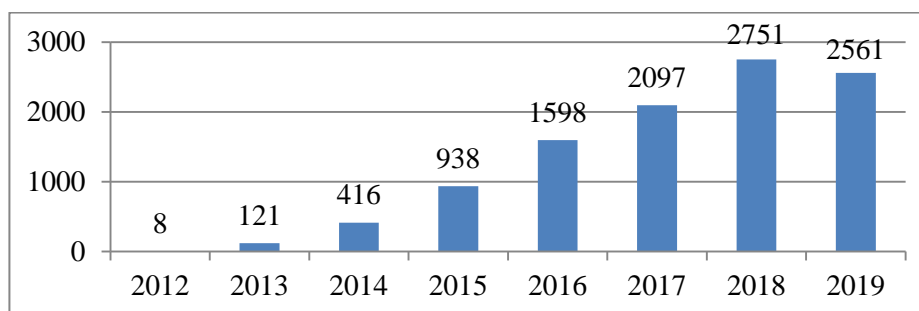


Figure 2.1 Numbers of Related Studies from 2012 to December 2019

Source：https://kns.cnki.net/KNS8/AdvSearch?dbcode=SCDB

Data mining technology in education has been gradually applied in Chinese universities, and of such examples, the intelligent laboratory project of Donghua University has been a pioneer in applying data mining to education. By recording and analyzing the times that students enter laboratories, as well as the use of instruments and equipment, the daily use of such laboratories can be managed intelligently, thus effectively improving autonomous student learning(Wu et al., 2011). Based on the achievements of over a decade of campus informatization, Fudan University reformulated its information-empowered business processes in light of user categories and business cycles. It implemented data analyses and utilization based on data centralization; it integrated cross-department businesses, extracted common services and established portal applications adapted for user habits and new media, and it formed a "one-stop" service platform integrating information services, application services and comprehensive statistical services(Zhao et al., 2014). Tsinghua University is also carrying out data analyses on student growth to establish a student growth model, thus laying a foundation for the personalized education of students in the future(F. J. Liu, 2014).

Since 2013, scholars represented by Schönberger and Zhou (2013) have introduced the concept of "big data" into China through books and other media, after which a series of research papers were published, causing the potential value of big data to attract the attention of the education sector. This shows how applied research using big data in education in China has entered an initial stage of development. Over the following five years, the number of scientific papers increased dramatically, year by year, which accelerated the research and application of big data in education.

Unlike in foreign countries, the data on online education in China is insufficient due to the overall low level and unbalanced development of online education in China. Therefore, most of the research targets of data mining are related to offline behavioral data. Indeed, this thesis is also built on an analysis of the offline behavioral data of students and teachers.

## 2.1 Big data applications in education

Big data in education, as the name implies, refers to the application of data analysis in the education sector. There are two main data sources in education. First, with the popularization of computers and the maturity of online education, many students have begun using online learning. Thus, a large volume of data related to student learning has been generated on various online education systems developed by educational institutions or online education technology companies(Guan & Li, 2014). Second, there are offline classroom teaching data gen-

erated in normal teaching activities and the behavior data generated by interactions between students and school information management systems. For basic education, data analysis systems can be established regarding educational administration, teaching innovation and application innovation.

Considering the actual circumstances at Tianli schools, this thesis focuses on the collection and analysis of student behavior data and the work data of teachers at school, after which it reports on applied research, which is why this literature review has focused so heavily on this aspect.

### 2.1.1 Predicting academic achievement with student behavioral data

A large number of studies have shown that intelligence(Stabler et al., 1994), height, weight(Fuxa & Fulkerson, 2011; Mo-Suwan et al., 1999) and even DNA(Okbay et al., 2016) are related to the academic achievement of students. Therefore, educators can carry out customized education in light of individual student characteristics.

Behavioral analysis originated from psychology and sought to describe, explain, predict, and control the actual behavior of organisms. User behavior analysis discovers rules, improves problems in existing activities, predicts user behavior and increases revenue by analyzing existing user behavior data. User behavior analysis, in a narrow sense, focuses on internet websites, such as the number of pages visited when browsing a website or the amount of terminal data downloaded when visiting a website.

User behavior analysis has made great achievements in user engagement, social networks and the like. Regarding engagement, Khan (2017) conducted an online survey of 1,143 YouTube users and discovered what motivated YouTube users to participate in content consumption through user analysis. Gupta et al. (2017) studied the correlation between news sources for product information and the popularity of cellphones, and they conclude that a rise in commodity prices leads to declining popularity. Chen (2015) studied consumer behavior in the context of the big data era with the aim of discovering a distribution of target consumers and ultimately promoting sales through creative forms. As for social networks, Yang et al. (2017) collected mobile traffic data on intelligent devices and classified mobile users into different groups to study resource consumption on the mobile internet.

Chen and Sharma (2015) concluded the key factors influencing the public's attitude toward social networks based on an analysis of 822 survey results. Li and Liu (2014) constructed a regional Weibo community map to analyze user behavior, after which they calculated the coefficient of the clustered community graph and explored the impact of popularity on social

networks. In other related fields, Shi (2020) proposed classifying the words in comment data with computer sentiment analysis and noted the evolution of customer demand by combining the dynamic characteristics of word frequency. To improve the efficiency of three-dimensional parking garages, Guan and He (2019) studied parking locations based on user behavior and proposed a corresponding scheduling strategy. Yang (2018) predicted future traffic development and enriched researchers' understanding of complex dependence in traffic networks based on monitoring sensor values. After this, they proposed a Petri net-based user behavior analysis method for evaluating the trustworthiness of user identities in cloud environments, thus ensuring the security of user identities and resources in cloud environments.

Academic achievement is the most important and basic index for evaluating a student's learning. As such, teachers should be able to gain a solid grasp over student learning and provide targeted teaching guidance by analyzing their academic achievement. Divided into online and offline scenarios, student behavior data reflects their learning styles and daily habits. Achievement analysis and prediction is a research branch of data mining in education. Existing studies mainly focus on achievement prediction through an analysis of curricula or historical performance, whereas behavior-based analyses are still limited to mining for rules of association between single behaviors and achievement.

Regarding online learning, six MOOCs offered by Peking University were available on Coursera in the fall of 2013. Jiang et al. (2015) analyzed and mined the massive learning behavior data of more than 80,000 learners participating in these six courses to completely show the styles and features of MOOC learning activities. Furthermore, this was the first time anyone had classified learners of Chinese MOOCs by their learning behavior features for an in-depth investigation into the relationship between learning behavior and achievement. On this basis, it was also the first to predict the final learning outcomes of learners via features of their typical behaviors. The results show that a feature analysis based on learning behavior can effectively determine whether learners will successfully complete their learning tasks and obtain certificates, and it can also pinpoint potential serious learners, which provides a basis for more accurate evaluations when offering MOOCs in the future.

An empirical analysis of the online learning platform of Harbin University of Science and Technology conducted by Li (2017) defines the concepts and classification of online learning behavior in light of behavioral science and AI theory. It analyzes the associated factors of online learning behavior in a big data environment, and it constructs an online learning behavioral analysis model along with a vertical process for online learning behavior analysis based

on behavior clustering, personalized course recommendation and association rules between learning behaviors and achievement.

More than 600,000 learning behavior records from 16 of the 17 courses offered by Harvard University and MIT on edX from the 2012-2013 academic year were selected by He and Wu (2016) to draw conclusions about learning behavior features. Together, they conducted data mining on typical behavior features and predicted achievement via a logistic regression method. The time spent learning, number of learning events, sampling statistics, video views, chapters studied, and number of posts were selected as key records of learning behavior. The results show that such an analysis of the typical learning behaviors of learners can effectively determine whether they can complete their learning tasks and obtain certificates.

Wei and Lin (2006) proposed a new approach called "Boosting" to investigate student behavior. This algorithm can be treated as a data mining method that tries to infer the essential factors of academic success and their relationships from a large amount of training data. Academic achievement can be predicted based on a training model, which can then be used to assist students in adjusting their learning behavior. Also, an analytical comparison was conduct between on-campus students and off-campus students regarding the essential factors selected by the Boosting algorithm. More importantly, these findings are of great importance to academic administrators, teachers, and instructional developers to improve teaching models and online courses.

As far as offline scenarios are concerned, some valuable results have been obtained after several preliminary attempts at student-based behavior analysis were made. Most student behavior data from schools are collected via campus cards, as such cards comprehensively record student behavior throughout their studies and daily activities. From eating, bathing, and fetching hot water to entering or leaving libraries and dormitories, as well as shopping in supermarkets, all student behaviors are recorded by their campus cards, which are a relatively rare but useful tool for data collection, as they can almost completely cover the full suite of student behaviors regarding learning and daily life.

Wu (2018) analyzed the actual student card data of 18,960 undergraduates at the University of Electronic Science and Technology of China and tried to use actual entropy and cumulative activity counts to respectively quantify two student personality characteristics: precision and achievement. Through an electronic data analysis of their daily behavior, the subjective problems of traditional psychological questionnaires and assessments, as well as unreliability due to insufficient samples in traditional psychological research, can be avoided. In addition, a mapping algorithm was used to create a visual presentation of card access data, and this vis-

ualization of the data verified its reliability. Separately, a study of personalized teaching models based on big data was put forward by Zeng et al. (2016) of Beijing Jiaotong University. Relying on big data analysis, they modeled personalized teaching in four steps: personalized information collection, big data analysis, portrait construction and teaching applications. A portrait was constructed by using big data analysis technology, thus forming a personalized tag via data analysis, and endowing it with a weight demonstrating the credibility of the information. Finally, they put forward a personalized portrait model.

Based on previous studies, Liu and Xu (2002) turned his analysis from the personal information and past achievements of students to a variety of behavioral data generated by students on campus, including consumption data, access-control data, and book-borrowing data. Liu did so to discover the student behavior models behind their behavior data, as well as the factors influencing their performance. Behavior features were extracted from the behavior data of students in two grades. Student performance prediction models were built by means of a data mining algorithm, and the effect of different models were then compared to determine the best performance prediction model. Selecting two middle schools in WH, China, as research targets, S. Liu et al. (2019) conducted a baseline survey and two follow-up surveys for all of the schools' seventh grade students in 2015, 2016 and 2017. According to the results of their generalized estimation equation, and after controlling for influences caused by gender and grade, academic pressure and screen time were determined to be risk factors for learning achievement, whereas sports was a protective factor. The path analysis model was well-fit, and for both boys and girls, screen time had the greatest impact on learning achievement; indeed, sports and screen time indirectly impacted academic achievement through academic pressure. As a result, to keep academic pressure low, screen time should be kept at less than two hours a day, and sports time should be properly increased to thus generate a more positive impact on the academic achievement of adolescents.

Cao (2016) proposed the Big Five Personality Model in psychology to solve the problem of educational institutions finding it difficult to estimate changes to student scores before examinations. Behavior features related to performance were screened for via analysis, and according to the screening results, many students' behavior data and achievement data were obtained and quantified. Activity counts and actual entropy were used to quantify discrete behavior data, and normalized ranking was used to quantify achievement data. Finally, a correlation analysis between their quantified behavior model and score ranking was made. The results show that achievement-related behavior features (behaviors related to academic activities, such as borrowing books) were significantly related to achievement, and order-related

behaviors (behaviors related to time and space regularity, such as swiping one's card in the cafeteria) were also related to performance. Given the fact that great differences existed in the behavioral features of students with different levels of order, the hypothesis that differences between daily behavior patterns are related to regional factors was put forward. Specifically, they are related to the difficulty of the UESTC entrance examination in the region where an individual was located. The results showed that the difficulty of the UESTC entrance examination in different regions was weakly negatively related to the behavior of swiping one's card to enter the library but not related to bathing. It was, however, positively related to the behavior of swiping one's card in the cafeteria. Rong et al. (2016) collected data from 2013 regarding students at a college of SZ University, China, via questionnaire. Their analysis shows that student card factors with significant correlations to achievement include the average number of trips to fetch water per week, the average number of books borrowed per week, the average number of books borrowed per semester, whether or not borrowed books were course books, whether or not the borrowed books were specialized, technical books, the average borrowing time and the main purpose of average monthly consumption. On the other hand, non-student card factors include the average number of times spent by oneself in a study room or library per week, whether or not borrowed books were finished and whether or not the purpose of book borrowing was to prepare for examination. In addition, free time activities among non-student card factors played a decisive role, and their impact on achievement was greater than that of the student-card data.

The research team of the UESTC Big Data Research Center collected and analyzed about 30 million card swipe records from nearly 20,000 students regarding four kinds of behaviors: dining in the cafeteria, bathing in the dormitory, fetching water from teaching buildings and entering and leaving libraries. An academic effort index for students was generated based on the data on fetching water in teaching buildings and on entering and leaving libraries, whereas a rule-of-life index was generated based on the data on dining in the cafeteria and bathing in the dormitory. By comparing these two indices with student achievement, the team found that academic effort was positively related to achievement, as was the regularity of campus life, which was even more interesting. The regularity of campus life and academic effort were not, however, related to each other. Furthermore, the research team trained a machine learning model by taking the regularity of campus life as an important behavioral feature to improve the AI prediction ability of achievement(Cao et al., 2018).

Wang (2019) collected data from 397 valid questionnaires from all first-year students in a high school in Yangzhou, China. First, a data mining decision tree classification algorithm

was used to model and analyze the correlation that the students' daily habits (sleep, breaks, diet, and exercise) and academic habits after class (previewing and reviewing) had with their achievement, and it was found that the correlation between academic habits after class and achievement was stronger than that of daily habits and achievement. The order of correlation, from strong to weak, of these six behavioral habits with academic achievement was as follows: reviewing, previewing, sleep, diet, breaks and exercise.

Based on the book-borrowing data of undergraduates of different majors at a university from 2011 to 2015, Pan et al. (2019) conducted an empirical study on course scores and book borrowing differences from four aspects: the number of books borrowed, the category of books borrowed, the duration for which books were borrowed and the period during which they were used. As a result, a difference between majors existed in the book-borrowing habits of undergraduates due to the different training objectives among different majors, and such differences directly or indirectly affected student course scores.

Based on the usual performance of students, Grivokostopoulou et al. (2014) effectively tested student achievement in various subjects by means of decision tree mining, which enables teachers to accurately understand student learning, as well as to put forward feasible suggestions based on their actual learning conditions, thus further improving teaching quality. This method of prediction still needs further improvement. Later, Elbadrawy et al. (2016) creatively introduced a personalized regression and matrix decomposition to the study of predicting students achievement, and they developed a model for students to avoid failure. Zollanvari et al. (2017) used machine learning technology to build a GPA prediction model, and they verified the model. Wati et al. used Bayesian and Decision Tree C4.5 algorithms to predict student achievement based on an academic database and related data. Qu et al. (2018) proposed a multi-layer perceptron (MLP) approach based on layer supervision to predict student achievement. Jie et al. (2017) developed a double-layer model composed of multiple basic predictors and a series of set predictors to predict changes to student learning, and then they proposed a data-driven method based on a potential factor model and a probability decomposition to analyze curriculum relevance and to build a basic predictor. Based on the online learning environment of MOOCs, Qiu et al. (2016) collected a complete set of data for all student interactions, analyzed key factors affecting student participation in MOOCs and predicted the efficacy of their studies. Lee et al. (2019) classified data on self-criticism, self-reinforcement, self-management, social evaluation, learning strategies and learning achievements into cognitive and emotional adjustment functions of internal language to predict student achievement.

**2.1.2 Psychological warning signs with big data on behavior**

In traditional K12 schools, student mental health is often attended to in psychological courses, though proactive warnings and interventions lack any scientific basis. Given how all ages of individuals now enjoy the rapid development brought by information technology, it is imperative for school administrators to use big data technology and cluster analysis to analyze their students more accurately, fully understand them and guarantee their mental health. Indeed, this is one of the areas in urgent need of key research regarding information-based campuses.

Dr. Fei Lipeng, the executive director of Beijing Suicide Research and Prevention Center, has pointed out that suicide has become the fifth leading cause of death in China and the first cause of death among people aged 15-34. According to his calculations on youth suicide in China based on figures released by the Ministry of Health, the suicide rate in the 5-9 age group was about 0.28 per 100,000, accounting for 0.42% of the total number of suicide deaths in China. The suicide rate in the 10-14 age group was about 1.87 per 100,000 (3.46% of all suicides). And the suicide rates in the 15-19 and 20-24 age groups were about 15.57 per 100,000 (16.46% of all suicides) and 32.36 per 100,000 (22.33% of all suicides), respectively. These figures show that the suicide rate for Chinese students rises with age, and after the age of ten, the suicide rate and number of deaths begin to increase rapidly, with the inflection point not appearing until the age of 35(Zhang, 2018).

Knowledge about mental illness among most people, however, especially primary, and secondary school students, is inadequate. Even if a student suspects that he may have a mental illness, his willingness to take the initiative to see a doctor is generally insufficient due to the fear of what others might think. In such cases, schools are unable to know until it is too late. Thus, it is difficult to intervene in the early stages of mental illness, a fact that is not only harmful to students' mental health but that also dramatically reduces campus safety.

At present, traditional research on predicting mental states can be divided into two aspects. One is based on social network data. For example, in a series of studies predicting the personalities of Weibo users, Bai et al. (2014) adopted multi-task regression and incremental regression to analyze Weibo data and predict the Big Five personality traits. The results show that correlations between each personality dimension and Weibo behavior are significant. In their research on depression prediction, Hu et al. (2016) used machine learning to establish a depression-prediction model based on network behavior data. As such, the correlation between the predicted results and the traditional scale was 0.25-0.39. Zhang et al. (2014) built a suicide-prediction model based on the textual content published on Weibo to screen for people at

high risk of suicide. First, a document-subject matrix was designed with a subject model. Then, the features of user text were extracted via an unsupervised method, after which a supervised learning method was used to build a model based on these extracted features.

An obvious drawback of these studies is, however, that not all college students have social network accounts, and it has not been definitively shown that the activity levels of people with mental problems and of people without mental problems are consistent. People with mental problems might not be socially active, which could result in inaccurate data collection that affects the results of analysis.

Another drawback is in the analysis of factors influencing psychological state. For example, He and Luo (2015) used the Self-rating Depression Scale (SDS) to conduct a logistic regression analysis of 1,186 college students at six universities in Beijing, and the results show that a series of factors can lead to depression among college students, including an unsatisfying major, unsatisfactory academic performance, poor physical health, a low willingness to use psychological services and low average monthly living expenses ($P < 0.05$). Liu et al. (2015) conducted an analysis of undergraduate and graduate students with the Center for Epidemiological Survey Depression Scale (CES-D) and the Big Five Personality Test Questionnaire, and their results show that the incidence of depression among sophomores, students of medical majors, students with siblings and rural students is higher than that of other students. These studies, however, are limited by the descriptions and interpretations of psychology and are neither predictive nor interventionary.

In the big data era, each action taken by a student on campus can be transformed into a recorded piece of data, which enables prediction and intervention regarding psychological events using big data technology. We should innovate new platforms for providing warnings about psychological crises by introducing new media. We should also dynamically grasp the thoughts and behaviors of college students through big data analysis, and we should turn college students from passive objects of intervention into passive subjects of self-intervention by broadening information channels, expanding platforms that reflect the psychological conditions of college students and establishing effective interactive mechanisms. The aim should be to fully reflect and give full play to the subjective initiative of college students in triggering psychological crisis warnings and in engaging in suicide prevention, thus truly realizing psychological crisis intervention.

Yu et al. (2015) believes that the characteristics of big data coincide with the characteristics of Chinese culture and Chinese epistemology, which presents the opportunity for Chinese psychology to shed western influences and reconstruct the discipline of Chinese psychology.

They hold that this discipline can be constructed based on the relationships between heaven, earth and humans. From the study of the psychological representation of culture and spirit - as well as the influence of restrictions to social life - to the individuals' physical and mental experience of cognition, action, emotion, reason and morality, the final scientific realm of mankind described by Comte can be realized; that is, "the behavior of an individual organism with social characteristics in a cultural context" can be made real, which also happens to be the Chinese psychology they advocate. Under this new theoretical system, Chinese psychology, with big data as its basic research paradigm, will overturn the two-dimensional arguments of traditional psychology - sample-population, individual-law, situation-research, and data-behavior - and create a new psychological research paradigm.

Liang and Luo (2018) processed the data of 11,400 students at South China Agricultural University from 2011 to 2013 using big data association analysis, after which they proposed degrees of achievement as pruning association rules. Big data mining was introduced to analyze the student data in the university's student management system, allowing for the study of the association rules for personality traits, mental health information, scores, and other student data. This provided a more effective scheme for the development of a university-wide psychological warning system. Li et al. (2019) put forward that new evidence-based mental health practices should be based on "internet plus" psychological platforms to achieve communication and information sharing among the people concerned, as well as among clinical psychologists, researchers, and managers, thus creating the best treatments (fitting the preferences of the people concerned) via the best research evidence and professional skills.

Zhang and Wang (2015) constructed a personalized emergency response mechanism for psychological crises among college students using big data. This mechanism includes a six-level psychological emergency response system consisting of the school, a mental health education center, family, the college, classes, and the dormitory, all of which create a psychological crisis treatment system and a psychological crisis relief system. The authors systematically conducted psychological crisis warnings for college students using a prototype developed via big data technology, and they had a certain degree of success. College students were turned from passive objects of intervention into active subjects of self-intervention, which fully reflected and gave full play to their subjective initiative in triggering psychological crisis warnings and in engaging in suicide prevention, thus truly realizing psychological crisis intervention and control.

Yi and Zou (2019) point out that big data has broad prospects for application in solving traditional security problems and in avoiding new security risks. One example is the potential

intervention in ideological or psychological crises among students. They also remind us, however, of some practical dilemmas, such as imperfect data platforms, inconsistent data sharing mechanisms, inadequate data security and the urgent need to improve the data literacy of administrators.

With big data technology, Wang (2016) formed a dynamic network platform for the psychological conditions of students by integrating with a dynamic database, thus realizing the dynamic tracking of student psychological conditions as well as the information and network management of crisis warning data. Although advanced information technology such as big data was used, such warning platforms also require the support of a large volume of psychological data on students, which is hard to obtain. Chen and He (2018) propose a model for a big data-driven warning platform for psychological crises among students at school. Their model provides data support for school psychologists by mining a psychological warning database. The on-campus big data platform developed by Xia Hu, an associate researcher of the University of Electronic Science and Technology of China, uses student participation records in various competitions, as well as in innovation and entrepreneurship studios and other club activities, to reflect whether they actively participate in group activities. In addition, by evaluating student card swipe records in cafeterias and libraries, the loneliest 800 students were selected. The probability of having a psychological diagnosis or treatment records among these students was 19 times higher than that of the average student!

Collecting and collating more than 27 million pieces of data from the UESTC Student Forum, Tang (2017) established a student psychological model from the analysis of the emotional tendencies, interests and socializing patterns of students. Tang made full use of students' actual emotions as expressed in the open and free atmosphere of a forum to explore how to extract students' emotions from the forum's text. Traditional emotional analysis based on dictionaries was used to study the posts and replies on the forum, which achieved good results. In the analysis of student interests, general sections of the forum, such as the "Sailor's Home," had huge amounts of data without clear topics. Thus, existing forum data were used to classify posts with unknown topics. Finally, the author used the questionnaire results of admitted students to test the student psychological model, strongly confirming the accuracy of building a student psychology model based on school forum data.

Similarly, existing foreign studies also focus on the correlation that depression and suicide ideation have with personality. For example, Lin and Chih-Che (2015) conducted four psychological tests on 814 undergraduates. Analyzing their structural equation model, the authors found that gratitude has an indirect impact on an individual's self-esteem, levels of de-

pression and suicide ideation. In addition, self-esteem was found to have a direct impact on depression. According to the research conducted by Bengü and Ahmet (2018), medical undergraduates with internet addictions had serious social anxiety and inferiority complexes, and they were more likely to be depressed than those without internet addictions. Moreover, the proportion of college students suffering from depression was generally high, but their willingness to seek help was relatively weak. Amarasuriya et al. (2018) established an analytical model to predict the possibility that depressed students would seek help from multiple dimensions, such as students' socio-demographic characteristics, their ability to recognize problems and their sense of shame about depression. This study found that patients with high levels of shame about depression would not seek professional or non-professional help, and female patients were more inclined to seek non-professional help. Hence, it is essential for us to make more people realize the importance of seeking help and helping others.

## 2.2 Organizational change and organizational change in education

### 2.2.1 Organizational change and development

Organizations are a basic way to create products or services and do so by integrating employees and enterprises. Organizations implement a macro, strategic plan into daily business processes to achieve their expected strategic objectives. Enterprises ensure the effective implementation of strategies by making decisions about organizational structure, organizational culture, human capital, evaluation indicators and other factors(Gulati et al., 2016).

Ma (2009) believes that organizations are an organic whole with clear goals, ordered structures and conscious, coordinated activities. They also have close contact with the external environment. Humans have a spirit and a body, as do organizations. The "body" of an organization is its "hardware," which include its organizational strategies, modes of operation, business processes, organization structure, technology and products or services. The "spirit" of an organization is its "software," which include its people, culture, behavior patterns and mindsets. From a macro perspective, an organization encompasses organizational design, culture and transformation.

In his book Structure in Fives: Designing Effective Organizations, Mintzberg (1992) defines the structure of an organization as the sum of various methods that divide work into several different tasks and appropriately integrate them to achieve work objectives. The design of an organizational structure and the selection of its design parameters must be processed to re-

alize internal consistency and harmony and to become consistent with the organization's status, including its scale, history, business environment and technology systems. The main purpose of "collaboration mechanisms" is to control and communicate. The basic methods by which an organization collaborates can be roughly divided into five types: mutual adjustment, direct supervision, the standardization of work, the standardization of output and the standardization of skills. The basic parameters of organization design include individual position design, superstructure design, lateral structuring, decision making and the four situational factors of organization design. There are five organizational archetypes, namely, the simple structure, the machine bureaucracy structure, the professional bureaucracy, the divisional form and the adhocracy.

According to Barnard (1948), the originator of modern organization management theory, an organization must rely on a common goal, a willingness to coordinate and communication. The organization and management of an enterprise form a system that appropriately coordinates the vitality or strength of more than two individuals. The earliest organization theory is based on the management theories of Frederick Taylor and Henry Fayol. These theories identify, divide, and assign tasks to those who are responsible. In this sense, management is systematic and structural work. The German scholar Krähe (1950) further divides such work into two parts: the organizational setting (structural organization) and the organizational setting of the work process (process organization). The former involves task division and coordination, whereas the latter involves the structure of the work process in time and space. This theory has been given considerable attention throughout the campaign of business process reengineering (BPR). The application of knowledge in other disciplines has promoted the further development of organizational theories. Some scholars focus on the establishment of reasonable decision-making models to study organizations quantitatively, thus incorporating game theory, team theory and price control theory, among other theories. They put forward the idea that organizations should be rational and science oriented. Other scholars apply the results of psychology and social psychology to organizational research, as represented by Weber (1947) who takes the form of the hierarchical organization as a proper means to analyze the division of labor in industrial production and management processes, as he holds that the principle of the hierarchy has definite significance. Later, Simon (1976) combined the characteristics of human behavior with the structural characteristics of organizations to form the behavioral school of organization theories. With the development of information technology, scholars began to study the systematic influence of technology on organizations; this began in the early 1960s and reached a peak with the development of the internet in the 1990s.

Since the emergence of the theory of organizational development, there have been many discussions on organizational change. Salamon (1981) believes that organizational change affects the standing of organizational structure or the plans of enterprises or institutions. Simon (1976) think that organizational change is a method to promote the change and development of structure, processes (such as interpersonal relationships and roles), personnel (such as styles and skills) and technology. Mosher (1967) believes that organizational change refers to the planned change of an organizational structure, including increases to the number of job positions, the rearrangement of tasks, changes of incumbents and budgetary changes.

Over the past more than 20 years, inspired by the practice of organizational change in companies, many scholars have established numerous theories about organizational change, such as the constellation organization, the 7-S framework, enterprise reconstruction theory, company regeneration, cluster organization structure theory, enterprise reengineering theory, the strategic alliance and the process redesign concept.

In the 1970s, scholars invented the constellation organization. Simply put, the constellation structure is a collection of a number of independent but interrelated companies regarding property rights or management, which is similar to enterprise groups in China, holdings companies in Belgium and industrial groups in France. On the basis of constellation theory, Toffler (1987) asserts that the enterprise should not be composed of traditional, rigid departments but should be a highly flexible structure consisting of a framework and units. In other words, the enterprise becomes a part of a constantly evolving "constellation" of company organizations and institutions, where the framework coordinates by combining temporary and standardized units, forming, in his words, the "adaptive company." According to this point of view, in the consultation, Toffler proposes that Bell should have separated some key functions, such as manufacturing, while retaining and strengthening its R&D function, so that the company could offer the market things that competitors could not produce. This idea is closely related to subcontracting and outsourcing today.

Constellation organization theory enables enterprises to extend their boundaries closer to the market and to reduce the rigidity of their internal organizational structure. Due to people-centric management, creative task forces and organizations without superiors and BPR, the cluster organization of Daniel emerged(Mills, 1991). A cluster is a group of people who come from different fields and work together in a semi-permanent state. It can deal with a variety of administrative affairs with its various areas of expertise, strong customer-oriented information sharing and accountability for business results. The greatest advantage of this kind of organization is how it gives full play to the initiative of employees and its empowerment of them in

a real sense. This concept has brought about a change in customer-oriented organizational forms and the rise of customer relationship management (CRM).

In the 1980s, Megatrends: Ten New Directions Transforming Our Lives by Naisbitt (1982) and the theory of reinventing corporations drew tremendous attention. In a society with abundant information, power delegation, globalization and multiple choices, people's values are based on high technology, perception, work networks, democratic participation and long-term development. Therefore, to create a work environment suitable for employees, enterprises should abandon old organizational structures and cater to communication, self-management, flexible working hours, profit sharing and flexible welfare. ESOPs (employee stock ownership plans), working from home, welfare "buffets" and other management methods commonly found in today's enterprises are similar to this concept. In In Search of Excellence, Tom Peters puts forward the 7-S framework, seven variables concerning management effectiveness, namely, structure, strategy, personnel, management style, system & procedure, values and skills, which together generate the macro and flexible evaluation of an enterprise developing from a micro, fixed company, thus making cultural changes the theme of the mid and late 1980s.

The theory of change in the 1990s is represented by the book Reengineering the Corporation by Michael Hammer and James Champy, published in 1993, which made procedural change the mainstream form of change. They argue that enterprise activities, events and business processes should be the basic elements of organization design. Thus, originally fragmented workflows (including business processes and management processes) can be integrated. The starting point and goal of BPR is customers or markets. What BPR seeks is the thorough transformation of working modes by abandoning the hierarchical organization formed by positions, departments and other entities and replacing it with a new organization focused on processes. As a result, such an organization is less hierarchical, which echoes the "cluster organization" theory mentioned above(Michael & James, 1993).

Organizational change is a complex and dynamic process. Effective and influential theoretical models include Kurt Lewin's three-stage model, Leavitt's model, Kotter's model, Fremont Kast's system change model and Schein's adaptive cycle model.

Lewin (1951) believes that organizational change is the process of breaking and reshaping organizational balance. Based on organizational psychology, a planned organizational change model featuring unfreezing, changing and refreezing is proposed to explain and guide how to launch, manage and stabilize organizational change. The model is also called the "force field" organizational change model. So far, it has been the most influential, with many studies carry-

ing out in-depth analyses and optimizations of it. (1) Unfreezing refers to detecting resistance to organizational change, taking measures to overcome them, and portraying a blueprint for organizational change with clear targets and a clear direction, thus forming a relatively mature plan of organizational change to be implemented. (2) Change: the main task of change is to carry out specific organizational transformation according to the requirements of the proposed plan, thus steering an organization to transform from its existing structural model to the target model. In this step, it is imperative to set examples for new work attitudes and behaviors, including the use of role models, guidance offered by tutors, expert speeches, and group training sessions. Lewin believes that change is a cognitive process featuring new concepts and information acquisition. Therefore, communication and cooperation should be given particular attention. (3) Refreezing often happens in practice. After organizational change, both individuals and organizations tend to return to their original behaviors. To avoid this, managers responsible for change must take measures to ensure that new behaviors and organizational forms can be continuously strengthened and consolidated. Therefore, in this stage, it is necessary to enhance the new systems, policies, and processes to stabilize new attitudes and behaviors, thus solidifying the organizational change. Without this step, the results of change may falter or disappear, having only a short-term influence on the organization and its members.

Naisbitt (1982) proposes a systems approach. He believes that organizational change includes four aspects: goals and tasks, people (actors), technology and structure. Tasks refer to the goals and assignments set by an organization. For an enterprise, they are the product or service that the enterprise provides to society. This task, within an enterprise, is decomposed into specific tasks at all levels and in all aspects. A change in products or services, such as adjusting product structures and making new products, is also an important part of organizational change. People, on the other hand, refers to the attitudes, skills, expectations, beliefs and styles of a company's leaders and employees. Changes to an organization's personnel structure and quality are another important part of organizational change. Technology refers to an organization's products, technical equipment and procedural methods of operation. Technological upgrading, new technology and new materials are the main form of technological change, and they also constitute a significant part of organizational change. Finally, structure refers to the organizational structure, such as the division of power and responsibility, the institutional setting, the degree of centralization and the modes of coordination. Leavitt's systems approach mainly demonstrates how changes in these four aspects are highly interdependent. For example, to adjust a product structure and produce new products with advanced technology requires changes to production technology. It also necessitates the improvement

of the skills of all members in the organization and appropriate adjustments to organizational structure and labor management. Leavitt believes that these four changes often happen simultaneously.

Kotter (1995), an expert in leadership research and change management, distills eight main factors related to failed enterprise change based on the experience of enterprise change, and he then puts forward an eight-stage model: (1) increased urgency, (2) building a powerful, guiding team, (3) getting the right vision, (4) communicating the vision with employees, (5) empowering action, (6) planning and achieving short-term wins, (7) consolidating results and pushing for more change, and (8) forming new rules. Kotter's model can be regarded as an extension of Lewin's three-stage model and essentially follows the order of unfreezing, changing, and refreezing. Moreover, the importance of communication and employee participation is also emphasized throughout these eight stages(Meng, 2005).

A systems model is proposed by Johnson et al. (1973). This model explains the relationship between variables throughout the process of organizational change. It includes three parts: inputs, the element of change and outputs. (1) Inputs includes internal strengths and weaknesses, as well as external opportunities and threats. Its basic framework is the mission, vision, and corresponding strategic planning of the organization. Organizations use mission sentences to justify their existence. Their vision is about long-term goals, and their strategic planning consists of a plan of action to achieve long-term goals. (2) Elements of change include objectives, personnel, social factors, methods, and organizational systems. These elements influence each other. To achieve goals, an organization must combine the corresponding elements of change according to its strategic planning. (3) Outputs include the results of change. An organization should strengthen its overall efficiency in three aspects - its state of organization, its departments and groups, and its individuals - according to strategic plans.

According to this model, Christensen et al. (2008) - representatives of the school of systems theory - propose six steps to implement organizational change. (1) Review the status quo. Review, reflect, evaluate, and study the internal and external environment of the organization, and gain insight into changes to its internal and external environments. (2) Problem detection: Identify problems in the organization and determine the need for organizational change. Also, provide specific and accurate information about the necessary change to the relevant departments within the organization. (3) Clarify gaps between the status quo and the ideal state and analyze existing problems. (4) Methods design: Put forward and evaluate a variety of alternative methods and make choices based on discussion and performance measurement. (5) Implement change according to the selected method and action plan. When implementing

change, it is necessary to reduce or control negative effects caused by such change. (6) Feedback: Evaluate new products and results generated by this change and give feedback. With timely feedback, it is possible to further observe the consistency between the external and the internal environment and to evaluate the results of change. Evaluate a second time if there are any problems.

Schein (1992) thinks that organizational change is a process of adaptation that is generally divided into six steps. (1) Observe changes to the internal and external environment. (2) Provide the relevant departments with specific and accurate information on these changes. (3) Change production processes within the organization according to this information input. (4) Reduce or control the negative effects of change. (5) Produce new products and new results because of change. And (6) further observe for consistency between the external environment and the internal environment, and evaluate the results of the change via feedback. The steps and methods proposed by Schein and Kast are similar. Nonetheless, Schein pays more attention to the process of information transmission via management and points out methods for solving difficulties in each process.

In today's society, increasingly many organizations are faced with complex and dynamic changes. To better develop, an organization must constantly adjust its goals and structural forms to survive and develop sustainably. Organizational change is a basic aspect of organizational management, and it is a lasting theme for the survival and development of an organization. Only by constantly adapting to the external environment can an organization develop soundly. Under these circumstances, managers must pay the utmost attention to change and the management of change to achieve real transformation(Zhang & Xia, 2006).

The action of promoting organizational change is generally manifested as a process in which an executive team systematically rolls out reform in four aspects: organizational strategy, culture, products & services, and organizational structure. The corresponding drivers for organizational change include vision as the driver, cultural development, innovative breakthroughs and innovative structure(Xie & Tu, 2016).

A successful organization has a successful organizational culture. An organizational culture develops gradually throughout production and operation over a long period of time, and it reflects an organization's mission, values, and moral code of conduct to which employees are committed. At present, however, organizations are increasingly faced with dynamic and volatile environments, resulting in frequent and intense organizational changes. As such, organizational cultures are exerting an ever more pronounced influence on organizational reform. When leading smooth organizational change, an organization may be held back or facilitated

by its culture. Also, an organizational culture is expected to facilitate rather than hold back organizational reform(Yang, 2010).

From the micro perspective, organizational behavior is about people and their activities. Any given organization consists of people and their behavior. The essence of an organization can be understood as a collaborative, holistic and interactive mix of people and their behavior(Zhu, 2017).

Kotter and Cohen (2012) hold in the book The Heart of Change that the core issue of organizational change is not about strategies, systems, or culture. These factors matter, but the most critical issue is undoubtedly one of behavior - how should the substance and methods of work be changed? Based on this, the authors put forward three patterns of successful leadership throughout organizational change, namely, to see, to feel and to change. Likewise, the eight steps of leadership throughout organizational change are to create a sense of urgency, to establish a guiding team, to create a vision for change, to communicate this vision effectively, to empower people, to create short-term wins, to maintain momentum and to make changes stick.

Therefore, organizational change is an organizational activity carried out by an organization to cope with changes of the internal and external environment, thus allowing the organization to better adapt to change and gain the capacity for sustainable development(Gulati et al., 2016).

The substance of organizational change includes the components of the organization at hand. The core of change is to transform and innovate the behavior of the organization and its employees. This is also the theoretical backing of the research adopted by the author in this thesis - leading organizational change through the collection and analysis of behavioral data for teachers and students.

In the AI era, there is an unprecedented, urgent need for personalized and innovative talent committed to exploring the unknowns and creating new knowledge. Redesigning schools to face the complex challenges of the future has become an international consensus. Future schools will be characterized by human-friendliness, liberalization, diversification, and personalization.

IT is facilitating the innovation of education concepts, the transformation of how teaching is organized and the renewal of the values of academic content. Knowledge will be everywhere, and students will acquire it through various channels. Ubiquitous learning has become a trend. The first priority of school-based education is no longer to impart knowledge but to cultivate the creative use of knowledge to solve problems, as well as an awareness and ability

to innovate. The report Rethinking Education: Towards a Global Common Good released by UNESCO (2017) endows "knowledge" and "learning" with new interpretations. The meaning and extension of knowledge have crossed conscious awareness into emotion and value. Knowledge has been widely understood as the "information," "attitudes" and "values" obtained through learning. Learning is not only a cognitive behavior based on the acquisition of static knowledge, as it is also a process, a result, a means, and a purpose, as well as a form of personal behavior and collective effort. Traditional classroom teaching is no longer the only form of learning in the AI era, as modern IT has become an important supporting tool for how teaching is organized. Due to the explosive growth and renewal of knowledge in the information age, the conflict between this unlimited expansion of knowledge and the limited capacity of curricula has intensified. Thus, the selection of curricula should also be renewed. All these changes put forward new requirements for teaching and learning. These requirements can be satisfied not only by changing curricula and teaching methods but also by changing the organizational form and structure of teaching.

Xu et al. (2013) believe that the era of big data will have a profound impact on organizational change. First, employees will be more collaborative in the era of big data. All parties in an enterprise will be able to choose the best ways to interact with each other, and they will participate in their work in a more flexible manner. Second, employee performance in the era of big data will be more transparent. Collaborative tools in the era of big data can monitor and record the work behavior of employees, and the deep mining of such data can recreate the full picture of how employees work and can even predict their future work behavior and results. Third, flexible work networks will be widely used in the era of big data. The visualization of data will enable each employee to learn more about his or her behavior characteristics in the work network, thus improving his or her connection with the network. This visualization will also help the organization effectively coordinate different personnel as they complete specific tasks. It will do so by building a high-quality and flexible, collaborative work network. Fourth, if an organization wishes to cultivate its core capacity to cope in the era of big data, and if an enterprise seeks to fully realize the "flexibility" of its work network, it must deeply introduce data mining technology into its work platforms, as these will inevitably offer data indexing, data presentations, intelligent recommendations, and other data-based functions. Also, special talent should be assigned to manage and analyze big data to ensure that data management and analysis departments are upstream in the enterprise. It is also essential that organizations cooperate with experts from different fields, thus using collective wisdom to solve problems.

The new technical revolution represented by big data and computing is having a profound impact on organizational structure and coordinated innovation in various fields. According to B. Wang (2017), the reasons why enterprises are undergoing organizational change in the information age include the following. Outside an enterprise, IT has changed the way information is acquired and transmitted, which has put forward new requirements for information leadership, command, management, proficiency, and production efficiency. Inside an enterprise, traditional bureaucracies have long chains of command and too many levels, resulting in redundant personnel, distorted information, large-scale companies with numerous departments, a lack of coordination and frequent friction, all of which put higher requirements on internal management models and this new round of organizational change. On the other hand, B. Wang (2017) also proposed directions for organizational change in the era of big data. First, organizational efficiency should be improved by reducing size and scope. Second, organizational efficiency should be improved by optimizing module structures. Third, organizational coordination should be strengthened through centralized command and scheduling. Fourth, front-line authorization and activate organizational vitality should be emphasized. Fifth, the focus should be placed on unit efficiency and on enhancing organizational capacity. And sixth, organizational boundaries should be diluted, and organizational flexibility should be increased.

Feng (2018) conducted research on organizational evolution in the era of big data. As a typical technical feature of a new technology paradigm, big data improves the efficiency and flexibility of information acquisition and transmission between organizations, and it effectively solves the problem of information asymmetry. In addition, big data helps make production and management decisions by mining the value of data heterogeneity and the relevance between organizations. This is encouraging structural changes to production costs and transaction costs. Likewise, it is reshaping the relationships between and within organizations, and it is leading to changes in organizational form. Because of the decreasing marginal cost of data, its increasing returns and the aggregation of big data, organizational change in the era of big data is different from traditional organizational change in terms of power, model, and form. Specifically, the networking of enterprise organization, the "full duplex communication" model of production, and integration, virtualized space agglomeration and extended industry convergence are being driven by data.

B. Wang (2017) believes that, in the context of big data, traditional production-driven enterprises have begun to turn into enterprises driven by demand along with customer-centric value chains. In other words, on the premise of meeting the individual needs of customers, human, material, and financial resources should be invested to provide the most suitable

products and services for customers, as well as the assets and core capabilities supporting these resources. Data provides a tool for enterprises to integrate external resources, namely, to integrate users, suppliers, distributors, and other valuable resources into their own value chains, which extends their external boundaries and maximizes their profits. In the era of big data, data from different fields, from different departments and of different types within an enterprise can be obtained more widely, and data will become transparent and transmittable between departments in real time, thus realizing the effective spread and interpretation of data within an enterprise. In addition, the efficiency of communication within enterprises will be greatly improved by effectively integrating data of different departments and by establishing real-time relationships with data. By changing our procedures via big data technology, we can reorganize departments to form networks in which all are able to participate in the enterprise's production and decision-making activities.

Chang and Fu (2019) show that platforms have great economic value in the digital economy era. Platform strategies not only endow enterprises with the network effect, allowing them to accumulate valuable strategic resources from many users, but they also provide enterprises with the opportunity to engage in platform management. This indeed is becoming a new dynamic ability for supporting sustainable development. Compared with the platform innovation strategies of internet enterprises, the platform strategies of traditional enterprises now face unique issues of organizational transformation and change. Taking a large, state-owned enterprise as an example, the authors analyze the background as well as the external and internal environments of the "two wheel-driven platform strategy" formed by building inner and outer ecosystems. They then introduce how the group in question realized organizational change by using this platform strategy to complete horizontal, embedded upgrades "from a chain to a ring," as well as a vertical, embedded upgrade based on "the organization, the institution and rent." The authors then discuss the impacts that these changes brought: "the unfreezing of cognitive models," "guidance for business processes" and "changes to organizational structure." For traditional, large-scale enterprises committed to digital platform transformation, the authors give three management suggestions. First, traditional enterprises should establish a proper strategic transformation-focused concept of the digital economy. Two, the key to digital economy transformation at traditional, large-scale enterprises is the construction of a platform strategy. Third, traditional enterprises should pay attention to the process of organizational change when implementing their platform strategies. The design and implementation of a project-based platform strategy is a good starting point for organizational change at large enterprises. Such organizational change should be affected by gradually

changing the enterprise's cognitive modes, business processes and organizational structure by "establishing the new and then getting rid of the old." In addition, the occurrence of organizational change and the implementation of a platform strategy complement each other. Also, the matching of organizational structure with resources that increase capacity strongly support the construction of such a platform ecosystem, thus promoting the strategic enterprise transformation and the generation of dynamic capabilities.

At present, the research results of organizational change at schools are concentrated in management, sociology, pedagogy, and other disciplines. Among these results, those in sociology are the most abundant and systematic. For example, Yu (2009), from the perspective of sociological institutionalism, looked through the historical context of organizational change at schools in China and divided such changes into three stages: politicization, institutionalization and specialization. Based on this, he puts forward the realistic dilemmas presented by such changes and analyzes the reasons for them. Next, he analyzes organizational change at schools in terms of the relevant organizational field, puts forward three field-specific elements of organizational change (value, power and interest) and analyzes the level of such fields from the four aspects of technology, system, strategy and culture. Finally, three factors influencing the success of organizational change at schools in China are identified: consensus, input and confirmation.

Regarding schools as an organizational system using the theory of organizational sociology, H. Y. Wang (2013) uses the organizational elements of a school as well as the members of its organization as a thread to probe into the basic theoretical problems of organizational change at schools in terms of "vision and goals," "organizational structure" and "organizational culture." Wang then explains how a particular primary school changed its organization in the context of curriculum reform. In addition, the motivations, and operating mechanisms of organizational change at the school, which promoted the success of its curriculum reform, are further discussed, and the following conclusions are reached. First, having the support of a national policy is the best opportunity for organizational change to occur at schools. Second, educator-type presidents can point out the direction of organizational change at schools. Third, the formation of a cohesive community is the key to success for such organizational change. Fourth, systems for independently running schools create the conditions for such organizational change. And fifth, the formation of a long-term mechanism can guarantee the sustainability of organizational change at schools.

From a multi-disciplinary perspective, Bo (2015) raises the topic of "research on the value paradigm of organizational change in primary and secondary schools in contemporary

China" based on the ethical issues of educational change. Bo discusses the relevant concepts, historical changes, current situation, and difficulties in the value paradigm of organizational change at schools, finally proposing a way to improve such change in primary and secondary schools in China after rethinking and drawing lessons from the value paradigm of organizational change at American primary and secondary schools. The three keys to school organizational change are as follows. First, there must be an awareness for the problems of the times fostered by the value paradigm of "utility theory" for organizational change at schools. In addition, the application scope of the utility theory paradigm should be regulated. Second, the organizational system should be encouraged to actively respond to environmental change, and a forcing mechanism leading to public responsibility - such as designing more public spaces for easier participation and moderately stimulating conflicts of interest - should be formed. Also, the options for internal and external personnel should be broadened to stimulate the generation of an ecosystem characterized by mutual responsibility. Three, basic conditions for public governance should be created to improve the security system for generating public responsibility, such as by eliminating the value gap of binary information systems and by promoting the construction of interactive platforms among multiple subjects. Also, the interactive relationship between mankind, nature and systems should be faced squarely to avoid various manmade conflicts.

There are few pedagogical research results on organizational change in schools. Three studies were published by the Principal Studio of Famous Primary and Secondary Schools in Beijing: "Research on Organizational Change in Schools from the Perspective of Principals," "Principal-Led Trial Implementations of Organizational Change in Schools" and "Winning the Future by Transforming Instructional Organization in Schools." These studies systematically introduce the organizational changes made by several primary and secondary schools in Beijing from different perspectives and in different ways. They also examine the reasons, goals, content, and approaches of organizational change in these schools. But such studies are just summaries of practical experience and thus offer no in-depth data mining. No systematic theory of organizational change in schools is formed. Among these studies, Z. Wang (2013) attempted the top-level design and overall advancement of organizational change. Aiming to solve existing problems in traditional education and the organizational modes of teaching, as well as to meet the challenges of the information age, the author referenced the values of the Affiliated High School of Peking University and replaced its traditional organizational form of classes and grades with five diversified and independent departments based on the academy and residential college systems of a university. The author then improved these systems

into two departments, five centers, four colleges and seven academies. In addition, the author formulated and implemented several supporting systems for credits, course selection, mobile learning, and tutoring, developed multivariate courses and designed and operated an education environment adapted to the real-life environments of students.

According to Y. Q. Lu (2013), organizational change should focus on changes to teaching methods, as such changes can facilitate changes to organizational structure and culture. As the principal of the High School Affiliated to BIT, Mr. Lu carried out organizational change using five strategies, including the combination of research-driven and administrative promotions, the combination of organizational structure optimization and organizational function improvement, the combination of conceptual guidance and mechanism guarantees, and gradual improvement in small steps.

He (2017) discusses the relationship between the initiation of classroom teaching reform and environmental factors, as well as applicable management strategies, and also discusses: (1) the processes and strategies for promoting classroom teaching reform and teaching system reconstruction, (2) the theory and strategies of management system improvement to meet the needs of classroom teaching reform, (3) the types and strategies of leadership change to deepen classroom teaching reform, (4) the process of organizational change caused by classroom teaching reform and (5) the key factors and implementation principles of organizational change. Based on an analysis of a five-layer, concentric, circular vortex model centering on classroom teaching reform and its motivational forces, the author finds that the motivational forces of organizational system change originate from the demonstration and guidance of the "subjective" values of teachers and students throughout the change of various systems centering on classroom teaching reform. They are driven by professional, powerful, and moral leadership, transformed by organizational strategy, and maintained and stabilized by forming into a system. This is the continuous integration of four forces: the leading power of ideas, change driven by power, organizational transformation, and system maintenance.

Analyzing how the bureaucratic management model restricts teacher team development, Wang and Li (2013) points out the goals of specialized organizational change as specified in this new round of basic education curriculum reform. After clarifying the "organizational changes based on learning-type teacher team construction," the author extracts the basic strategies of organizational change: (1) build a value system to form centripetal force via the organizational structure, (2) lead teachers to plan their own development with an emphasis on professionalism, (3) enrich learning among teacher teams in school-based trainings based on practical problems, (4) shift from centralization to empowerment in management, (5) shift

operational mechanisms from competition to both cooperation and competition, and (6) build a comprehensive evaluation system characterized by professionalism.

In the current information-based society, educational institutions, especially large educational institutions run by groups, rely on excellent educational talent as their core factor for development. As for schools run by business groups, the continuous increase in the number of schools located in various regions means that in addition to recruiting numerous outstanding talents, it is also necessary for such schools to properly manage their human resources and lay a good foundation for the development of internal personnel. As such, it is particularly important for a school's long-term, high-level development that it build an intelligent human resource platform driven by big data technology. Scientific decision-making and predictive abilities resulting from big data-based quantitative analysis allow data to guide decision making. In addition, human resource departments equipped with big data analysis capabilities can transform from supporting service departments into departments that help with group-wide decision making.

Tang (2014) believes that HR management reform in the era of big data is essential. Such reform can be divided into two aspects. First, regarding macro-level changes to HR management at the national and government levels, a system-integrated management strategy based on big data should be introduced to whatever extent possible to rationally promote personnel system reform at the national and government levels. Second, in the micro-level HR management of enterprises, hospitals, universities and other organizations, big data-based management thinking, and methods should also be applied to talent recruitment, training, and development, as well as to performance management, evaluation, and the handling of labor relations issues.

According to Huang and Xiang (2013), "big data" will lead the development of HR management systems in three directions. First, the application of HR management systems will be pan-internet; that is, HR management systems will have a wide range of data interfaces to obtain various structured, semi-structured and unstructured data from the internet. Second, such systems will provide HR management with more comprehensive references for quantitative analysis. The application of HR accounting or talent evaluation and analysis can truly manifest the concept of human capital and provide analysis results along with strategic predictions. Third, HR management systems will create more favorable conditions for optimizing organizational structure and realizing the flatting of personnel management and employee services. In the era of big data, HR management systems will eliminate the traditional organizational

model, generate more interactive data, encourage better employee participation in personnel management and establish more standardized workflows.

X. R. Zhang et al. (2015) conducted a comparative analysis on the big data applications in HR management by two well-known internet technology companies. Google's big data-based HR management includes four aspects: intelligent recruitment, talent retention, a management manager and working environment design optimization. This kind of refined HR management model based on data has made Google the leader in global HR management model reform. On the other hand, Tencent's big data-based HR platform is composed of three parts: an application layer, a functional layer, and a team. The application layer describes the scenarios, requirements, and implementation of big data applications, and it displays HR businesses supported by HR big data. The functional layer, whose core modules include metadata management, data quality management and logical modeling planning, ensure the quality and value of data, as well as the scientific management and use of data. They also show the back-end operation of HR big data. Generally, HR big data teams consist of people with work experience in one or more fields, such as human resources, HR information technology, databases, and HR consulting, thus ensuring team quality and work efficiency. These HR big data platforms have made real achievements in the stability of candidate identification, accurate recruitment, policy-resources coordination and management, the improvement of staff efficiency and employee satisfaction and engagement.

Affirming the advantages of HR management in recruitment, training and performance management in the era of big data, Hou (2019) also reminds us of some limitations to big data applications in HR management. For example, different enterprises use the same big data platforms for assessment, but the assessment indicators of these platforms are not well adapted to all enterprises, leading to biased results. In addition, the authenticity of attendance, work logs and other data, as well as the data integrity and authenticity on both sides of recruitment, cannot be guaranteed. These deficiencies urge us to make continued improvements to existing human resource systems to better promote healthy enterprise development.

Su (2017) puts forward three misunderstandings about big data-based HR management: (1) the more data, the better, (2) equating information digitization with information digitalization and (3) equating data acquisition to data management. Additionally, the author also gives thoughts on how to commence the big data era of HR management. First, we must introduce modern talent evaluation tools and technologies both technically and operationally, and we must realize the quantification and standardization of basic talent quality evaluations, as well as establish basic talent databases. Second, we must improve the talent management concepts

of managers - especially senior managers - to better their understanding of the benefits of digital talent management for long-term enterprise development, improve their daily management efficiency and gradually establish a comprehensive talent evaluation system. Third, throughout the establishment of evaluation mechanisms, we must introduce the technological and service-based tools of independent, third-party professional evaluation institutions for the evaluation of key talent, thus ensuring that evaluation data are scientific, objective, and valid.

According to Xu and Wang (2019), with the advent of the "internet plus," the HR management of enterprises has achieved the extensive application of statistical technology based on big data and cloud computing; it has enabled management departments to fully understand internal HR distributions through the construction of HR management information databases, and it has led to the further efficient evaluation of recruitment. This has realized the optimization and improvement of overall HR structures, and it has driven the long-term, healthy development of enterprises. Due to effective analyses empowered by data technology throughout enterprise development, human resources at various organizations and enterprises can be used more efficiently via sharing and integration.

Additionally, Y. Y. Wang (2017) applied big data technology to specific links of HR management to study talent recruitment, selection, assessment, incentives, evaluation and development. Zhang et al. (2018) propose an intelligent HR management platform targeting intelligent HR management and operation by intelligently responding to talent selection, development, training, salary distribution, performance evaluation and other requirements. Facing the main problems in HR information management at banks, Li (2016) puts forward innovative big data technology-based applications in five aspects: overall HR planning, personnel recruitment, employee management, assessment & incentives and training & development.

Scientific decision making and prediction endowed by quantitative analysis based on big data enable data to guide decision making. It is also expected that HR departments equipped with big data analysis can transform from supporting service departments to departments that help guide group-wide decision making. Data plays a decisive role and comes not only from internal HR departments but also from external behavior information collected by measurement labels, task flow systems and internal, real-time communications systems. In the research laboratory designed by Prof. Pentland (2015) of MIT, social measurement labels installed on volunteers were used to discover that the flow of ideas is directly related to the growth of productivity and the output of creativity. Furthermore, productivity rises, and pressure decreases when team members communicate more. Later, Prof. Pentland applied this conclusion to the break room arrangements of Bank of America's call center so that more

employees could enjoy breaks at the same time. This single change increased the annual output of the call center by USD 15 million, revealing that external data is sometimes more powerful than business data.

Y. J. Liu (2014), L. Y. Zhang et al. (2015) constructed a "work network" and a "social network" based on internal HR data as well as the "external data" of 104 employees' daily communications, after which they analyzed 12 indicators to measure the importance of nodes in these networks. They found that the average performance of several employee evaluations was positively related to the indicator of the corresponding node and were more strongly related to social network indicators. This data was also used by Jia et al. (2015) to predict the turnover and promotion of employees.

The changes caused by big data technology bear on the futures of most companies, which means that corporate leadership must keep pace with the times. Leadership based on big data is a subset of leadership and represents a new exploration of what it means to lead in the era of big data. Ding (2019) defines leadership based on big data as the ability of leaders to improve big data awareness, change big data management, develop big data resources, activate big data value, and promote the realization of organizational goals by guiding, influencing, and driving others. To gain this ability,Ding (2019) believes that leading officials should improve their big data literacy, take the lead in the application of big data, and reshape interpersonal and departmental relationships within their organizations through reform. In addition, leaders need to build new, big data-appropriate leadership modes, reconstruct organizational environments and reshape superior-subordinate relationships, ultimately forming a mechanism conducive to big data application.

The quantitative research results obtained by Odai (2018) show that when determining and assessing the impact of big data on leadership and decision making, the perceived use and perceived ease of use of big data can promote and enhance the decision-making power of leadership, which in turn empowers them. Additionally, gender and communications technology experience have a direct impact on the relationship between big data and thus empower leadership. Finally, Odai suggests that a variety of infrastructure concerning big data application and data generation should be provided, as this can enable departments to use the necessary data to help leadership empower subordinates and make the best decisions for excellent performance and policy making.

Through an analysis of leadership, the big data environment and enterprise operations, Tan (2016) concludes that enterprise leadership in the era of big data should include the following powers: (1) data mining, (2) data-based decision making, (3) resource integration, (4)

employee incentives and (5) risk control. These five powers constitute the enterprise leadership elements of the era of big data, and they promote the sustainable growth of leadership.

Jin (2018) concludes three reasons for the lack of leadership in the era of big data: (1) enterprise rules and regulations that lag behind the big data era, (2) the inadequate efficiency of enterprise organization and management and (3) inadequate employee incentives. Considering these three points, the author puts forward corresponding strategies for improvement. First, enterprise leadership should - considering the development of the enterprise at hand, as well as the market, relevant science and applicable technology - systematically modify the sections of rules and regulations that fail to satisfy the requirements of modern markets and the big data era. Such leadership should strengthen their efforts in this regard. Second, enterprise leadership should improve their own information and digital literacy by targeting standardized, intelligent, and automatized organizational management. Finally, enterprise leadership should emphasize environmental elements in the development of employee incentive mechanisms. They should establish organizational cultures and cultural backgrounds suitable for employee development in terms of organizational relationships, human-friendly care, and values. They should consolidate environmental foundations and social premises for enterprise growth, and they should lay a solid foundation for sustainable development. Wang et al. (2020) also point out that in the era of big data, enterprise leadership should face up to the challenges brought by big data and change their ideas and management methods accordingly. Big data is an inevitable trend for the development of contemporary enterprises. Thus, such enterprises should recognize and seize the opportunities brought by big data. With the help of big data technology, the data analysis of production, sales, management, and other aspects should be conducted to formulate the best operations and management plans for improving leadership and the economic benefit of enterprises.

In light of Wu and Li (2016), the problems of enterprise management in the era of big data include the low efficiency of big data due to a lack of talent capable of analyzing big data, problems with data extraction, problems with analysis technology and ability, and low leadership attention. Another challenge is that data security management must be strengthened. Based on this, the authors suggest improving enterprise rules and regulations, establishing, and fostering scientific leadership at the macro level, strengthening data acquisition and analysis, and improving data-based decision making.

As for governance, many scholars propose strengthening the information-based leadership of officials. Such proposals can be referenced throughout the governance of enterprises and schools. Han (2017) believes that government leaders who want to improve their leader-

ship should master internet thinking. Specifically, internet thinking involves ideas related to information-based civilization, data-based decision making, relevancy, decentralization, human-friendliness, and computation.

According to R. X. Zhu (2016), the key to government internet thinking leadership lies in five aspects: (1) thinking about the user by taking "people-oriented" and "people-first" principles as the foundation of governance, (2) thinking about platforms by building open, fair, efficient and rule-of-law network platforms, (3) thinking iteratively by continuously improving and incrementing the reform of governance strategies and approaches, (4) thinking about big data by using data to support decision making rather than to verify political achievements and (5) thinking about information openness and data sharing by promoting the informatization and modernization of ruling systems via the internet.

After studying and discussing how to realize auxiliary government decision-making mechanisms through diverse and complex big data and AI information technology, W. C. Liu et al. (2019) give four suggestions on how to improve AI applications in government decision making: (1) establish AI thinking, optimize public service functions and accelerate the transformation to a service-oriented government, (2) improve IT abilities to facilitate government decision making, (3) raise public awareness, let the public participate in policy decisions and improve the scientific backing of decisions, and (4) build high-quality talent teams to ensure that AI plays its due role. The author believes that the application of AI technology based on complex big data in government decision making will inevitably promote the efficiency and quality of decision making and inject fresh blood into government. Accurately grasping the specific direction of future economic and social development by fully exploring, analyzing, and processing big data is conducive to ensuring the rationality and modernization of government decision making.

Sergiovanni (1984) divides the leadership of principals into five levels based on the object and mode of such leadership: technical leadership, interpersonal leadership, educational leadership, symbolic leadership, and cultural leadership. As such, he comprehensively interprets the leadership of principals. According to Zhao (2009), schools are the basic unit of educational reform, and their gatekeepers are principals. As such, strong and creative leadership has become the most common desire of all schools. The leadership of principals mainly refers to the ability to influence teachers and students to achieve common goals. Teachers and students are the main objects of their influence. Principals cause teachers and students to change positively through their ability to influence. The schools in China at present are generally over

managed and under led; hence, it is necessary to strengthen the school administration and research approaches of principals.

Wan (2018) regards the principal, the administrator of a school, as the school's soul and argues that the role of a principal should be reviewed in the AI era. After much research, the author provides a professional training goal for principals. They should strive for theoretical attainment, the renewal of management technology and the expressive ability needed throughout the process of becoming "an ethical school leader, a school designer with a vision and a tasteful builder of culture." In addition, they should aim for school achievement. Also, school managers should provide goals for more people, support their efforts and build joint learning organizations where each member's growth and effort get the respect they deserve.

The information-based leadership of principals is an important factor in the development of school education informatization. Zhi and Zhao (2016) created a questionnaire on the informational leadership of middle school principals and distributed it among teachers. Then, they analyzed the data with structural equation modeling through Maple software. They show that the information technology abilities of middle school principals have a direct, positive effect on their information planning abilities. Likewise, their information planning abilities have a direct, positive effect on their information evaluation and management abilities, and their information evaluation abilities have a direct, positive effect on their information management abilities. Finally, their information management abilities have a direct, positive effect on school information efficiency. Based on these results of their data analysis, the focus should be placed on improving information management abilities, information planning abilities and information technology abilities among middle school principals.

Zhao and Dai (2016) reviewed the research results regarding information-based leadership and its efficiency around the world. They analyzed the current characteristics of information-based leadership and its efficiency among primary and secondary school principals via questionnaires and data analysis, after which they put forward four suggestions for the development of information-based leadership among principals. First, principals should strengthen guidance and assessment throughout school administration. They should improve their information-based school administration planning abilities, thereby improving their information-based teaching-evaluation planning abilities in support of quality management. Also, they should improve their information-based development of academic resources with a focus on quality and fairness. And finally, they should improve their information management of HR with an attention to teacher incentives. Based on an analysis of technology integration goals, Zhao and Liang (2018) discuss the development goals of information leadership among

principals. These include enhancing the participation of students, broadening fair participation channels, achieving the effective professional development of teachers, and building a leadership support network based on information sharing. Moreover, from the perspective of the role of technological integration, the authors interpreted the development goals of information leadership among principals as leadership focused on learning, student rights, teacher capacity building and information resource management.

In addition to basic education, the improvement of leadership among presidents of higher education institutions is also imperative in the era of big data. According to Yang (2016), the digital era is having a great and profound impact on promoting cooperation and exchange in higher education. It is also influencing the personalized development of higher education while accelerating the global sharing of high-quality education resources. Also, with the rapid updating of knowledge and skills in this digital era, traditional education modes are changing, which is forcing higher education to develop unique characteristics and to improve in quality. All these changes are posing new challenges for the reform and leadership-related work of institutions of higher education. Presidents of private colleges and universities should be aware of all the various changes brought about by the digital era. They should constantly cultivate sober and keen judgment and decision-making abilities. In addition, they should focus on innovation and entrepreneurship, as well as inclusive learning, to build a set of abilities that satisfy the development needs of the digital era and that drive the successful reform and development of their colleges and universities.

Outside of China, research on principal leadership is drawing increasing attention in North America. Using scientific knowledge mapping and literature analysis, Li and Duan (2018) discovered that research on principal leadership in the United States is trending, with the focus changing from the overall reform of schools to aspects including principal leadership types, supporting leadership strategy research and teaching leadership. The research focus in China, however, evolved from comprehensive, theoretical research on the leadership of principals to teaching leadership and then to curriculum leadership and informational leadership. The research in North America has focused on the improvement of schools as a whole via the leadership of principals, whereas China's focus has been placed on the development of information in education. In the future, we should promote the development of principal leadership in both academic research and practical application.

According to Wang and Zhao (2017), the evaluation criteria for the information-based leadership of American principals have grown more diverse. They analyze the current development of information-based leadership evaluations regarding knowledge, skills, self-

awareness and training performance in the United States, the main characteristics of which they distill as (1) multiple subjects of evaluation, (2) diverse value needs and (3) multi-dimensional paths of participation. Three implications gained from this study of the informational leadership of American principals are as follows. First, the intrinsic value orientation of evaluation criteria should be enriched in terms of its value demands. Second, external evaluation criteria should go hand in hand with the self-awareness of the subjects of evaluation. Third, the time, space and means of capacity evaluation should be dimensionally broadened.

Yang et al. (2018) reviewed the criteria and improvement programs of information-based leadership in education in China and the United States, after which they comparatively analyzed the applicable objects of evaluation, as well the main tasks and specific content of both country's sets of criteria. They found differences in the leadership systems of primary and secondary schools in the two countries, and these differences led to a wider variety of applicable objects in the American criteria as well as clearer tasks in the Chinese criteria. After comparing curriculum structures and evaluation patterns, as well as support measures and certification methods of the improvement programs in the two countries, the authors also found that the American STLI/STL program had a wider range of curricular content, and its teaching methods could meet the personalized needs of learners, whereas China's "improvement programs" had more targeted content but relatively poor certification methods and support measures. Based on this, their paper suggests that when improving information-based leadership among principals in China, the focus should be put on innovating training modes, standardizing the implementation of curricula and guaranteeing certification mechanisms.

**2.2.2 Starting and applying organizational change in educational management**

Management is a profound, systematic, and dynamic science. It is a specific set of behaviors for the arranging, handling, and coordinating of people, things and issues in a system or an organization. As such, it is indispensable in daily work. Management was initially applied in industries and commerce. Only later was it adopted in the education industry(Hao, 2017).

Education management refers to educational activities in schools and is mainly concerned with managerial activities including the planning, organization, and control of teaching activities. It seeks to coordinate the internal departments and links of a school and to establish and improve various necessary systems so that the work of the school can be carried out in an orderly and efficient way(Yang, 1987).

Therefore, it is reasonable that education management is a subdivision of management. Facing the complex internal and external environments of today, management must continue

to carry out organizational reform to adapt to changes. Likewise, as a branch of management, education management must address organizational change.

Throughout the history of education, the reform of education took place along with the revolution of production methods and technology. For a long time, there were no schools on earth. People imparted experiences and beliefs through production and labor. With the advent of the Agricultural Revolution and written words, however, the first schools were established in which there were people responsible for teaching. During the Industrial Revolution, the modern school system and compulsory education system came into being. Schools are a product of educational development and have been changing continuously. Today, as the "internet plus" era is giving rise to MOOCs, traditional schools are facing severe challenges presented by the vision for the schools of the future(Y. X. Zhu, 2016).

At present, there are many problems with school organizations and their management in China. Such problems include bureaucratic school organizational structures, highly administrative processes and management patterns, and experience-oriented methods of management. These problems have seriously reduced the effectiveness of school organizations, resulting in increasingly rigid schools that lack vitality, as well as the constrained initiatives and creativity of both faculty and students(Pu, 2005).

Regarding global educational management reform, in the book Disrupting Class: How Disruptive Innovation Will Change the Way the World Learns,Christensen et al. (2008) argues that an inevitable trend in education is that the present teaching tasks that teachers dominate and undertake will be gradually transformed into student-centered learning activities. Christensen also argues that science and technology will be the starting point for student-based teaching reform. Most successful charter schools in the form of public-private partnerships identify two categories of organizational structural innovation, and these categories are not mutually exclusive. The first consists of new learning and teaching systems characterized by innovative teaching and learning. The second focuses on extracurricular and after-school activities that attempt to improve the factors that affect student behavior while meeting the needs of children with special needs.

## 2.3 Education management in the era of big data

How the functions of education management should be executed to improve education quality, increase the benefits of school administration, support orderly teaching, improve school-administration conditions and promote education development is related to the means and

methods of education management. From the perspective of data, based on the quantity and quality of data used throughout the process of performing the functions of education management, education management can be divided into education management in the non-data era, education management in the sample data era and education management in the big data era.

Education management in the non-data era refers to the management without data before scientific education management appeared. Such management "relied on experience, theory, hypothesis and values to discover laws in unknown fields in the absence of empirical data." In the sample data era, scientific education management was employed alongside data collection to consciously support the performance of certain management functions. But "in the long history of humankind, and even during the rapid development of modern society, people still primarily relied on sample data, partial data and one-sided data." In the big data era, with the development of modern science and technology, people can now execute the functions of education management according to "total, hybrid and relevant" data; that is, "'comprehensive, complete and systematic data'" are obtained and deeply used in many fields to explore the laws of the real world, as well as to obtain knowledge and opportunities beyond what was possible in the past"(Schönberger & Zhou, 2013). Therefore, comprehensive research on big data-based education management reform along with the feature analysis of the performance and functional achievements of education management in the big data era can provide effective references for formulating more effective education management measures and methods, as well as better realize the purposes of education management.

According to Zhou (2014), there are five trends in education management that fall under the background of big data: (1) warning data highlighting the timeliness of education management, (2) predictive data highlighting the foresight of education management, (3) differences highlighting the personalization of education management, (4) shared data highlighting the integration of education management, and (5) dynamic data highlighting the contingency of education management. Also, in the context of big data, education managers must change their ideas, improve their data awareness and possess the necessary skills for data analysis and application. In addition, challenges regarding data sharing and security are issues that we must face directly.

Hu and Wang (2015) conclude that educational management reform in the era of big data will shift from administrative management and empirical decision-making to service-oriented management and data-based decision-making. In the context of big data, school management becomes a data-based behavioral science, and the decision-making modes of schools are also

changed from traditional, top-level decision making and popular, innovative decision making to data-based decision making. The authors also stress that great importance should be attached to the guiding role of empirical research results in education. We can adopt the methods of empirical research, select a certain perspective and determine the corresponding dependent and independent variables. Then, we can use the approaches and technology of big data to collect, mine and analyze data on educational activities, after which we can draw the corresponding conclusions, enable the data to speak and, ultimately, guide and improve educational and teaching activities, as well as education management.

From the perspective of the philosophy of science, technology, management, pedagogy and sociology,Chen (2017) conducted research by means of expert interviews and questionnaires. As such, Chen found that after more than a decade of development, achievements have been made in the information-based education management of Chinese institutions of higher education. These achievements include the initial establishment of a CIO system, the gradual increase in financial investment and the initial effects of education management. But there are also some problems in the big data-based education management in China, such as its lack of top-level design, capital guarantees, data talent and a sharing mechanism, as well as imperfect laws and regulations. Considering these problems, Chen puts forward a series of countermeasures. Chen states that Chinese institutions of higher education should establish a concept of education management based on big data. They should adhere to being human friendly, make the best use of advantages, avoid harm and use both "the carrot and the stick." They should also achieve the big data development goal of "avoiding risks and giving full play to advantages" by strengthening top-level design and system regulation, establishing mechanisms for coordination, sharing and evaluation, fostering data-based teacher resources and constructing other operation and maintenance systems. Obviously, these experiences from colleges and universities are also valuable at basic education schools.

Through a questionnaire- and interview-based case study on the education management of town "S" in the Pearl River Delta,Xu (2019) discovered problems with existing private school management, such as inadequate administrative management, limited fee standards, managers with non-standard operational concepts, principals with limited decision-making power and instable teacher teams. Xu thus offered some suggestions, including the need for external support such as inclusion in a public policy framework, the implementation of management responsibilities, the formulation of development plans and internal development, such as the rectification of ideas on school-administration, the improvement of governance structures and the strengthening of teaching and education research.

## 2.4 Short summary

To sum up, in the era of big data, education management can build teachers' and students' portraits by collecting data and carrying out in-depth data analysis in education and its related fields. As a result, more comprehensive understand of teachers' and students' needs for teaching and learning can be identified, which helps establish a more targeted system and optimize the allocation of educational resources to make education management more scientific and professional and build an innovative educational management model.

The big data era provides more abundant information for education management. Teachers can search for teaching slides, lesson plans, test questions, and other teaching-related information online. Students are able to solve their puzzles given the access to the Internet. Moreover, the education management department can identify high-quality teaching resources and methods that help better allocate teaching resources, including the online teaching system, the classroom monitoring system, the lesson preparation system, the teaching and education research system, the student evaluation system, etc. In a word, teaching resources can be greatly shared in the era of big data.

The education management system integrates the education database and the professional data processing platform in education, making education management model in the era of big data remarkably different from the traditional one. By analyzing ever-changing education data, education managers generalize the rule of data change incorporating features of teaching. The analysis of trends of data change enables managers to anticipate the future landscape of education and formulate targeted development plans and solutions for a more scientific and professional education management.

As education management enters the big data era with education data, sufficient and timely education data is regarded as the basis for more targeted and timely education decisions. In this sense, education data has become the core competitiveness of schools, regions, and even countries. A major challenge confronting education management in the highly competitive field of education is to establish the fresh systems and standards guided by big data-based thinking, with big data management at the core, to upgrade education management in the big data era. Big data is bound to be the data asset and serve as the revolutionary force in teaching models, data collection, resource allocation, smart decision-making, and so forth.

# Chapter 3: Research Methods and Design

## 3.1 Research strategy: experimental methodology

This thesis is mainly based on experimental research methods.

In experimental research, researchers often put forward hypothetical explanations and quantitative descriptions of the phenomenon at hand. These explanations and descriptions are based on observations, reasoning, and calculation. Researchers then verify their hypotheses with experiments, and they attempt to establish direct causal relationships between variables. Experimental research honors the principles of local control, randomization, and replication.

Experimental research methods were first primarily adopted in the natural sciences. From the Renaissance, the adoption of experimental methods established connections between theories and empirical facts, which thus fueled the rapid development of the natural sciences. In recent decades, researchers in the social sciences have increasingly realized the importance of experimental methods and have begun to make efforts at applying experimental methods to their specific disciplines, including psychology, which is highly related to educational technology.Lay (1912) advocates for education to carry out rigorous experimental research such as that of psychology. Such research should be based on educational experiments and should apply the logic and methods of experiments and hypotheses, as well as quantitative descriptions, to identify causality or correlations between various elements in educational activities, as this can overcome the problems of previous educational theories, which merely relied on speculation.

With the development of modern science and technology, as well as statistics and other related disciplines, educational research has access to more scientific and high-tech approaches. By adopting computers to carry out testing, description, simulation and quantitative analysis via mathematical methods, educational theory is now capable of embarking on a rigorous, scientific path. The research in this study is experiment-based. It documents data acquisition and summarizes the relevant experimental research results. Then, it generates theoretical conclusions.

Compared with traditional methods, the experimental research methods adopted in this thesis are somewhat innovative due to their use of big data. As opposed to controlled inter-

vention, in which cause and effect is established as a prior and then verified experimentally, this researcher employed the methods of big data analysis to explore the correlations between variables after experiments and data collection, thus producing more interesting conclusions from the data.

Big data analysis in research at the University of Electronic Science and Technology of China by Cao et al. (2018) shows the positive correlation between orderliness and academic performance, which lends insight into experiment design of the current research that collected data relevant to students' orderliness on campus (e.g., on-time return on Sundays) to verify results generated on the university campus among the K12 students.

## 3.2 The selection of experiment sites: Tianli schools

These experiments studied the schools under Tianli Education Group.

Founded in Sichuan, China, in 2002, with the mission of becoming "an innovator and leader of private education in China," Tianli Education has gradually grown into a competitive private, basic education group in China through 19 years of development. In July 2018, Tianli was listed on the main board of the Stock Exchange of Hong Kong (Stock Code: HK.01773).

By February 2022, the group's school network had covered 32 cities in 13 provinces and municipalities, including Sichuan, Shandong, Henan, Guizhou, Yunnan, Jiangxi, Gansu, Anhui, Zhejiang, Hubei, Chongqing, Inner Mongolia Autonomous Region and Guangxi Autonomous Region, with a total of 46 schools (including schools under operation and under construction). These schools covered the four stages from kindergarten to high school and were home to more than 72,000 students, making Tianli one of the top three K12 education groups in terms of its student population in China. The company has also won the "China Educational Innovation Demonstration Company," "Chinese Education Group with Competitive Brands," "Chinese Education Group with Outstanding Comprehensive Strength," "Model Group of China's Education Industry," "Enterprise for Public Welfare in China's Education Industry" and "Chinese Education Group with Corporate Social Responsibility" awards.

The Education and Teaching Research Institute and the Educational Science and Technology Research Institute are located at Tianli Education's headquarters.

The Education and Teaching Research Institute, with a basic focus on student growth and national curricula, put forth in 2016 a unique curriculum system centering on independence, ethics training, academic achievement, manners, individuality, positive mindsets and wholis-

tic development. This system inherits traditions, embraces modernity, and integrates education methods in China and other countries. At present, this curriculum system has developed well along with China's national curriculum and includes a variety of courses, such as canoeing, beach volleyball, tennis, drama, mind mapping, animation, non-fiction writing and children's reading of various levels, all of which enjoy extensive student participation and the warm recognition of parents.

The Education and Teaching Research Institute is committed to the planning and development of the information system of the entire group. It is also committed to the collection and analysis of big data on education, K12-related research and services, the research and promotion of educational technology, and the digital upgrading of management and decision-making. Over the past two years, it has paid more attention to advanced information technology to reform and upgrade its education and teaching modes. It has actively promoted the implementation of internet education technology in offline schools, and it has applied advanced technologies such as double-teacher classrooms, intelligent pens and automatic grading in pilot schools to promote the integrated online and offline development of Tianli Education.

Tianli boasts its Institute of Educational Architectural Design, which carries out in-depth research on the functions and performance of the school. The institute has built schools with Chinese architectural characteristics by integrating local cultures with modern science and technology. In recent years, Tianli has become the first among China's basic education schools to establish museums of Chinese culture, science and technology on new campuses. These buildings offer courses in traditional Chinese culture, science and technology - the crown jewel of Tianli's unique curriculum system.

Tianli's schools are chosen as the objects of this study, because:

1. Tianli Education, as a leading enterprise of basic education in China, is typical and representative yet also distinct.

2. Tianli Education highly values the research and application of educational technology. It has an open attitude toward research on education and teaching. In addition, its headquarters and subordinate schools are closely connected, which enables the effective and efficient administration of these experiments and ensures the accuracy of the experimental data used in this thesis.

3. Tianli has many subordinate schools, allowing this researcher to carry out experiments at schools for different stages. The reproducibility of the experimental method employed also enhances the reliability of this thesis' experimental data and conclusions.

In summary, by studying Tianli's schools in this thesis, the researcher can not only apply the conclusions of this thesis to all of Tianli's schools but can also promote them in other basic education schools thanks to Tianli's leading role in basic education in China. As such, this thesis can even provide research support for innovating and upgrading the teaching modes in China's basic education schools.

## 3.3 Research design

### 3.3.1 Data collection

The collection of experimental data is a critical component of experimental research methods. Such collection requires an appropriate experimental design to ensure the authenticity and objectivity of the collected data. In addition, it involves the reorganization and cleaning of original data. Only in this way can subsequent data analysis be meaningful and generate convincing conclusions. The main data used by this thesis are primary experimental data, though a small amount of secondary data was collected from outside Tianli's schools.

#### 3.3.1.1 Primary data collection

The primary data of this thesis were obtained through experiments designed by the researcher. These experiments can be divided into two categories: in-school behavioral data on students and teachers.

In-school student behavioral data were mostly obtained through intelligent campus IoT facilities, and the smart bracelets worn by students. One type of data consisted of physical health and sports, including real-time heart rates (not studied in this research) and daily steps taken, whereas the other type consisted of location data acquired through an intelligent Bluetooth gateway. This could be used as attendance data for students at specific locations. These two kinds of data were automatically obtained through an information system on the condition that students wear their bracelets during the experiment period.

In-school behavioral data on teachers mostly consisted of information on their daily tasks and working hours. This study classifies these tasks into two categories, teaching and management, with each category having several specific subcategories. Teachers filled out this data daily. To make it easy for them to do so and to make it easier for the researcher to collect follow-up data, a special smartphone app was developed, a method that also ensured the timeliness and accuracy of the data.

### 3.3.1.2 Secondary data collection

To analyze the background of human resources in teaching, this thesis collected the financial data of six Chinese basic education groups listed in the United States or Hong Kong. These secondary data came from the annual reports and prospectuses of listed education groups and covered items including overall revenue, the number of teachers on payroll, labor costs as a proportion of total costs, teacher output and the teacher-student ratio. These six listed education groups, to a certain extent, represent high-quality, private schools in China, and their levels of teaching quality and operational efficiency are high. By analyzing their financial data, the researcher was able to explore their advantages and, more importantly, discover common shortcomings in pursuit of a systematic approach to improve the operational and management efficiency of China's private, basic schools.

### 3.3.2 Data processing

In general, this thesis contains qualitative and quantitative primary and secondary data.

### 3.3.2.1 Qualitative data processing

The qualitative data of this thesis is mainly reflected in its classification of teacher behaviors at school. As described in 3.3.1.1, we divide the tasks of teachers into two categories: teaching and management. Specifically, teaching tasks include meetings, teaching classes, grading homework, breaks, monitoring independent study, lesson planning, communication, class activities, school activities, asking for leave, grading tests, supervising exams, contacting parents, providing individual assistance, checking dorms, having meals with students, sending students to see doctors, training and helping with student enrollment. Management tasks include planning, summarizing, work communication, work meetings, activity organization, supervision, guidance, examination, assessment, enrollment, publicity management and other daily activities. This classification enabled the researcher to observe the distribution of teacher time spent on various tasks to improve their work efficiency and happiness.

### 3.3.2.2 Quantitative data processing

Most data in this thesis, especially the primary data, are quantitative.

To analyze how students' behavioral data is correlated with academic performance, apart from automatic data preprocessing according to filter conditions programmed in the system, the IBM SPSS Statistics (vision No.26) was also adopted.

For the specific teacher tasks mentioned in the section above, the starting and ending times of each task were collected, and the major tasks for teachers were analyzed given the time they consumed. Finally, a portrait of the daily time distribution for teachers was developed. And through the smart bracelets, the researcher collected daily step count data from students, which indicate the extent of their daily exercise. Programs were written to carry out statistical analysis.

### 3.3.3 Objectivity of data sources and analysis

This dissertation aims to seek for the development path in line with the strategic goal of Tianli Education Group, both theoretically and practically, based on difficulty in developing China's basic education, and, in particular, running this group. With "seeking truth from facts" as the fundamental premise of all research activities, various methods were applied to ensure authentic data sources and unbiased data analysis.

Two independent teams were established, responsible for data collection and data analysis, respectively. While the IOT on campus automatically obtained data to ensure the objectivity and authenticity of students' data, team members ensured data authenticity by monitoring teachers as they filled out data with rewards and punishment after observing teachers' daily work on site.

Data analysis was conducted either by programs independently written for this research or the professional software, SPSS, to avoid deviation and errors caused by manual data processing.

All these methods serve the credibility of experiment results, which largely guarantee the reasonable and appropriate organizational change based on research results.

# Chapter 4: Field Work - An Experimental Study in Tianli Schools

## 4.1 A big data analysis of student behavior based on the smart campus and IoT

The idea of the Internet of Things (IoT) - in which all things can be connected to the internet by sensors such as Radio Frequency Identification (RFID) tags to accomplish intelligent recognition and network management - was first proposed by the Massachusetts Institute of Technology (MIT) in 1999. The concept of the IoT was addressed in *ITU Internet Report 2005* as the state in which all things can connect to each other at any place and at any time via RFID technology, wireless sensor networks technology, intelligent embedded technology and nanotechnology(Yao, 2010).

Specifically, IoT is divided into perception, network and application layers. The perception layer is its "skin and facial features," which it uses to identify objects and collect information. The network layer is its central nervous system and brain, where it transfers and processes the information acquired by the application layer. Finally, the application layer integrates the IoT's "social division of labor" with industry needs to realize deep industrial intelligence.

The IoT offers the full use of a new generation of IT technology for all. Specifically, it embeds and equips sensors into power grids, railways, bridges, tunnels, highways, buildings, water supply systems, dams and oil and gas pipelines. Among these objects, the IoT is then integrated with the existing internet to realize the integration of human society and physical systems. In this integrated network, there is a super-powerful central computer group that can integrate people into the network. On the basis of the real-time management and control of machines, equipment and infrastructure, humans can thus manage production and life in a more sophisticated and dynamic way, achieving "smart" status, improving resource utilization and productivity, and improving people and their relationship with nature(Huang, 2009).

At present, vigorously implementing an innovation-driven, big data-led development strategy in education requires a full understanding and a full unleashing of the important supporting role of the IoT in fostering new driving forces for the development of the education industry. It requires facilitating the adjustment of the education industry's structure and im-

proving the service capacity of school governance. Based on this, we actively explore the application of IoT in schools in this thesis. On the one hand, we hoped to collect and analyze the behavioral data of students in school through the construction of an on-campus, intelligent IoT to subsequently play a positive role in the appropriate education of students. On the other hand, we hoped that an IoT on campus would enable teachers and students to truly feel that advanced technology had entered their daily lives, thus fostering student interest in science and technology, as well as improving the overall scientific and technological literacy of teachers and students.

### 4.1.1 Research design and implementation

### 4.1.1.1 Scheme design

Based on the establishment of an on-campus, intelligent IoT, this study sought to collect student behavioral data in school, including real-time locations and daily step counts. This was done using smart, wearable devices. This study then sought to correlate such behavior data with academic achievement using big data analysis to scientifically improve education and teaching activities, as well as the quality of teaching and academic achievement.

The real-time location data of students recorded by this IoT were applied in the following ways.

(1) They covertly kept real-time attendance records outside of the students' awareness. This was done to obtain real-time attendance data within the mobile-learning course selection system of China's new curriculum reforms.

(2) They allowed for the accurate search for students who were not in designated areas during class time via real-time positioning data, thus improving campus security.

(3) They divided key areas within the campus and recorded student activity hotspots, which made it easier to carry out targeted activities that students prefer.

These smart, wearable devices not only collected exercise data and real-time heart rates, thus gradually improving student health records, but also monitored their physical conditions in real time - especially during sports - to strengthen PE reform and scientifically improve physical fitness.

### 4.1.1.2 Constructing the perceptive IoT

Regarding the selection of smart, wearable devices for the perception layer, we think that smart bracelets were well-suited to school applications, as they have the following advantages.

(1) They are easy for students to wear and have a minimal impact on their daily lives and learning activities.

(2) They can last an entire week before needing to be recharged, which is convenient for students at boarding schools like those of Tianli.

(3) Besides communicating with Bluetooth gateways to record attendance, of which the students were unaware, they also interacted with consumer machines and access control equipment in cafeterias and supermarkets, allowing for their application in more scenarios in the future.

(4) They can also record heart rate data, daily step counts and other data in real time, thus providing basic data for the keeping of student health records.

Bluetooth communication technology in the transmission layer allows such smart bracelets to communicate with intelligent gateways, through which collected data can be transmitted to physical data transfer nodes and finally to a central control server.

Hence, regarding hardware, the construction of an intelligent campus perception network composed of smart sensors, intelligent communications gateways, data transfer nodes and a central control server can be completed as in Figure 4.1 below.
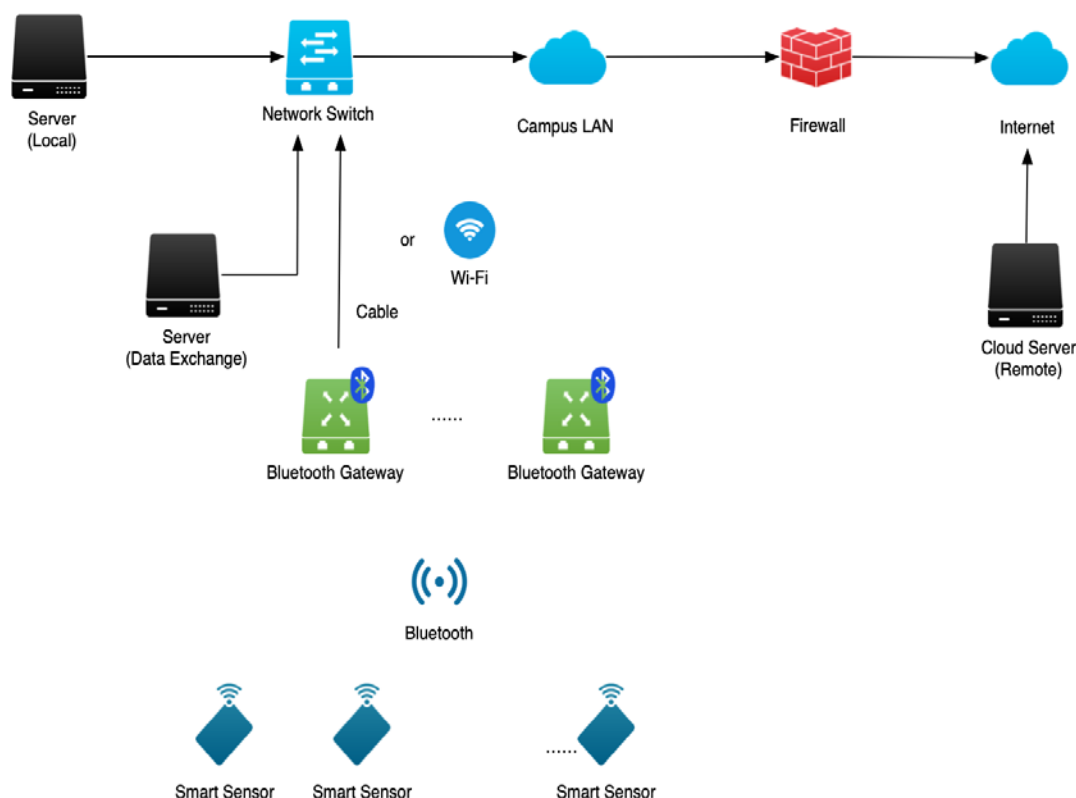


Figure 4.1 Intelligent Campus Perception Network

### 4.1.2 Data pre-processing

### 4.1.2.1 Data collection

This study was performed in Deyang Tianli School, Sichuan, China, in May 2019. As a newly built school in September 2018, it has good hardware facilities and high-quality teachers who are committed to innovation. For this reason, however, the school had relatively few students in the first through seventh grades, as well as in the tenth grade. Considering the need to wear bracelets for a long time, 268 students from six classes in the seventh grade were selected as the first batch to participate in this research.

The collected data consist of two types: in-school student behavioral data from their smart bracelets, as well as regular examination results.

Based on IoT-empowered intelligent campus perception, the data collected by the smart bracelets worn by the students include real-time locations (the school is divided into a teaching building, a cafeteria, a playground, a dormitory building and other areas), daily step counts, real-time heart rates, location-based attendance records, cafeteria consumption records and boiler room entry records. In addition to the data directly recorded by the IoT, the frequency of bracelet wearing, tardiness records, whether students dined in the cafeteria and other data could also be acquired through statistical analysis.

Focusing on the results of four standardized examinations in May, July, September and November of 2019, academic achievement data consists of single subject scores, total scores and grade ranks, which are mainly used for the correlation analysis with student behavioral data.

With all this data, we can roughly determine the students' activities and behavioral habits throughout daily life. From this, we can gain valuable results through data analysis. Based on this principle, this study attempts to mine the factors and specific behavior features related to academic achievement from these behavioral data by means of data mining technology. The aim is to assist students in improving their academic performance through accurately regulating their daily behaviors.

Since too much data can, at present, be too much to process, only the data from May through November of 2019 (excluding July and August, when students were on their summer vacation) were collected in this study. This way, the data mining would be more efficient and accurate. Some tables of data are listed below in Table 4.1 and in Table A.1, Table A.2 and Table A.3 Annex A.

The data above typify most of the data used in this study. The actual data tables contain more fields, in which some have no bearing on this study and were consciously excluded dur-

ing the process of data acquisition. The final data tables were fitted to a standard format and stored in a local database.

Table 4.1 Student Activity Data

| Field No. | Field Name | Field Type | Field Description |
|---|---|---|---|
| 1 | Student_Name | varchar | Student's name |
| 2 | Student_Id | varchar | Student's ID |
| 3 | Date | date | Date |
| 4 | Steps_Daily | int | Daily steps |
| 5 | Steps_Avg | double | Average daily steps |

**4.1.2.2 Data cleaning**

The next step after data acquisition was to clean the data, a necessary step for removing empty, abnormal and duplicate values. After observing the collected data, we found that there were many problems to be solved.

For example, regarding empty values, only a small amount of valid data was collected due to some students having failed to wear their bracelets regularly. After analysis, we found that there were two main circumstances at play. One consisted of bracelet malfunction or loss, resulting in long stretches of empty values for the behavioral data. Upon discovery of this problem, we contacted the students to replace their bracelets with new ones were they willing to continue wearing them. Similarly, we continued to track the academic achievement of those unwilling to wear the bracelets, as this data could be used for comparative analyses later. The other problem consisted of the presence of long intervals between two valid points of data - intervals longer than five days, for example - due to students improperly wearing their bracelets. Though they returned no data, such behavioral habits are also valuable, so we retained these data points for comparative analyses later. Data for students who were transferred to or from the school during the research period were considered incomplete and regarded as invalid. As such, they were deleted from the overall sample statistics.

Abnormal values were more common in daily step count statistics due to the following circumstances. First, a student would only wear his or her bracelet for a short period of time on a particular day, resulting in a count value greater than 0 but less than 500. Such values were deemed as a student not wearing his or her bracelet, and such data points were eliminated. Second, the count value on a particular day would be 30% higher than the average during a period of time. Such values would be compared against the student's schedule on that day and were retained if they were due to excessive exercise during PE lessons.

Redundant (duplicate) values, which mostly existed in behavioral data records, were deleted. Different data-dependent criteria were used to judge if a particular data point was a du-

plicate. For example, for time field data, such as data on Sunday attendance, we only recorded whether students returned to school on time. Thus, we only had to keep the earliest timestamp recorded for a given student on a given day. Conversely, for data without timestamps, such as academic achievement data, student ID fields, exam times and subjects were used to determine whether duplicates existed, after which such duplicates were deleted.

After cleaning the data using these methods, we obtained relatively clean and complete student behavioral data that could be used for data analysis and data mining. In total, over 21,536 performance data points, 2,128 attendance data points, and over $1.47 \times 10^8$ steps of 268 students from six classes in the seventh grade were obtained, which will be the abundant data basis for future research.

### 4.1.3 A big data analysis of student behavior

This study sought to discover the correlations between specific student behaviors and their academic achievement through a comparative analysis of behavior data and academic achievement. It is necessary to consciously guide, regulate and strengthen the specific behaviors that are positively related to academic achievement. Likewise, certain methods and means should be used to prevent behaviors negatively related to academic achievement. This way, students will improve their academic performance.

The smart bracelets recorded two types of student data. One consisted of physical health and exercise data, including real-time heart rates and daily step counts. Heart rate data are of reference value for evaluating student health and are especially useful for determining personalized exercise intensity when students engage in large amounts of exercise. Such data, however, have a low correlation with the theme of this study, so we conducted the subsequent analysis mainly based on daily step count data, which can objectively reflect the daily exercise volume of students, and which are regarded as an important dimension of in-school student behavior. We also used location data collected by the intelligent Bluetooth gateway, as well as student attendance data based on their designated locations. According to the boarding system implemented by the private school in this study, students had to leave school every Friday afternoon and return at three o'clock every Sunday afternoon. Thus, whether each student returned to school on time could be accurately judged via the student data from the Bluetooth gateway at the school gate each Sunday. As a good reflection of the students' compliance with this timetable, these data were used heavily in the subsequent analysis. Similarly, when students lined up for meals every day, the regularity of their dining times could be re-

flected through their smart bracelets and other consumer devices. Since, however, the mealtimes of boarding schools are relatively fixed, such data were not included in the subsequent analysis due to their lack of variability.

When analyzing student academic achievement, in addition to a horizontal analysis of subject scores and rankings, this study also conducts a horizontal comparison between each student's current and previous rankings (raw score data are not comparable and were excluded because they are significantly affected by the content and difficulty of the exams) in subject scores and overall scores. Also, students were labeled according to their ranking range (such as "top 1%," "top 5%" and "top 10%").

Finally, in this thesis, the correlation between behavioral habit data and academic achievement is analyzed.

### 4.1.3.1 Bracelet-wearing habits analysis

Due to the summer vacation splitting the research period in two, the bracelet-wearing data for students are divided into two phases. Phase I, from May 20 to July 12, 2019, excluding weekends and national legal holidays, totals 40 days, and Phase II, from September 1 to December 31, 2019, excluding weekends and national legal holidays, totals 122 days.

Based on different frequency ranges for the bracelet wearing, as well as the numbers of times that the bracelets were worn, the data of all 260 students in Phase I are divided into five levels, which are shown in Table B.1 and Figure 4.2.



**The Distribution of Wearing Times in Phase I**

■32-40　■24-31　■12-23　■4-22　■0-3
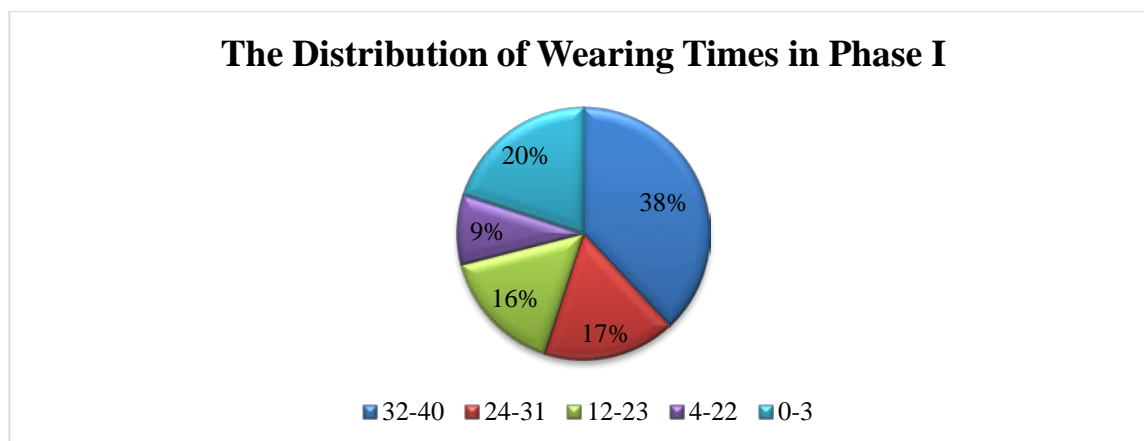
Figure 4.2 The Distribution of Wearing Times in Phase I

As shown in the table and figure above, 99 students wore their bracelets 32 times (accounting for 80% of the total wearing time) or more, accounting for 38% of the total student number. These students exhibited excellent wearing habits. On the other hand, 51 students wore their bracelets less than four times (accounting for 10% of the total wearing time), accounting for nearly 20% of the total student number. These students exhibited abysmal wear-

ing habits, which can also be regarded as a poor daily habit or as a lack of discipline. Due to their extremely low bracelet-wearing frequency, this group of students is not included in some other subsequent data analyses, such as the determination of the students' average step counts.

Similarly, the bracelet-wearing data of the students in Phase II are divided into five levels, as shown in Figure 4.3 below.
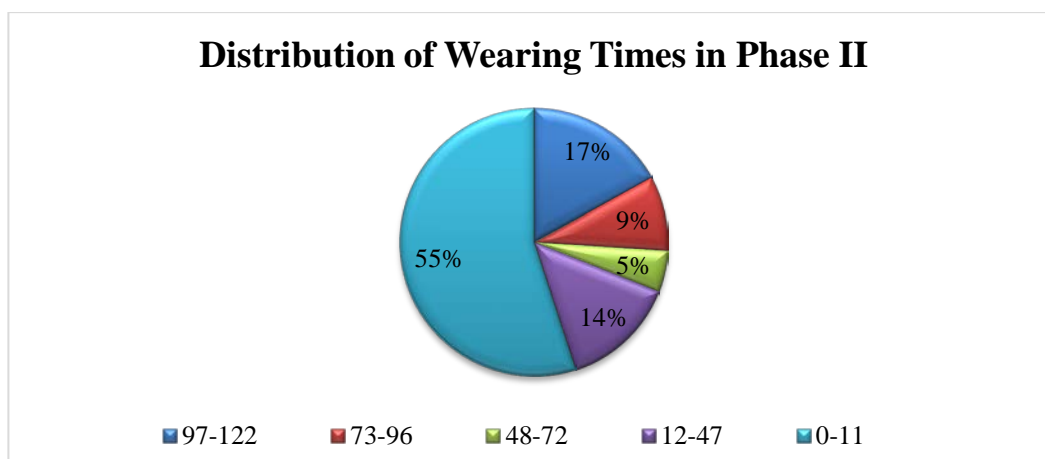


Figure 4.3 The Distribution of Wearing Times in Phase II

Source: Experimental Statistics (See Table B.2 for more information)

It can be seen from these statistics that, compared with Phase I, the overall bracelet-wearing frequency of the students in Phase II decreased significantly. In particular, the proportion of students who wore their bracelets less than five times is over 50%.

Figure 4.4 illustrates how the students' bracelet-wearing habits obviously weakened after the summer vacation. The main reason is that the school had no rigid regulations on students in this respect, and this was also a rule specially formulated during the research design stage to investigate the continuity of the students' bracelet-wearing habits without supervision. Another reason is that all the students participating in this study were in their first year of junior high school, and students in this age group typically lack self-discipline.
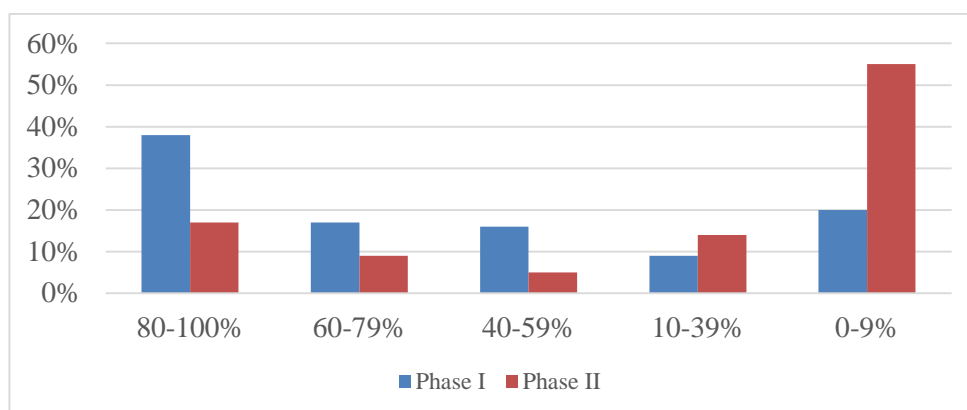


Figure 4.4 Wearing Frequency Comparison between the Two Phases

**4.1.3.2 Exercise data analysis**

Given the statistical patterns in the last section, the analysis of exercise data in this thesis is also divided into two phases. "Exercise data" refers here to the daily step counts recorded by the students' bracelets. Considering the validity of the samples, only data with a bracelet-wearing frequency greater than 10% are selected.

In Phase I, there are 209 students with bracelet-wearing frequencies above 10% (they wore their bracelets at least four times), accounting for 80% of the total number of students. They took an average of 8,306 steps per day, of which the maximum is 15,343 steps (1.85 times the average); the minimum is 1,674 steps (only 20% of the average). The distribution of daily steps in phase I is shown in Figure E.1 in Annex E.

In Phase II, there are 117 students with a bracelet-wearing frequency of more than 10% (they wore their bracelets at least 12 times), accounting for 45% of the total number of students. Among them, the average daily step counts of nine students are less than 1,000; considering the normal amount of exercise in school, the data for these nine students are abnormal and are not included in the overall statistics. Therefore, the remaining 108 students took an average of 5,876 steps per day, which is nearly 29% lower than that of Phase I. The maximum is 10,290 steps (1.75 times the average), whereas the minimum is 1,304 steps (only 22% of the average). The distribution of daily steps in Phase II is shown in Figure E.2 in Annex E.

By comparing the data of the two phases (Table 4.2), we find that the overall data of Phase I is better than that of Phase II in all respects. Also, the number of valid samples in Phase I is nearly twice as many as that of Phase II. This means that, at the beginning of this study, the students had good bracelet-wearing habits; that is, most of the students remembered to wear their bracelets, but after returning to school over the summer vacation, nearly half of the students failed to maintain this habit. As a result, it was difficult for these first-year junior high school students to develop this habit without it being mandated and enforced by their teachers. A total of 61% of the students' average daily step counts are, however, above the average in Phase II, which is better than the 55% of Phase I. This shows that the students who had good bracelet-wearing habits also persevered in their physical exercise.

Table 4.2 Exercise Data Comparison Between the Two Phases

| Items | Phase I | Phase II |
|---|---|---|
| Number of Valid Samples | 209 | 108 |
| Daily Step Count | 8306 | 5876 |
| Max. Daily Steps | 15,343 | 10,290 |
| Min. Daily Steps | 1674 | 1304 |

In addition, the overall average daily step counts of Phase II is less than that of Phase I. We think the main reason for this is that, as the weather grew colder from September to December, the students' enthusiasm for exercise was not as high as it was from May to July. This also reminds us that we should appropriately increase the number of PE lessons in Phase II to guarantee that the students are getting a regular amount of exercise.

### 4.1.3.3 Sunday attendance data analysis

According to the boarding system implemented by the school in this study, students must leave school every Friday afternoon and return to school every Sunday afternoon. The arrival time stipulated by the school is 3:00 p.m. on Sunday. Whether or not a student returns to school on time on Sunday is also a good reflection of whether he or she is punctual and abides by the school's timetable. Their bracelets' signal is picked up by intelligent campus IoT perception via the Bluetooth gateway installed at the school gate. Thus, a punctuality record for each student can be used to determine whether they arrive at school on time.

Return-to-school data for 16 weekends from September 1 to December 31, 2019, were collected in this study, in which 133 students' data are valid, like those of section 4.1.3.2. See Table B.5 and Figure 4.5 below.
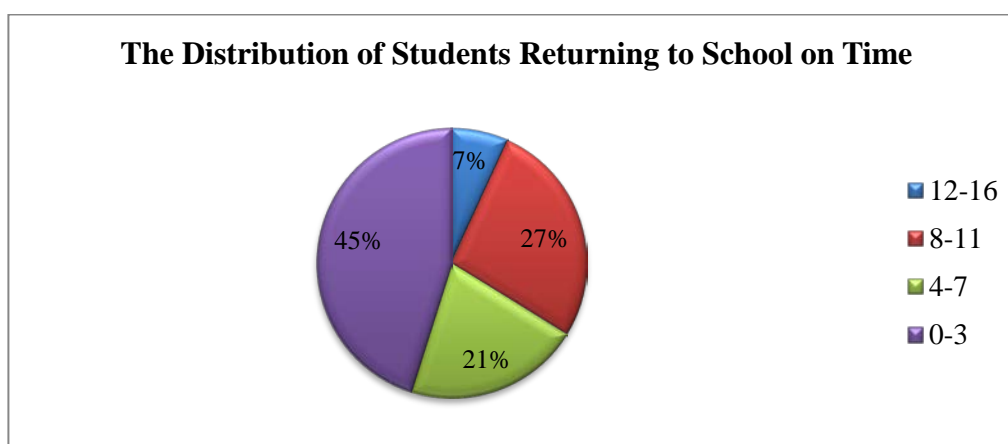


Figure 4.5 The Distribution of Students Returning to School on Time

According to the statistics for these 16 weekends, only 34% of the students' punctuality rates exceed 50 percent, and nearly half of the students return to school on time four times or less - a punctuality rate of less than 25%. In other words, when dealing with rules that are only loosely enforced (rather than strict timetable rules for classes and gatherings), the overall performance of the students in this age group is poor. The reason for this is that the students and their parents pay little attention to such rules. They think that returning to school any time on Sunday is sufficient and that there is no need to be punctual, which is more or less consistent with the conclusion of section 4.1.3.1.

**4.1.3.4 Correlation analysis between students' behavior and academic performance**

We believe that the wearing habits of students' bracelets, daily exercise habits, and returning to school on time on weekends reflect the regularity and preciseness of students' behavior habits at school to a certain extent. In the traditional Chinese education, it is believed that students' behavior is closely related to their academic performance, but this conclusion lacks scientific and rigorous tests. Here we try to analyze the correlation between students' behavior habits and academic performance through the experimental data, which will help us to have a deeper understanding of the main factors affecting students' performance and is also of great significance to the realization of personalized education and student management.

(1) Average daily exercise and academic performance

We take the average daily exercise steps of students in the two stages and their examination results in the two stages (the final examination results in July 2019 in the first stage and the half-term examination results in November 2019 in the second stage) as the basic data of the analysis. Figure B.1 shows the distribution table of two-stage exercise steps and grade ranking (the top 100 with exercise step records). It can be seen that the average daily exercise steps in the top are slightly larger than those in the bottom. Further, we compare and analyze the average daily exercise of the top and last 20 students in the two stages. The results are shown in Figure 4.6:

The average daily steps of the top 20 students are 9745 steps, and the last 20 students are 8022 steps.

The comparison results of the second stage are shown in Figure B.2, in which the average daily steps of the top 20 students are 6026 steps, and the average daily steps of the last 20 students are 5130 steps. The results of the two stages show that the students in the top rank also have more average daily movement steps.
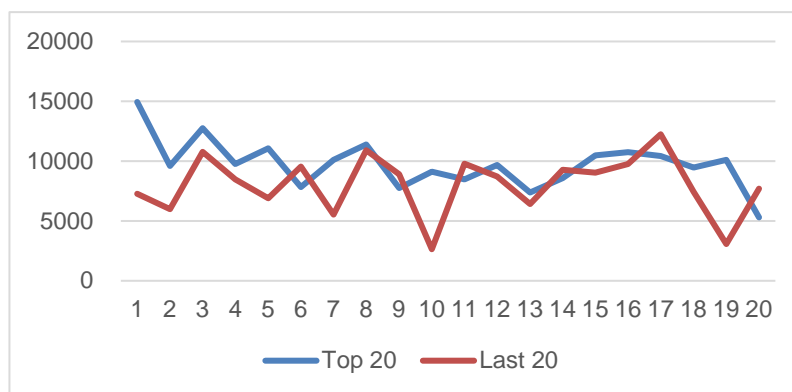


Figure 4.6 Comparison of daily average steps of the top 20 and last 20 during the first stage (with daily steps recorded)

(2) Bracelet wearing times and academic performance

Using the same analysis method as above, the wearing times and grade ranking of bracelets in the two stages are shown in Figure B.3 and Figure B.4 respectively.

Among them, the average wearing days of the top 20 in the first stage is 32.8 days, and the last 20 are 23.1 days. In the second stage (September 2019), the average wearing days of the top 20 are 17.9 days and the last 20 are 15.9 days.

We got similar results: the result analysis of the two stages showed that overall, the top students wore more.

### 4.1.4 Short summary

Based on the above experimental data analysis, we get the following conclusions:

1. The students who participated in the experiment did not have good behavior habits at school without the supervision of teachers, which can be seen from the gradual decline of the overall wearing rate of bracelets and the low rate of returning to school on time on Sundays;

2. Students with large daily average exercise and more days of wearing bracelets also have better overall academic performance, indicating that there is a certain positive correlation between good behavior habits and academic performance.

In particular, among the students in the experiment, the students who ranked first in the average daily exercise also ranked first in the overall academic performance in the statistical cycle, which also aroused our deeper thinking, which is how to formulate a personalized teaching model more suitable for these "gifted students" with excellent comprehensive quality and better help them develop.

## 4.2 A big data analysis of teacher work behavior

It is common to see issues in human resource management (HRM), such as data organization and analysis problems in human resource planning, limited and passive information collection by recruiters, a lack of scientific personnel evaluations and poor training results. The advent of big data technology, however, has the potential to solve these problems.

Traditional HRM has problems with human resource planning, recruitment, career evaluation, training, performance management, salary management and employee growth management due to its limited access to data, backward technology and man-made interference.

At present, the managerial methods and conceptualization of human resources in schools still focus on the accuracy of personnel information and salary payment, and this is especially

true for basic education, which lacks scientific and efficient management modes and urgently requires optimization.

With the promotion of information systems in school management, human resources have begun accumulating data, which makes it possible to use big data to solve current HRM problems. By effectively incorporating big data technology with human resource theory and applying such data to the various fields of HRM, human resource managers will be better able to not only improve management efficiency but also promote value.

The era of big data is revolutionizing management. Likewise, HRM should conform to the trends of the times and give full play to big data technology to collect, organize and analyze data. The selection of useful information from big data sets can provide a basis for decision making in HRM departments.

The research in this chapter was designed to scientifically collect big data on the in-school activities of teachers using an information-based approach. With data generated from teachers' daily work logs, and by incorporating big data processing, teachers can be managed to perform better, and the pain points of their daily work can be more accurately determined so that targeted measures can be taken to reduce repetitive labor and improve work efficiency.

### 4.2.1 Research background

By the end of 2018, there were six domestic private basic education groups listed in the United States and Hong Kong: Tianli (TL), Fengye (FY), Ruijian (RJ), Bojun (BJ), Boshile (BSL) and Hailiang (HL).

Table 4.3 Overall Revenue and Teacher Contributions

| Item | TL | FY | RJ | BJ | BSL | HL | Average |
|---|---|---|---|---|---|---|---|
| Revenue (in units of 100 million yuan) | 6.40 | 13.41 | 12.47 | 2.31 | 17.19 | 11.69 | 10.58 |
| Operating Costs (in units of 100 million yuan) | 4.48 | 7.17 | 7.02 | 1.69 | 10.91 | 8.04 | 6.42 |
| Employment Costs (in units of 100 million yuan) | 2.87 | 4.59 | 3.15 | 0.98 | 7.54 | 4.07 | 3.86 |
| Employment Costs as a Share of the Total | 64% | 64% | 45% | 58% | 69% | 51% | 59% |
| Number of Teachers* | 1,852 | 2,955 | 2,670 | 580 | 4,297 | 1,856 | 2,368 |
| Average Revenue Generated perTeacher (in units of 10 thousand yuan) | 34.61 | 45.38 | 46.70 | 39.83 | 40.00 | 62.98 | 44.92 |
| Gross Margin Generated perTeacher (in units of 10 thousand yuan) | 10.37 | 21.12 | 20.41 | 10.69 | 14.61 | 19.67 | 17.00 |
| Teacher - Student Ratio | 13.02 | 11.33 | 16.19 | 12.43 | 8.54 | 11.91 | 12.24 |

Source: Data on FY, RJ, YH, BJ and BSL in the financial year ending August 31, 2018; Data on HL in the financial year ending June 30, 2018

According to the annual reports and prospectuses of these six companies, the following table was compiled. It covers their overall revenue, their total number of teachers, their labor costs as a proportion of total costs, teacher output and teacher-to-student ratios.

Note that these results may not be accurate due to varying end dates for each company's fiscal year, their non-standardized employee classifications regarding operating costs and the varying time lengths of employment, among other issues, so these data are provided only for general reference.

According to the data shown in Table 4.3 and the actual circumstances on the ground at Tianli, it can be concluded from the perspective of human resources that for private schools - especially private education groups that run schools across the country - there are pain points in human resources, as follows.

1. The overall profitability of private schools is low, and their labor costs amount to a high proportion of revenue.

2. Amid the rapid proliferation of private schools, the demand for high-quality teachers is growing, but the supply of excellent teachers has fallen behind this demand growth.

3. In recent years, despite the rapid development of information technology, modes of education remain traditional, and new technology has not obviously improved the efficiency of education and teaching.

These three problems are slowing the rapid and healthy development of private, basic education. Thus, only by fundamentally solving these problems can schools gain an edge amid fierce market competition and improve.

## 4.2.2 Survey goals

To fundamentally solve the three problems mentioned at the end of section 4.2.1, it is necessary to further examine how teachers work. This study aims to use information technology to collect teacher work data objectively and scientifically. It also aims to reveal obstacles to the improvement of their work efficiency through big data analysis to thereby improve their labor productivity and enhance their output. This will enable teachers to have more time and energy to serve students and parents. The specifics are listed as follows.

1. Big data technology will be introduced to conduct quantitative analyses of the duration and intensity of teachers' work to explore education and teaching reform and to improve teaching efficiency.

2. New teacher selection and training modes will be explored to optimize faculty structures and to increase the professionalism and standardization of school jobs.

### 4.2.3 Research tasks

Prior to this experiment, specific research tasks were clarified and assigned. First, the in-school behavioral data of teachers at work would be collected and analyzed via an information-based approach using surveys. Then, by carrying out curriculum standardization, establishing an information platform and optimizing financial standardization, Tianli would improve its faculty staffing. This is referred to as "trimming staff and streamlining administration." The specific division of tasks is shown in Table 4.4.

Table 4.4 The Division of Work in Tianli's Push to "Trim Staff and Streamline Administration"

| Department in Charge | Major Tasks |
| --- | --- |
| Human Resource Center | Carry out internal surveys in pilot schools |
| Education Management Center | Develop Tianli's teacher training system, textbooks and lesson planning standardization |
| Financial Center | Develop standardized Tianli faculty revenue systems |
| IT Department Under the Planning and Operations Center | Develop an information-based education platform |

### 4.2.4 Research data collection and big data analysis

### 4.2.4.1 Sampling

To ensure that the data is objective and scientific, five school districts in various stages of operation - Luzhou (LZ), Yibin (YB), Guangyuan (GY), Deyang (DY) and Zunyi (ZY) schools - were selected to implement this study simultaneously. This research classifies these schools into three types based on TL's internal standards and the schools' years of operation: the brand development stage (0-3 years), the growth stage (3-6 years) and the mature stage (6 years and above). In addition, this experiment attempted to achieve "full coverage" of the three types of schools, as well as "full coverage" over all stages of study - including kindergarten, primary school, elementary school and high school. Likewise, it attempted to cover all types of teachers, including new, experienced and core teachers, as well as teachers who have taught students enrolled into Peking or Tsinghua University (PT-teacher for short, the same below). Finally, it attempted to cover faculty responsible for all manner of subjects, as well as all administrators, with full consideration of all working hours. To this end, all five school districts carried out this study seriously by issuing administrative orders to prevent fraud and to generate objective and authentic data.

In total, there are 141 participants from five school districts in the survey, including 14 teachers with one responsibility (teaching only), 127 teachers who also served as head teachers, administrative personnel or teaching & research personnel (see Table 4.5).

Table 4.5 The Number of Participants in Five Tianli schools

| School District | Kindergarten | Primary School | Junior High School | High School | Total |
|:---:|:---:|:---:|:---:|:---:|:---:|
| Luzhou | 15 | 13 | 14 | | 42 |
| Yibin | 3 | 6 | 13 | | 22 |
| Guangyuan | 0 | 6 | 10 | 10 | 26 |
| Deyang | 0 | 6 | 10 | 11 | 27 |
| Zunyi | 0 | 8 | 8 | 8 | 24 |

**4.2.4.2 Teacher work log data collection**

Obtaining complete and authentic data from all participants' schoolwork logs requires not only technological support but also systematic guarantees. All original work log data were provided by teachers and checked by Tianli's HR Administration Center staff. There were incentives for those who finished their logs completely and accurately; failure to do so would void these incentives, and the corresponding data would be regarded as invalid and removed from the sample to ensure the authenticity of the data.

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To effectively improve the convenience, timeliness and accuracy of data collection, we developed a special app for teachers to submit data online via forms, and we trained all relevant faculty in this regard. Also, back-end management functions for school group leaders and group investigators were developed, and incentive and punishment mechanisms for submitting data were formulated so that the researcher could have constant access to data, real-time alerts and effective data collection for the benefit of efficient data collection in the schools. Moreover, according to periodic log reviews, the functions of the app were adjusted and improved to increase the accuracy of data collection. The interface of the app is shown in Annex E Figure E.3.

The data recorded in the teachers' work logs reflect the content of their work throughout every working hour and includes the following information.

(1) The starting and end times of various tasks are recorded.

(2) There are two types of tasks: teaching and management tasks. Tasks relevant to teaching include meetings, teaching classes, homework grading, breaks, the monitoring of independent student study, lesson planning, communication, class activities, school activities,

leave, test grading, supervising exams, contacting parents, providing individual assistance, checking dorms, having meals with students, sending students to see doctors, training and helping with student enrollment. Management tasks include planning, summarizing, work communication, work meetings, activity organization, supervision, guidance, examination, assessment, enrollment, publicity management and other daily activities.

(3) Work tasks include descriptions.

These are optional items in which teachers were asked to provide detailed descriptions in their work logs.

### 4.2.4.3 A comparison of work hours in pilot schools

To present the survey data more truthfully, objectively and clearly, and in consideration of the COVID-19 epidemic that ravaged the world in 2020, this survey data is presented in two stages: a pre-epidemic stage (from December 9, 2019, to January 15, 2020) and a post-epidemic stage (from February 10, 2020, to April 30, 2020). The researcher began by adding and comparing teachers' work hours, which, to some extent, demonstrate their work intensity.

1. The Pre-epidemic Stage

This was the first stage of the experiment, which lasted from December 9, 2019, to January 15, 2020. During this stage, five school districts registered 2,343 days of work logs with a total survey time of 1,386,501 minutes. The details are presented in Annex C Table C.1.

2. The Post-epidemic Stage

This stage was from February 10, 2020, to April 30, 2020, during which the five school districts registered 1,460 days of work logs with a total survey time of 650,013 minutes, as shown in Annex C Table C.2.

### 4.2.4.4 The proportion of work hours spent on specific tasks in pilot schools

In the previous section, the researcher calculated the total work hours of teachers and thus generated comprehensive, quantitative statistics for on-duty teachers. In this section, the researcher lists the top five work activities of the various stages of study at each school based on the collected data. The researcher also attempts to produce portraits reflecting the work activities of on-duty teachers, thus providing quantitative support for the subsequent trimming of staff and streamlining of administration.

In the selected five school districts, the schools in Luzhou and Yibin are kindergartens, for which the researcher lists the top five most time-consuming tasks before and after the epi-

demic in Table 4.6. Similar statistics are produced for all teachers at the tops of the remaining tables.

Table 4.6 The Top Five Most Time-Consuming Work Tasks for Teachers Working in Two Kindergartens Before and After the Epidemic

| Kindergarten | | | |
|---|---|---|---|
| All Schools | | | |
| Pre-epidemic | | Post-epidemic | |
| Ethics Training | 35.71% | Material Handling | 19.40% |
| eaching Classes | 12.74% | Training | 15.87% |
| Meetings | 8.21% | Work Communication | 12.27% |
| Meals and Doctor Visits | 8.20% | Supervision and Guidance | 8.80% |
| Work Communication | 5.59% | Meetings | 8.71% |
| Luzhou Tianli | | | |
| Pre-epidemic | | Post-epidemic | |
| Ethics Training | 41.13% | Trainings | 18.39% |
| Meals and Doctor Visits | 10.68% | Material Handling | 16.50% |
| Meetings | 9.84% | Work Communication | 14.78% |
| Teaching Classes | 7.44% | Training Supervision and Guidance | 10.73% |
| Work Communication | 6.15% | Examination and Assessment | 9.90% |
| Yibin Tianli | | | |
| Pre-epidemic | | Post-epidemic | |
| Teaching Classes | 28.39% | Material Handling | 32.17% |
| Ethics Training | 19.68% | Class Visits | 25.56% |
| Student Communication | 9.54% | Teaching Research | 25.41% |
| Examination and Assessment | 9.46% | Meetings | 5.13% |
| Lesson Planning | 9.28% | Training | 4.72% |

The following conclusions can be drawn from Table 4.6.

(1) There were major changes concerning the primary tasks of kindergarten teachers at both kindergartens before and after the epidemic. This is reasonable considering that the kindergartens suspended teaching, and students mainly stayed at home, thus causing teachers to switch from teaching-based tasks such as teaching courses on ethics to handling school affairs including administration and training.

(2) There is a distinct difference in the major tasks of the teachers at these two kindergartens. This is primarily due to the lack of a standardized teaching program catering to kindergartens in China. As such, kindergartens carry out teaching activities based on their specific facilities and teachers. Thus, kindergartens can give full play to their unique features, but the level of standardization of their teaching activities is low, as the valuable teaching content and teaching experience of one region can be difficult to duplicate in another.

The five participating schools include primary, junior and senior high schools. The top five most time-consuming work tasks for the teachers of these schools before and after the epidemic are shown in Table 4.7,Table 4.8 and Table 4.9.

Table 4.7 The Top Five Most Time-Consuming Work Tasks in the Primary Schools of Five School Districts

| Primary School | | | |
|---|---|---|---|
| **All Schools** | | | |
| Pre-epidemic | | Post-epidemic | |
| Teaching Classes | 29.94% | Teaching Classes | 17.10% |
| Ethics Training | 10.66% | Lesson Planning | 15.37% |
| Homework Grading | 8.63% | Homework Grading | 13.88% |
| Meetings | 8.24% | Material Handling | 7.21% |
| Lesson Planning | 7.37% | Training | 7.10% |
| **Luzhou Tianli** | | | |
| Pre-epidemic | | Post-epidemic | |
| Teaching Classes | 23.59% | Teaching Classes | 16.68% |
| Ethics Training | 11.82% | Homework Grading | 14.40% |
| Homework Grading | 10.20% | Lesson Planning | 14.11% |
| Meetings | 7.60% | Training | 8.53% |
| Planning and Reflection | 7.25% | Material Handling | 7.48% |
| **Yibin Tianli** | | | |
| Pre-epidemic | | | |
| | | Post-epidemic | |
| Teaching Classes | 41.32% | Lesson Planning | 22.74% |
| Meetings | 14.17% | Teaching Classes | 18.59% |
| Ethics Training | 12.22% | Student Communication | 15.32% |
| Lesson Planning | 9.34% | Homework Grading | 13.75% |
| Homework Grading | 6.11% | Material Handling | 6.95% |
| **Guangyuan Tianli** | | | |
| Pre-epidemic | | Post-epidemic | |
| Teaching Classes | 36.95% | Recruitment and Publicity | 23.14% |
| Meals and Doctor Visits | 9.64% | Monitoring Independent Study | 22.62% |
| Ethics Training | 7.57% | Teaching Classes | 21.54% |
| Examination and Assessment | 7.33% | Ethics Training | 9.59% |
| Test Design and Marking | 6.24% | Meals and Doctor Visits | 7.34% |
| **Deyang Tianli** | | | |
| Pre-epidemic | | Post-epidemic | |
| Teaching Classes | 27.80% | Meetings | 27.01% |
| Homework Grading | 12.71% | Teaching Classes | 17.65% |
| Lesson Planning | 12.25% | Homework Grading | 13.89% |
| Meals and Doctor Visits | 9.03% | Work Communication | 13.81% |
| Meetings | 7.81% | Parent Communication | 13.81% |
| **Zunyi Tianli** | | | |
| Pre-epidemic | | Post-epidemic | |
| Teaching Classes | 33.25% | Training | 61.59% |
| Lesson Planning | 15.00% | Material Handling | 19.21% |
| Ethics Training | 9.20% | Planning and Reflection | 19.21% |
| Homework Grading | 7.59% | | |
| Meetings | 5.10% | - | |

Table 4.8 The Top Five Most Time-Consuming Work Tasks in the Elementary Schools of Five School Districts

| Junior High School | | | | |
|---|---|---|---|---|
| All Schools | | | | |
| Pre-epidemic | | | Post-epidemic | |
| Teaching Classe | 27.34% | | Lesson Planning | 20.68% |
| Lesson Planning | 13.01% | | Teaching Classes | 13.65% |
| Monitoring Independent Study | 11.53% | | Training | 9.41% |
| Homework Grading | 7.38% | | Homework Grading | 9.14% |
| Ethics Training | 7.30% | | Material Handling | 8.38% |
| Luzhou Tianli | | | | |
| Pre-epidemic | | | Post-epidemic | |
| Teaching Classes | 25.17% | | Lesson Planning | 18.35% |
| Monitoring Independent Study | 12.99% | | Training | 12.21% |
| Lesson Planning | 11.02% | | Teaching Classes | 9.85% |
| Homework Grading | 7.07% | | Material Handling | 9.55% |
| Training Supervision and Guidance | 7.06% | | Work Communication | 9.07% |
| Yibin Tianli | | | | |
| Pre-epidemic | | | Post-epidemic | |
| Teaching Classes | 29.30% | | Teaching Classes | 50.66% |
| Monitoring Independent Study | 14.67% | | Lesson Planning | 30.70% |
| Lesson Planning | 12.42% | | Homework Grading | 16.56% |
| Ethics Training | 9.42% | | Meetings | 2.08% |
| Supervising Exams | 9.22% | | - | |
| Guangyuan Tianli | | | | |
| Pre-epidemic | | | Post-epidemic | |
| Teaching Classes | 35.39% | | Teaching Classes | 70.88% |
| Lesson Planning | 13.19% | | Lesson Planning | 10.39% |
| Examination and Assessment | 7.86% | | Meetings | 8.04% |
| Ethics Training | 7.71% | | Monitoring Independent Study | 4.12% |
| Supervising Exams | 6.93% | | Material Handling | 2.35% |
| Deyang Tianli | | | | |
| Pre-epidemic | | | Post-epidemic | |
| Teaching Classes | 22.54% | | Lesson Planning | 50.79% |
| Supervising Exams | 15.97% | | Meetings | 21.77% |
| Lesson Planning | 13.70% | | Material Handling | 16.49% |
| Test Design and Marking | 11.24% | | Student Communication | 7.92% |
| Monitoring Independent Study | 7.73% | | Homework Grading | 3.03% |
| Zunyi Tianli | | | | |
| Pre-epidemic | | | Post-epidemic | |
| Teaching Classes | 21.54% | | Lesson Planning | 30.68% |
| Lesson Planning | 15.98% | | Class Visits | 18.20% |
| Monitoring Independent Study | 12.28% | | Homework Grading | 14.21% |
| Homework Grading | 10.63% | | Teaching Classes | 9.97% |
| Meetings | 7.79% | | Student Communication | 6.03% |

Table 4.9 The Top Five Most Time-Consuming Work Tasks in the High Schools of Five School Districts

| Senior High School | | | | |
|---|---|---|---|---|
| All Schools | | | | |
| Pre-epidemic | | | Post-epidemic | |
| Lesson Planning | 23.16% | | Lesson Planning | 18.05% |

| | | | |
|---|---|---|---|
| Teaching Classes | 20.26% | Teaching Classes | 16.00% |
| Monitoring Independent Study | 14.99% | Homework Grading | 12.51% |
| Supervising Exams | 8.28% | Material Handling | 9.46% |
| Homework Grading | 6.29% | Student Communication | 9.25% |

**Luzhou Tianli**

| Pre-epidemic | | Post-epidemic | |
|---|---|---|---|
| Work Communication | 18.85% | Lesson Planning | 20.51% |
| Supervision and Guidance | 17.91% | Work Communication | 18.78% |
| Teaching Classes | 13.72% | Planning and Reflection | 14.75% |
| Training | 12.88% | Homework Grading | 11.57% |
| Monitoring Independent Study | 11.91% | Teaching Classes | 11.01% |

**Yibin Tianli**

| Pre-epidemic | | Post-epidemic | |
|---|---|---|---|
| Teaching Classes | 21.48% | Teaching Classes | 29.58% |
| Lesson Planning | 20.44% | Lesson Planning | 29.49% |
| Monitoring Independent Study | 18.96% | Student Communication | 26.27% |
| Supervising Exams | 6.92% | Meetings | 6.08% |
| Homework Grading | 6.64% | Homework Grading | 3.89% |

**Guangyuan Tianli**

| Pre-epidemic | | Post-epidemic | |
|---|---|---|---|
| Lesson Planning | 30.18% | Lesson Planning | 36.77% |
| Teaching Classes | 21.69% | Teaching Classes | 21.92% |
| Monitoring Independent Study | 13.25% | Monitoring Independent Study | 11.28% |
| Supervising Exams | 9.03% | Homework Grading | 8.40% |
| Supervision and Guidance | 6.39% | Student Communication | 3.98% |

**Deyang Tianli**

| Pre-epidemic | | Post-epidemic | |
|---|---|---|---|
| Teaching Classes | 24.39% | Lesson Planning | 26.38% |
| Lesson Planning | 19.36% | Meetings | 14.99% |
| Monitoring Independent Study | 16.77% | Teaching Classes | 14.47% |
| Supervising Exams | 10.33% | Homework Grading | 11.32% |
| Ethics Training | 6.72% | Student Communication | 5.04% |

**Zunyi Tianli**

| Pre-epidemic | | Post-epidemic | |
|---|---|---|---|
| Lesson Planning | 24.45% | Material Handling | 19.09% |
| Teaching Classes | 18.56% | Teaching Classes | 17.77% |
| Monitoring Independent Study | 13.98% | Student Communication | 15.22% |
| Supervising Exams | 10.47% | Homework Grading | 14.81% |
| Homework Grading | 7.89% | Lesson Planning | 9.73% |

According to these three tables, the following conclusions can be drawn：

(1) Since there is no standard syllabus for China's primary schools, elementary schools and high schools, such schools follow various local teaching standards and requirements. Such requirements include the required time for extracurricular activities and ensure relatively consistent teaching activities. Likewise, they lead to consistent work hours for teachers, which helps standardize school education and teaching, as well as human resource arrangements.

(2) Due to different syllabi, differences in teaching quality and varying teacher competence across provinces and regions, work hours for teachers vary. For instance, teachers at

Zunyi spend most of their time handling materials rather than teaching or preparing lessons, which constitute the main tasks of teachers in other schools.

(3) After the outbreak of COVID-19, the Chinese government has required schools to provide online classes. Thus, teachers continued to spend most of their work hours teaching, just as they did before the epidemic. To begin online teaching, most teachers focused on lesson planning, material collection, teaching classes and homework grading. This represents progress made by teachers in promoting information-based teaching competency in this smart era.By analyzing the teachers' distribution of tasks by time spent doing them and by comparing vertically, this study obtained the following results.(1) The work performed by teachers before the epidemic better matched the normal working conditions of the school.

(2) Due to their different business models, the distribution of various tasks by time differed significantly from school to school. In addition to time spent in class, teachers of the younger students spent more time on ethics education, communication and homework review, whereas those teaching older students focused more on lesson preparation, teaching classes and monitoring independent study.

(3) Regarding improving teacher productivity, in addition to strengthening skills training, it is important to upgrade teaching tools (collective lesson preparation and standardized class delivery) via scientific and technological means.

**4.2.4.5 The work hours of various teaching positions in pilot schools**

1. Work Hours for the Same Position: Teachers with One Position

The researcher compared the work hours and the three most time-consuming tasks of teachers with only one teaching position in the two pilot kindergartens, and the relevant data are shown in Table 4.10.

Table 4.10 The Tasks of Teachers Focused Only on Teaching in Kindergartens

| School District | Average Teaching Experience (years) | Teaching Hours Per Week | Top Three Tasks (%) | | | Average Work Hours Per Day |
|---|---|---|---|---|---|---|
| Luzhou | 5 | 25 | Ethics Training 32.56 | Teaching Classes 26.03 | Meals and Doctor Visits 14.07 | 8.82 |
| Yibin | 8.5 | 25 | Teaching Classes 22.54 | Ethics Training 16.6 | Material Handling 12.69 | 9.14 |

According to the statistics, only the schools in Luzhou and Yibin employed primary teachers whose only position consisted of teaching. Thus, the researcher only compared data

for these two schools. For more, see Table D.1. The same is true for the data on junior high and high school teachers whose only position consisted of teaching. For detailed comparisons, see Table D.2 and Table D.3 in Annex D.

According to the data from these three tables, the following conclusions can be drawn.

(1) Due to varying student ages and teaching goals, teachers who were only responsible for teaching in kindergartens spent most of their time on ethics education activities and lesson delivery, and they worked for an average of about nine hours.

(2) The top three core jobs of primary school, junior high school and high school teachers were similar. Primary school teachers responsible only for teaching spent most of their time on lesson planning, teaching classes and attending meetings. Similarly, such teachers in junior and senior high schools spent most of their time on lesson planning, teaching classes and homework grading (the only difference). Their work hours varied by school, which can be explained by their specific class hours (weekly class hours varied by subject), their percentage of time spent on other tasks and their time efficiency.

2. Work hours of teachers at the same position but different subjects: teachers + intermediate executives (2 positions)

The researcher also compared the work hours and the top three tasks of teachers responsible for teaching and two other intermediate executive positions in primary, junior high and high schools (see Table 4.11, Table 4.12 and Table 4.13, respectively).

Table 4.11 The Tasks of Teachers with Multiple Positions in Primary Schools

| School District | Average Teaching Experience (years) | Teaching Hours Per Week | Top Three Tasks (%) | | | Average Work Hours Per Day |
|---|---|---|---|---|---|---|
| Luzhou | 20 | 22.5 | Homework Grading 27.13 | Teaching Classes 17.34 | Lesson Planning 15.35 | 8.43 |
| Guang-yuan | 3 | 22 | Teaching Classes 37.18 | Student Enrollment 20.5 | Auditing Classes 13.5 | 8.6 |
| Deyang | 11 | 16 | Teaching Classes 25.72 | Planning and Reflection 18.60 | Meetings 18 | 7.11 |
| Zunyi | 2. | 12.6 | Teaching Classes 36.86 | Lesson Planning 19.45 | Homework Grading 11.93 | 6.84 |

Table 4.12 The Tasks of Teachers with Multiple Positions in Junior High Schools

| School District | Average Teaching Experience | Teaching Hours Per Week | Top Three Tasks (%) | Average Work Hours Per |
|---|---|---|---|---|

| | (years) | | | | | Day |
|---|---|---|---|---|---|---|
| Luzhou | 9 | 25.1 | Teaching Classes 33.97 | Lesson Planning 14.82 | Test Design and Marking 13.63 | 8.28 |
| Yibin | 13 | 28 | Teaching Classes 36.52 | Supervising Exams 18.52 | Monitoring Independent Study 13.15 | 7.6 |
| Guang-yuan | 29 | 16 | Teaching Classes 30.25 | Supervisions and Guidance 26.32 | Lesson Planning 12.2 | 10.2 |
| Deyang | 12 | 13.25 | Teaching Classes 34.56 | Supervising Exams 21.06 | Test Design and Marking 12.44 | 7.75 |
| Zunyi | 7 | 14.2 | Teaching Classes 24.77 | Lesson Planning 17.16 | Homework Grading 14.58 | 6.68 |

Table 4.13 The Tasks of Teachers with Multiple Positions in High Schools

| School District | Teaching Experience (years) | Teaching Hours Per Week | Top Three Tasks (%) | | | Average Work Hours Per Day |
|---|---|---|---|---|---|---|
| Luzhou | 7 | 25.1 | Teaching Classes 42.00 | Monitoring Independent Study 18.75 | Lesson Planning 11.28 | 10.2 |
| Yibin | 16 | 23.5 | Teaching Classes 26.02 | Lesson Planning 21.15 | Monitoring Independent Study 18.38 | 9.2 |
| Guang-yuan | 6 | 16 | Teaching Classes 28.43 | Ethics Training 18.1 | Student Communication 15.4 | 11.3 |
| Deyang | 12 | 9.3 | Lesson Planning 26.64 | Monitoring Independent Study 18.10 | Teaching Classes 17.31 | 7.9 |
| Zunyi | 6 | 16 | Lesson Planning 25.98 | Teaching Classes 22.86 | Monitoring Independent Study 18.15 | 11.81 |

According to the data from these three tables, the following conclusions can be drawn:

(1) Compared with teachers only responsible for teaching, those with multiple positions had shorter class hours. Indeed, their class hours were 14.9% shorter on average. The class hours of teachers with multiple positions in the high school department of Zunyi were an exception, as they were 4.91% longer than those of teachers only responsible for teaching.

(2) Teaching classes was one of the major tasks of teachers. This task ranked first among all types of work and accounted for 29.28%, 31.38% and 34.12% of the work hours for pri-

mary, junior high and high school teachers, respectively. Teachers with multiple positions in primary schools spent most of their time on teaching classes, homework grading and lesson planning. For such teachers in junior high school, teaching classes, supervising exams and supervision and guidance were the top three tasks. Teaching classes, lesson planning and monitoring independent study were the top three tasks for such teachers in high schools.

3. Work hours of teachers of the same subject (Chinese, Math, and English)

Chinese, Math and English are critical to the teaching activities of both exam-oriented education and quality-oriented education. Thus, the researcher investigated the work hours and the top three tasks of teachers teaching Chinese, Math and English in the participating schools, the data for which are shown in Table 4.14, Table 4.15 and Table 4.16.

Table 4.14 The Tasks of Teachers Teaching Chinese, Math and English in Primary Schools

| School District | Teaching Experience (years) | Teaching Hours Per Week | Top Three Tasks (%) | | | Average Work Hours Per Day |
|---|---|---|---|---|---|---|
| Luzhou | 26 | 17 | Teaching Classes 26.99 | Lesson Planning 17.6 | Homework Grading 14.04 | 8.26 |
| Yibin | 5 | 19 | Teaching Classes 41.45 | Lesson Planning 14.03 | Ethics Training 13.85 | 8.41 |
| Guang-yuan | 6 | 12 | Teaching Classes 32.5 | Lesson Planning 15.23 | Ethics Training 20 | 8.56 |
| Deyang | 9 | 16 | Teaching Classes 21.09 | Meals and Doctor Visits 14.97 | Work Communication 12.24 | 6.13 |
| Zunyi | 3 | 18 | Teaching Classes 44.92 | Monitoring Independent Study 22.02 | Homework Grading 15.34 | 6.11 |

Table 4.15 The Tasks of Teachers Teaching Chinese, Math and English in Junior High Schools

| School District | Teaching Experience (years) | Teaching Hours Per Week | Top Three Tasks (%) | | | Average Work Hours Per Day |
|---|---|---|---|---|---|---|
| Luzhou | 17 | 12 | Teaching Classes 23.78% | Homework Grading 20.64 | Inspection and guidance 12.46 | 8.92 |
| Yibin | 15 | 33 | Lesson Planning 22.32 | Monitoring Independent Study 20.22 | Teaching Classes 20.14 | 10.5 |
| Guang-yuan | 7 | 12 | Teaching Classes | Ethics Training 22.56 | Lesson Planning 12.4 | 11.45 |
| Deyang | 27 | 14 | Teaching Classes | Monitoring Independ- | Ethics Training | 8.6 |

| School District | Teaching Experience (years) | Teaching Hours Per Week | Top Three Tasks (%) | | | Average Work Hours Per Day |
|---|---|---|---|---|---|---|
| | | | 29.26 | ...ent Study 29.07 | | 14.53 |
| Zunyi | 5 | 14.5 | Teaching Classes 26.42 | Homework Grading 19.04 | Meetings 11.16 | 6.77 |

Table 4.16 The Tasks of Teachers Teaching Chinese, Math and English in High Schools

| School District | Teaching Experience (years) | Teaching Hours Per Week | Top Three Tasks (%) | | | Average Work Hours Per Day |
|---|---|---|---|---|---|---|
| Luzhou | 27 | 14 | Teaching Classes 42.00 | Monitoring Independent Study 18.75 | Lesson Planning 11.28 | 9.63 |
| Yibin | 26 | 30 | Lesson Planning 26.53 | Teaching Classes 22.02 | Monitoring Independent Study 20.18 | 8.66 |
| Guangyuan | 6 | 16 | Teaching Classes 28.5 | Lesson Planning 12.76 | Material Distribution 22.81 | 9.45 |
| Deyang | 15 | 14 | Lesson Planning 34.56 | Teaching Classes 21.93 | Monitoring Independent Study 16.04 | 8.0 |
| Zunyi | 17 | 14 | Lesson Planning 31.14 | Supervising Exams 15.67 | Monitoring Independent Study 15.55 | 8.37 |

According to the data from these tables, the following conclusions can be drawn：

(1) The class hours of each set of grades were similar in all schools except Yibin. Except for Yibin, the average class hours of the primary, junior high and high school teachers were 15.75, 13.13 and 14.50, respectively.

(2) In Yibin, teachers' class hours in primary school were like those of other schools; however, their class hours in junior high and high schools were over twice as much as those of other schools.

(3) Teaching classes was the most time-consuming task, representing 41.74%，31.20% and 28.61% of primary, junior high and high school teachers' class hours, respectively. Chinese, Math and English teachers in primary and junior high schools spent most of their time on teaching classes, lesson planning and ethics education.

**4.2.4.6 The proportion of teachers' various positions in pilot schools**

To analyze teachers' workloads at the pilot schools, this researcher further analyzed the positions of all the participating teachers. For the statistics of teachers at kindergartens, primary

schools, junior high schools and high schools, see Table 4.17, Table 4.18, Table 4.19 and Table 4.20, respectively. All figures in the table are percentages.

Table 4.17 Kindergarten Teachers with Multiple Positions

| School District | Teacher Only | Teacher & Head Teacher | Teacher & One Additional Position | Teacher, Head Teacher & One Additional Position | Teacher & Two Additional Positions | Teacher, Head Teacher & Two Additional Positions | Teacher, Head Teacher & Three Additional Positions |
|---|---|---|---|---|---|---|---|
| Number of Positions | 1 | 2 | 2 | 3 | 3 | 4 | 5 |
| Luzhou | 34.69 | 22.45 | 16.33 | 24.49 | 2.04 | | |
| Yibin | 6.98 | 83.72 | 9.3 | | | | |

Table 4.18 Primary School Teachers with Multiple Positions

| School District | Teacher Only | Teacher & Head Teacher | Teacher & One Additional Position | Teacher, Head Teacher & One Additional Position | Teacher & Two Additional Positions | Teacher, Head Teacher & Two Additional Positions | Teacher, Head Teacher & Three Additional Positions |
|---|---|---|---|---|---|---|---|
| Number of Positions | 1 | 2 | 2 | 3 | 3 | 4 | 5 |
| Luzhou | 3.16 | 31.58 | 16.84 | 33.68 | 7.37 | 6.32 | 1.05 |
| Yibin | 24.24 | 51.52 | 7.58 | 15.91 | 0.76 | | |
| Guangyuan | 48.45 | 31.96 | 12.37 | 5.15 | 1.03 | 1.03 | |
| Deyang | 16.44 | 34.25 | 12.33 | 35.62 | | 1.37 | |
| Zunyi | 7.89 | 21.05 | 34.21 | 13.16 | 21.05 | | 2.63 |

Table 4.19 Junior High School Teachers with Multiple Positions

| School District | Teacher Only | Teacher & Head Teacher | Teacher & One Additional Position | Teacher, Head Teacher & One Additional Position | Teacher & Two Additional Positions | Teacher, Head Teacher & Two Additional Positions | Teacher, Head Teacher & Three Additional Positions |
|---|---|---|---|---|---|---|---|
| Number of Positions | 1 | 2 | 2 | 3 | 3 | 4 | 5 |
| Luzhou | 43.32 | 19.79 | 22.99 | 8.56 | 1.60 | 2.14 | 1.60 |
| Yibin | 50.36 | 18.98 | 10.22 | 17.52 | 2.92 | | |
| Guangyuan | 36.36 | 18.18 | 29.29 | 9.09 | 4.04 | 3.03 | |
| Deyang | 8.64 | 29.63 | 11.11 | 35.8 | 3.7 | 9.88 | 1.23 |
| Zunyi | 17.14 | 37.14 | 28.57 | 11.43 | 5.71 | | |

Table 4.20 High School Teachers with Multiple Positions

| School District | Teacher Only | Teacher & Head Teacher | Teacher & One Additional Posi- | Teacher, Head Teacher & One | Teacher & Two Additional | Teacher, Head Teacher & Two | Teacher, Head Teacher & Three |
|---|---|---|---|---|---|---|---|

| | tion | | | Addition-al Position | Positions | Addition-al Positions | Addition-al Positions |
|---|---|---|---|---|---|---|---|
| Number of Positions | 1 | 2 | 2 | 3 | 3 | 4 | 5 |
| Luzhou | 48.25 | 14.04 | 20.18 | 7.02 | 2.63 | 6.14 | 1.75 |
| Yibin | 22.08 | 46.75 | 5.19 | 10.39 | 6.49 | 9.09 | |
| Guangyuan | 23..68 | 11.84 | 30.26 | 9.21 | 13.16 | 11.84 | |
| Deyang | 16.39 | 18.03 | 19.67 | 34.43 | 4.92 | 6.56 | |
| Zunyi | 53.85 | 3.85 | 7.69 | 19.23 | 11.54 | 3.85 | |

By comparing teachers with multiple positions, we can draw the following conclusions：

1. Teachers' positions varied by grades, and the proportion of teachers holding multiple positions in high school is elevated because their students are older. Overall, the Tianli school in Deyang demonstrated reasonable overall position management and distribution.

2. The proportions of teachers with only one position teaching students of various grades at pilot schools such as Yibin junior high school, Guangyuan primary school, Luzhou high school and Zunyi high school were about 50%, which indicates that their work efficiency had not been fully unleashed and improved.

### 4.2.5 Problem analysis

### 4.2.5.1 A comparison between "yardstick schools" and other schools in a school district

1. The comparison of personnel structure of each pilot school district is shown in Table 4.21, Table 4.22, Table 4.23 and Table D.4. All figures in the table are percentages.

Table 4.21 The Faculty Structure at Pilot Kindergartens

| School District | New Teachers | Experienced Teachers | Veteran Teachers |
|---|---|---|---|
| Luzhou | 36.73 | 55.11 | 8.16 |
| Yibin | 27.91 | 53.49 | 18.6 |

Table 4.22 The Faculty Structure at Pilot Primary Schools

| School District | New Teachers | Experienced Teachers | Veteran Teachers |
|---|---|---|---|
| Luzhou | 30.53 | 35.79 | 33.68 |
| Yibin | 11.36 | 69.70 | 18.94 |
| Guang-yuan | 38.14 | 59.79 | 2.06 |
| Deyang | 35.6 | 56.16 | 8.22 |
| Zunyi | 50.00 | 7.80 | 42.2 |

Table 4.23 The Faculty Structure at Pilot Junior High Schools

| School District | New Teachers | Experienced Teachers | Veteran Teachers |
|---|---|---|---|
| Luzhou | 17.11 | 59.89 | 22.46 |
| Yibin | 12.41 | 59.85 | 27.74 |
| Guang-yuan | 20.20 | 75.76 | 4.04 |

| | | | |
|---|---|---|---|
| Deyang | 37.04 | 30.86 | 31.10 |
| Zunyi | 28.6 | 34.30 | 37.1 |

Here we present a data-based analysis of these structures.

1. Schools with Full Student Enrollment (Luzhou, Yibin, Guangyuan)

(1) The proportions of new teachers in the primary school, junior high school and high school of Yibin were relatively low, indicating unreasonable overall structures that resulted in elevated labor costs.

(2) The overly high proportions of PT-teachers in the Guangyuan school district also led to high labor costs. On the other hand, its proportions of veteran teachers in primary school and junior high school were quite low, which negatively impacted its quality of education, teaching and brand satisfaction.

(3) There was still room for further improvement regarding the proportions of new teachers in the junior high and high schools of the Luzhou school district.

2. Schools Without Full Student Enrollment (Deyang, Zunyi)

(1) The proportions of new teachers in the high school at Zunyi was low, and the overall faculty structure of its primary school was unreasonable, which led to an unbalanced allocation of talent and increased overall labor costs.

(2) The overall faculty structure of the Deyang school district was reasonable. Considering its quality of teaching and brand reputation, however, its proportion of veteran teachers at its primary school should be increased.

**4.2.5.2 Factors influencing efficient position allocation**

(1) Work Hours

Employee working hours, to some extent, reflect job saturation. The survey data from this thesis show that the per capita working hours in Luzhou, Guangyuan and Deyang were more than those in Yibin. Given data on Yibin's staffing control and salary standards, among other information, there is still room for further job saturation for teachers.

(2) Work Content

Due to the various tasks related to teaching students of different grades, the proportions of time spent on various tasks differed significantly. In addition to teaching classes, teachers in kindergarten and primary schools were more inclined to carry out ethics education, communication and homework grading, whereas those in junior high and high school focused more on lesson planning, teaching classes and monitoring independent study. To improve the productivity of teachers, in addition to strengthening professional skills training, it seems necessary

to upgrade their tools (collective lesson planning and standardized class delivery) by incorporating science and technology in a standardized manner.

(3) Faculty Structure

An appropriate faculty structure is like a sound human body whose functions support and coordinate with each another. This is the most important factor for ensuring the quality of a school, its reputation, teamwork, the allocation of talent, budget control and teacher happiness at work.

The overall personnel structure at Deyang was relatively reasonable and balanced. The proportions of new teachers in the primary school, junior high school and high school of Yibin, however, were relatively low, which inevitably led to elevated labor costs. The excessively high proportions of PT-teachers working at Guangyuan's high school explains the high labor costs there. The proportions of veteran teachers in its primary school and junior high school will, however, affect the education quality, teaching quality and brand satisfaction of the school. The faculty structure at Zunyi's primary school was U-shaped, which could represent an unbalanced allocation of talent.

(4) Teachers with Multiple Positions

Organizations are built on the stability of their job positions. While ensuring work quality and appropriate workloads, when the proportion of employees engaging in multiple positions grows, staffing and labor costs fall, and the two-way benefits of the organization and employees rise. The proportions of teachers with only one responsibility in some pilot schools for various grades, such as Yibin's junior high school, Guangyuan's primary school, Luzhou's high school and Zunyi's high school, were around 50%, which implies that the work efficiency of teachers can be further developed and improved.

(5) Organizational Structure

The organizational structures of the pilot schools were roughly in line with the requirements of Tianli Group, but adjustments were also made based on the group's standards as well as the actual needs of each school. Establishing new departments increases management, communication and timeliness costs and adds posts and personnel selection efforts, which affect staffing control. Even if a new post is taken by an existing staff member, costs rise for them to cover multiple positions.

(6) The Ideas, Beliefs and Working Methods of Managers

The ideas, beliefs and working methods of managers, as team leaders, are the key to their teams. Streamlining administration is an arduous task and a long-term initiative. As the person in charge of each particular job must make painstaking efforts to optimize organizational

structure, he or she often finds himself or herself in a dilemma when facing work adjustments. Without their accurate, comprehensive understanding, firm beliefs and resolute implementation of their jobs, no progress can be made. But if they gain a fundamental understanding of their tasks at hand, their work will bear fruit. The Luzhou school district is a typical example of this and shows the importance of managers' ideas and attitudes.

### 4.2.6 Short summary

Through the experimental research and analysis of teachers' work behavior at school, we believe that Tianli Education Group mainly has the following problems in personnel management:

(1) Homework grading and lesson planning cost teachers a lot of working time, resulting in long average daily working hours;

(2) There are inconsistencies in the organizational structure of each school, and more posts lead to further increase of labor cost;

(3) Inappropriate personnel structure;

The discovery of these problems points out the direction for our follow-up personnel work and organizational reform. We need to introduce scientific and technological means and the advantages of school running under the Group, reduce the redundant and repetitive work of front-line teachers, unify the organizational structure and post setting, hire talents more reasonably, and maintain the vitality and efficiency of the enterprise.

# Chapter 5: Conclusions and Future Research

## 5.1 Conclusions: big data technology-based organizational change in private schools

Greiner (1997) asserts that organizational change can be found in various periods of enterprise growth. Organizational change and evolution occur in alternation that promotes organizational growth. Organizational change is inevitable. The ability to effectively engage in organizational change is a critical indicator of management effectiveness.

There should be three basic goals regarding organizational change in private schools.

(1) Private schools should be made more resilient.

In China, the growth of private education is largely influenced by the country's relevant national laws and policies. In 2002, to implement its strategy of rejuvenating the country through science and education, as well as to promote the sound development of private education and safeguard the legitimate rights and interests of private education and students, China formulated and implemented the Law of the People's Republic of China on the Promotion of Private Schools. Based on this law, the State Council passed its Implementation Regulations on the Law of the People's Republic of China on the Promotion of Private Schools in 2004, which the Standing Committee of the National People's Congress amended in 2013, after a second amendment in 2006. In 2018, the Ministry of Justice published its Draft Amendment for the Approval of the Implementation Regulations of the Law of the People's Republic of China on the Promotion of Private Schools. In October 2020, the Ministry of Education published its Reply to the Proposal from the Third Session of the 13th National Committee of the Chinese People's Political Consultative Conference (CPPCC) No. 3379 (Education, No. 343), in which it is clear that the Ministry of Education will continue to coordinate with the relevant departments to improve the supportive policies for private education, as well as strengthen the supervision and management of private schools, to create a sound environment for such schools and to promote the growth of private education. Clearly, in recent years, China's national ministries and commissions have issued several policies and regulations related to private education. These policies and regulations have not only identified norms for the healthy

and orderly development of private education but also shed light on the direction for reforming private schools.

To survive and thrive in this changing environment, private schools must comply with policies and regulations, as well as the new demands of this new era for education. They must adjust and change their long-term goals, organizational structures, sustainability, staffing and management systems. Only in this way can they effectively grasp the various opportunities available to them, identify and deal with threats, and make their organizations more resilient.

(2) More resilient managers are needed at private schools.

In both China and other countries, public schools receive financial investment from the government every year, and these funds cover all their expenses, including teachers' salaries, equipment upgrades and maintenance. Therefore, those in charge of public schools are fully committed, without any operational pressures, to enhancing the quality of their teaching on offer. By contrast, in private schools, since the construction of such schools and all their daily expenses are funded by investors, it is reasonable that they will face requirements for generating economic returns. Investors expect healthy operations so that their initial investments are paid off; in addition, they expect continuous development to generate healthy returns in the future. As such, this poses higher requirements for the managers of private schools; namely, they must not only develop good professionalism and maintain a high level of teaching quality but also have a high awareness for business operations and services to produce economic returns for the survival and growth of the school. They must do so by providing excellent teaching services, logistics and the like.

In private schools, principals, among other executives, are the primary decision makers and the allocators of organizational resources. Most of the executives of private schools used to work in the public education system. Therefore, when reforming their organizations, they must adjust their old leadership styles and decision-making processes to make their private schools more flexible and resilient. In addition, such executives must also make more targeted and feasible changes by taking into full account organizational hierarchies reconstructed based on their environment and team relationships.

 (3) More resilient faculty are needed in private schools.

Faculty are the most impacted by the organizational change of private schools. Most staff at private schools used to work in public schools. As such, attitudes such as egalitarianism are widely recognized in such organizations. The frequency and intensity of organizational change at private schools are often greater than that of public schools. If an organization fails to make its employees fully realize the importance of change, and if it fails to facilitate the

proper understanding, attitudes and behavior among its employees, its measures for change may not be recognized, supported or implemented by its employees.

## 5.1.1 Student selection (evaluation methods) and changes to education modes

In conventional schools, the selection or evaluation of students is mainly based on student scores, as they are deemed as important pieces of evidence for evaluating students' overall achievement. Some schools, which mainly focus on exam-oriented education, view academic performance as the only reference when evaluating students. Thanks, however, to the expansion of the open education management model and the rapid development of online education, students now enjoy increasing latitude; for example, they can independently set their own learning plans and goals. Therefore, it seems ever more imperative to adopt a more diverse and scientific method for evaluating and selecting students. In Chapter 4, the researcher analyzed the behavior of students at school. The purpose was to explore factors that cause changes to academic performance by analyzing the messages and correlations implied in the big data. Such an analysis could be used to predict future score change trends and to put forward suggestions on how teachers can improve their teaching to improve education, management and learning efficiency. Based on Section 4.1, we already innovated and explored based on a reflection of the existing selection and evaluation system for Tianli's students.

### 5.1.1.1 The selection of general students and changes to education modes

In the comparative experiment of Section 4.1 in which we studied the bracelet-wearing rate in an unsupervised state, the overall bracelet-wearing rate of the students during the second stage decreased significantly compared with the first stage. More than 50% of the students wore their bracelets less than five times (Figure 4.4). This fully demonstrates that in primary and secondary schools, students' spontaneous activities and habits require strengthening with the guidance of school management and supervision. Thus, schools should pay more attention to developing internal forces that support studying and good learning habits.

Taking the annual "quality kindergarten education evaluation" as an example, in 2020, the quality evaluation of children's daily habits and codes of conduct was strengthened. Specifically, during the evaluation section for "education and research," an emphasis was put on "implicitly focusing on the fostering of children's daily habits and appropriate public behavior through daily activities." In the "children's development" section, it was also required that students be trained to "follow basic codes of conduct and show respect, mutual help, cooperation, sharing and compassion throughout their activities."

In the Primary School Comprehensive Quality Evaluation, the fostering of student habits is manifested in two aspects: classroom habits and dormitory habits. The former requires students to "prepare well before class, keep their desks in order and review before class," and the latter requires students to develop good living habits, such as "placing shoes neatly in their shoe cabinets with the toes facing inward, keeping their towels, toothbrushes, cups and basins in order, keeping their clothes sorted, folded and stored neatly in their wardrobes, and keeping other items in neat arrangement." It also requires them "to make their beds with quilts folded and facing the outside and to keep no other items on their beds, ensuring that sheets are well-placed and clean."

In addition to these improvements, in 2020, Tianli Group clearly put forward the principles of "putting ethics training first, focusing on classes, pivoting on content and using science and technology as a support." "Putting ethics training first" is the group's top priority and shows that enough importance has been placed on personality and habit development. To support ethics training, Tianli Group introduced "chief ethics teachers" and education experts from Hengshui schools famous for their "passion about ethics training." Also, the group claims that ethics training is not only a standard of its schools but also a course more important than even its basic subject courses!

Because most of Tianli's schools are K12 schools or a configuration of primary school, junior high school and high school, many their students are selected from lower grades to study in its higher grades. The group's previous method of selection was often based on its students' academic performance and relied on teacher recommendations. In this sense, academic performance was the only reference for student evaluation, an inevitability of traditional selection; as a result, students' overall achievement may not have obtained enough attention. Even if such students had teacher recommendations, evaluators would have found it difficult to ensure objectivity and fairness in all respects. More importantly, this mode of recommendation and selection, to a great extent, affects the modes of education throughout various grades. Such an evaluation system, which values scores more than achievement, runs counter to the goal of training excellent talent for the future. Therefore, if we employ an information-based approach to record the behaviors and habits of students objectively and accurately at school, after which we scientifically analyze the features of such behavior through big data and incorporate correlation analyses between these features and students' core qualities - to develop comprehensive, data-based "portraits" of these students - we will be able to generate highly objective and effective evaluations. This will create a student selection system in which every student can be understood from a comprehensive, detailed and scientific manner,

thus allowing administrators of young students to gradually shift their teaching focus from improving academic performance to improving both academic performance and overall student achievement. As such, this will comprehensively support the development of students' core qualities in basic education.

### 5.1.1.2 The selection of talented students and changes to education modes

A small number of top-notch Chinese universities represented by the University of the Chinese Academy of Sciences and Xi'an Jiaotong University now provide select, outstanding high school students - so called "talent students" - with early access to university studies in the form of classes for the gifted. But in basic education, especially among younger students, there has been little in the way of teaching and education tailored to "gifted students." Drawing experience from individualized education, Tianli Group decided to establish its "Extraordinary Education Research Institute" as an innovative experiment to explore the Tianli mode of individualized education but also to creatively research a selection and training system for "gifted students." Tianli selects students with special talents from a huge pool of students. It then customizes its training system, its non-traditional "Extraordinary Education Training System," which gives full play to students' individuality and expertise, maintains their extraordinary gifts and ensures that they can leverage their unique talents in the areas that they will focus on in the future. As such, Tianli is fostering innovative development. Also, by training such talent, the group is fostering the potential for remarkable developments to be made in the natural and social sciences, thus benefitting the nation.

In today's globalized world, "extraordinary education systems" must incorporate increasingly many elements of international education across three major characteristics: (1) a solid foundation that cultivates independent study abilities and creativity, (2) comprehensive achievement and (3), fully developed individuality.

To educate gifted students aged 10-15, it is also important to choose competent teachers capable of teaching the "Extraordinary Education Training System." In general, Tianli Group looks for good teachers not only in China but also around the world. It is important to actively look for elite talent in various fields to serve as students' mentors instead of limiting the search to teachers with pedagogical backgrounds. Successful, outstanding talent in different fields have unique areas of expertise and insights. Considering that gifted students are able to learn effectively, their teachers' value lies more in guiding them with the big pictures of various subjects and in passing on values, which is unlike the needs of ordinary students. Only teachers with unique minds can provide guidance and help to unique students.

Tianli Education Group plans to recruit gifted students aged 10-15 as its target group for gifted education nationwide and it plans to hire elite teachers from around the world as their tutors. Of course, the selection of "gifted students" will be based on extremely high standards. In addition to conventional academic performance tests, factors not related to intelligence, including habits, manners and behavior, will also be evaluated via systematic and scientific methods. In the survey in Section 4.1.3.2, we found that the average daily step counts of the students whose academic results were the best were also the highest. This is not a coincidence. It shows that the small number of "gifted students" exhibit excellent academic performance and are endowed with superb athletic competence or exercise habits, which also suggests that we should take full account of extraordinary athletic talent, thus challenging the stereotype that people with excellent learning abilities might not be active in sports.

Throughout the process of training, given levels of intelligence and knowledge, these "gifted students" will be trained not only by special, excellent teaching teams but also via courses tailored to fulfill their individualized development. Their studies will follow personalized class schedules - a true impression of individualized education. Exceptional students will be allowed to skip grades and will be encouraged to target top universities around the world. Tianli encourages ambition and a global vision.

## 5.1.2 Changes to group headquarters and school organization

Since the start of this new curriculum reform, many schools have begun to draw up plans and begun reforming. Some schools have taken the reform of classroom teaching and learning as their starting point, whereas others have given full play to the development of a school culture. On the other hand, some have begun reforming by strengthening teacher training, and others have begun by reforming management mechanisms. Carrying out curriculum reform by changing how a class is delivered - such as by enhancing lesson planning, learning from excellent teachers and auditing classes - fails to a large extent. According to the researcher, this is because reforms that take place in the conventional education system are superficial and lack systematic, big picture planning. Changing how classes are taught is far from enough to manage curriculum reform. As an important vehicle for education and teaching activities, the school's organization must change with curriculum reform, as it is the systematic guarantee for the effective implementation of curriculum reform. In other words, if a school's organization remains unchanged, its curriculum reform will encounter enormous hurdles.

For the research focus of this thesis, Tianli Education Group and its subordinate schools, the school is the primary unit of operation directly facing students, whereas the group is a

secondary management unit that indirectly faces students. Therefore, we hold that there are three roles the group plays in better managing its schools. They are (1) enabling, (2) supporting and (3) managing and controlling. Tianli Group adopted a "school district principal accountability system" management and control mode during its period of rapid development. Specifically, the group manages principals of school districts. Principals of school districts manage principals of schools. Principals of various schools manage the directors of various grades. And the directors manage head teachers. At present, Tianli group has expanded its scope of management and control to include principals of various schools, as it seeks to unify the education and teaching quality standards of each school district while avoiding the inconsistency in action and results caused by different management styles and varying education and teaching concepts of school district principals. In the future, Tianli Education Group will gradually ensure the standardized implementation of the group's advanced education, teaching and management concepts through thorough rollouts.

To adapt to the development of the organization and the changes in its external education and teaching environment, Tianli Group must take a "planned reform" approach, actively adapt to changes, maintain its fast growth and ensure that the school's education on offer can better meet the needs of future talent. In addition, as the current regulatory policies of the Chinese government for private basic education have not yet been completely published, China's private education groups represented by Tianli Education Group must closely watch the latest policies, make plans to respond to potential new policies and maintain organizational sensitivity to enact the corresponding organizational reform measures.

For example, Tianli Education Group must change its organizational structure to ensure the efficient operation of its subordinate business centers and departments. Taking "work more to earn more" as its basic salary principle and "creating a blessed life for teachers and students" as its vision, Tianli Education Group is building its organizational culture and ensuring the vitality of the organization through HRM reform. By standardizing its work processes, the group can reduce ineffective staff tasks at all levels and trim its staff to enable excellent people to get more rewards while laying off those whose performance fails to meet the necessary requirements. In this way, the incomes of teachers and managers can increase, and they can thus be more motivated in the organization. Moreover, throughout this process of change, appropriate and targeted changes should be supported by data from experimental and big data analyses backed by science and technology.

**5.1.2.1 Establishing an independent department in the group headquarters - the IT department**

Tianli Group has adopted a flat management system in which the president of the group comprehensively manages daily affairs. Functional centers have been set up in which the directors of these centers report to the president directly. Under the existing Education Management Center, there is the Education and Teaching Research Institute and the Educational Science and Technology Research Institute, which are responsible for advanced technology research in education, teaching and information technology. Before 2019, there was no department dedicated to information-based education technology, with only two employees in charge of the normal operation of the group's network and information system. With the group's increasing emphasis on information technology, especially the advanced information technology represented by big data, 5G and AI, it has become more urgent to establish a research and application team for educational science and technology at the group's headquarters. This has resulted in several rounds of adjustment regarding organizational structure, staffing and IT department functions since September 2019. This demonstrates the group's great priorities and high expectations for educational science and technology.

1. In September 2019, the Educational Science and Technology Research Institute was transferred from the Education Management Center to the Planning and Operation Center, which reports directly to the president of the group. Also, new, high-level IT talent were recruited, and a new IT Department was set up to undertake research at the Education and Teaching Research Institute, as well as to undertake overall information-based planning and development. The group has thus invested more to promote the application of advanced information technology within the group and at Tianli's schools.

2. In September 2020, after separating from the Planning and Operation Center, the IT Department became an independent department with an independent budget and evaluation, significantly raising its role in the group.

3. Larger investments are being made toward the group's information-based development, and its budget is gradually increasing: The group's annual budget of the 2020-2021 academic year increased by nearly 30% compared to the 2019-2020 academic year. As the group continues to promote and place more emphasis on overall information-based planning, its information-based development is being reinforced with the development of hardware network and smart education systems infrastructure. Its budget for the 2021-2022 academic year is expected to double.

4. Since September 2020, "information-based development and applications" have been added as a new factor for the evaluation of the group's "sustainable development" in its annual appraisal of the targets (September 2020 to August 2021) of various schools as set by headquarters. This includes general training, the use of daily information systems, the data-based maintenance of various business systems and smart schools. These appraisals are expected to "enhance development so that school executives can attach greater importance to educational science, technology and information-based initiatives, as well as improve the informational know-how of faculty. The assessment of these factors will be carried out independently by the group's IT Department, and they are estimated to weigh more the following year. This will boost the group's information-based development, redoubling its commitment to exploring technological innovation as a driver for educational innovation on the path of "advanced technology leading educational change."

In addition, based on the needs for information-based development and business models in schools, Tianli Group established an education technology company in October 2020 dedicated to the research and development of online education. In January 2021, the initial development plan of this education technology company was in place. The group's Education Management Center and IT Department will work in tandem with this educational technology company. While meeting Tianli's needs for information-based education, they will gradually expand their services to more schools and students outside the group. As such, Tianli will contribute to the information-based development of basic education in China.

Technology companies are applying cutting-edge technology to synchronize "paper" and "screens" in the classroom; namely, smart hardware such as "smart pens and tablets" are being integrated with the software systems developed by such companies. This way, teachers are able to check their students' real-time answers through intelligent terminals displaying comprehensive data on student learning. Given such technology for big data analysis, points of interest and weak links in student knowledge can be presented, thus allowing for teaching that is more efficient, accurate and matched with student aptitude. As such, individualized teaching can be gradually realized.

In addition, the group piloted "dual-teacher classes" meant to train students for academic contests. It set up a live-streaming classroom at its headquarters, where the head coach for the competition tutored students from affiliated schools through mobile apps or smart education screen sets in classrooms. In addition, teachers locally assist these training sessions led by the coach. By applying science and technology, schools thus eased the shortage of high-level contest coaches, enabling high-quality teaching to be more accessible and improving contest

training group wide. As the "dual-teacher classes" were further rolled out, Tianli develops a new education and teaching model suitable for the specific situation of the TL schools and different from other online educational institutions. This also lays the foundation for the implementation of the "dual-teacher classes" for school subjects at TL schools.

It is likely that "dual-teacher classes" will become a major format in China's private basic education groups in the future because they make better use of expert teaching resources and pool intelligence regarding group teaching and research. They also effectively resolve a development issue - the unbalanced distribution of excellent teaching resources across China. Such classes will be supported by advanced educational technology applications such as data collection and the analysis of student academic performance, as well as by targeted and personalized exercises. With advanced information-based means, teacher work efficiency and student study efficiency are expected to improve, thus motivating organizations and increasing revenues. This mode can even be implemented in public schools in some regions under the guidance of the government.

**5.1.2.2 Reorganizing the Education Management Center and Broadening the Channels for Talent Selection**

As the most important business department of Tianli Education Group, the Education Management Center managed the Quality Department, the Education and Teaching Research Institute, the Operations Supervision Department and the Logistics Department before September 1, 2019. It was responsible for quality guidance and control, as well as the curriculum development and implementation of the whole group. It supervised various schools and the logistics management of various schools.

To further improve the teaching quality of each school, to better meet the needs of students and parents for better university admission rates and to promote the sound and sustainable development of each school, the functions and organizational forms of the Education Management Center were discussed many times in the middle of 2019. Finally, the comprehensive teaching quality improvement plan represented by the "22-50" strategy was developed for group-wide implementation. The strategy's name, "22-50," means that in 2022, the number of all schools of the group with students admitted to Tsinghua University and Peking University - the two top universities in China - will reach 50 (both universities recruit about 3300-3400 students per year from across China). If this target is achieved, it means that the teaching quality at Tianli Education has become the best among private schools in China. On this basis, the group also put forward the "27-200" strategy in which the number of students

admitted to Tsinghua University and Peking University is expected to reach 200 by 2027. When that happens, Tianli will become the leader in private school teaching quality in China, and it will also hold decisive regional leads.

The "22-50" strategy not only refers to major breakthroughs regarding student admission to the two top universities in China but also implies that a larger number of high school graduates will be admitted to the top ten and 50 universities in China. This would represent the more balanced and sustainable development of high-quality teaching at Tianli and will truly allow the group to achieve the goal of "reaching the peak while attaining the high ground" in terms of university admission.

The "22-50" strategy further identifies the relevant functions and sets higher standards on work requirements for the Education Management Center. In this regard, since September 1, 2019, Tianli Education has reorganized its Education Management Center with a focus on teaching quality and curriculum development. The specific measures are as follows.

1). The focus of the Education and Teaching Research Institute changed to curriculum development (the Chinese national curriculum and a curriculum focused on independence, ethics, academic achievement, manners, individuality, positive mindsets and wholistic development). As this develops further, an R&D company dedicated to curriculum content will be established to develop courses on "Chinese traditional culture" and "science and technology" to gradually produce high-quality courses while meeting the internal needs of Tianli's schools.

2). The group built a core teaching team composed of head teachers and contest coaches to lead its teaching teams, thus ensuring the balanced and efficient improvement of teaching at the group. In addition, the group diversified new-teacher recruitment by expanding its scope of recruitment from normal university graduates to comprehensive university graduates.

3). The group's former Logistics Department was separated from the Education Management Center to form an independent department responsible for the logistics of the group and its schools. A logistics management company is planned to be established to operate in a market-oriented way, providing quality logistic services to Tianli and other organizations.

4). The former Operations Supervision Department is now under the Planning and Operations Center. It now has less work concerning the group's core business, allowing the Education Management Center to focus on education, teaching and curriculum development.

**5.1.2.3 Trimming staff and streamlining administration**

Trimming staff and streamlining administration is about reducing personnel and scaling back administration to achieve the goal of improving enterprise efficiency and increasing business

revenues. The education industry itself is a labor-intensive service industry. From the big data analysis of teacher work behavior in 4.2, it was found that acting teachers spent considerable amounts of time on repetitive tasks such as lesson planning and homework grading. Through in-depth analysis, it is possible to employ scientific and technological means to reduce such inefficient and repetitive work, such as through collective lesson planning on a unified education and teaching platform, as well as through standardized teaching resources and the digitalized marking of exercises and test papers online. It is also expected that this will comprehensively improve the standardization of work, streamline administrative departments and optimize organizational structures through workflow reengineering, thus realizing flat management and overall staff reductions, as well as higher overall efficiency through more efficient individual work. Finally we can reduce the working hours of acting teachers and improve their sense of happiness.

In this regard, trimming staff and streamlining administration is one of the three core tasks of the group for the 2019-2020 academic year. Divided into two stages, a "pilot" stage and a "complete implementation" stage, this strategy is designed to allow Tianli to scientifically evaluate its job positions, staffing, structural optimization and mechanism improvement. It will also allow Tianli to stimulate the work potential of its staff, improve their work efficiency, continuously improve happiness at work and build a professional, standardized school job management system for the education industry. While enhancing the forces driving the rapid and steady progress of the group, Tianli aims to contribute to the innovative development of basic education in China with its wisdom and examples. To ensure these expected results, the key aspects of this implementation are as follows.

1. Organizational Support

In September 2019, the Job Structure Optimization and Innovation Group led by the president of the group (also its head principal) was established to carry out research on "job positions, salaries and performance." In this sense, the group scientifically evaluated the job positions and staff of the school, effectively stimulating its faculty's work potential, trimming staff and streamlining administration, as well as cutting costs, optimizing structure, improving work efficiency, effectively controlling total staffing, enhancing the specialization and standardization of school jobs and further building the "school job management system" of Tianli Education Group. See the members and their duties in Table F.1 in Annex F.

2. Mobilization

After confirming the group's organizational structure and action program of "trimming staff and streamlining administration," the group had to carry out top-down policy promotion

and mobilization efforts - taking into consideration over 6000 faculty members at more than 40 independent teaching sites in 14 provinces of China - to give everyone a better understanding of these changes and to better implement the group's major strategies.

On October 19, 2019, one month after "trimming staff and streamlining administration" was confirmed, the group held a seminar on human resources during which the president delivered a work report entitled "Adhering to a Results-Oriented Approach, Building a Long-Term Mechanism to Systematically Solve Deep-Seated Problems in Human Resources Work." In addition, group study, discussions and other activities were carried out to ensure that the strategy was understood by all principals of school districts and directors of HR departments. All school districts were asked to inform all faculty members of the content of the seminar to discuss and promote the strategy.

The implementation of "trimming staff and streamlining administration" had two stages: a "pilot" stage and a "comprehensive implementation" stage. In the early stage, representative schools were selected as pilot schools. The strategy was then carried out in the rest of the group after further improvement according to the feedback and conclusions of the pilot implementation. After identifying pilot schools, human resource and administrative centers made efforts to communicate and allocate tasks with the senior management teams of the schools. The principals of pilot schools adopted new attitudes and reached a consensus on the following changes.

1). "We should attach great importance to this investigation and personnel work. This is a strategic move of the group and a profound lesson for principals like us regarding personnel work. We will implement the strategy according to the requirements of the group."

2). "In addition to attaching great importance to the strategy, we should act in a unified and proactive way and independently handle problems. The organization need not be over-staffed, and each of its parts need not be overstaffed."

3). "The investigation was a kind of training, mobilization meeting and time for reflection. It is necessary to thoroughly understand the current situation and to identify responsibilities, jobs and staffing-related matters."

4). "We should develop a channel for personnel communication and smooth transition, and we should strive to balance staffing without causing severe conflicts. We can reasonably control and reduce the size of our staff through job transfers, secondary applications for job positions and independent recruitment at school districts."

5). "We should establish a salary system that is in line with the jobs on offer, reward hardworking employees while punishing idle ones, construct a structured salary system and transform and gradually phase out the annual salary system."

These statements reflect the principals' recognition and understanding of the organizational change that is "trimming staff and streamlining administration." They also reflect their work methods combined with the specific conditions of their schools. Generally speaking, this initial wave of mobilization was highly valuable and successful.

3. Key Measures

1). Coordinated and Efficient Implementation

All centers and schools of the group were required to attach great importance to trimming staff and streamlining administration. The schools responded in a proactive and coordinated way to ensure efficient implementation. After receiving their tasks, HR and administrative centers had to immediately set up investigation teams to select pilot schools, designate investigators and design statistical forms. The team led by the HRO visited pilot schools to conduct one-to-one, in-depth discussions with the school districts' management team, after which it assigned tasks. Also, investigators clarified their tasks and started working immediately.

Each pilot school district was required to actively cooperate with the investigation and implemented it quickly. Principals of each school district acted as team leaders. Directors of human resource departments acted as the executive chiefs of investigation work teams, work liaison networks and communication teams established at school district work meetings and school phase work meetings. Through these efforts, this investigation was vigorously implemented and thus built a foundation and organizational guarantee for the completion of the goal of trimming staff and streamlining administration.

2). A Comprehensive, Innovative Investigation

Human resources and administrative centers were required to work in a results-oriented way and paid special attention to the causes of problems. When issuing budgets for each school for the new academic year, they focused on targets and innovated the design of the "integrated budget table of staffing and posts." Their detailed budgets and final accounts for each school phase of the 2018-2019 academic year, as well as their detailed budgets for each school phase of the 2019-2020 academic year (including the number of students and teachers), were integrated in the same table with the same teaching subjects and the same statistical methods in rows. Combined with salary survey data from the areas where offline schools are located, the complete statistics allowed for comprehensive comparison, thus laying a solid data-based foundation for appropriate, scientific preparations and budget verification. Finally,

refined statistical analyses of the operational data of various schools in the group were conducted.

Also, during the process of trimming staff and streamlining administration, HR and administrative centers were required to carry out full dimensional investigations regarding areas such as organizational structure, department responsibilities, staffing and salary verification. In addition, they provided targeted assistance and solutions according to the specific problems and situations of the schools. Aside from the five pilot school districts, the centers were asked to carry out in-depth investigations on personnel recruitment and staffing management and control, after which they developed feasible solutions to school overstaffing in schools in Ulanqab, Dongying, Weifang, Rizhao and Zhoukou, among other places, thus helping such schools deal with overstaffing via student enrollment, job transfer, communication, task changing and relocation.

3). Responsibility Designation and Process Monitoring

Human resource and administration centers, as well as all schools, were required to be responsible for trimming staff and streamlining administration. Employees in each link of these various tasks had their own, specific responsibilities. This ensured the effective promotion of their work and the achievement of their goals. Since the launch of this work, human resource and administration centers have been tasked to review the staffing at the schools of the group every two months. They must closely monitor their progress, reveal problems in time, put forward solutions quickly and solve problems effectively. Prompt management and control mechanisms were employed to incentivize, strengthen and guide work on staffing control.

4). Competition Based on Mutual Learning for Internal Motivation

Through effective communication, regular inspections, multi-party assistance and the public release of achievements, among other measures, the group created a work atmosphere of "competition based on mutual learning" to continuously stimulate the motivation of its faculty. All schools took various measures, such as increasing enrollment, automatic class integration, spontaneously changing tasks, delaying job start dates and the delegation of several positions to single individuals to control staffing.

The number of teachers with one position exceeding the designated level in Zunyi district was ten in December. In February and April, its numbers of teachers with one position fell to three and one, respectively. Luzhou's schools reduced staffing to 3.85% below the designated total in December, to 6.01% in February and to 8.17% in April. At schools in Yibin, Wulan, Zhoukou, Baoshan and other locations, overstaffing in September turned into balanced staffing (according to designated positions) in January, and their numbers of positions fell below

the designated level in April. All schools looked for various ways to control staffing by fully leveraging the potential of their faculty.

5). Generating Synergy and Empowering Faculty with a Platform

The initiative of "trimming staff and streamlining administration" was a core effort shared by all schools in the group, thus resulting in consistent goals and actions. According to the group's work arrangements, human resource and administrative centers led the development of a communications platform to integrate resources and share experience among schools. Seminars, personnel training, sharing meetings, school district visits and other activities were organized to enable employees to learn together, work together, draw conclusions and exchange experiences. The building of various platforms for the group and schools helped make this initiative better understood and accepted by school faculty. Thanks to this, the initiative was no longer merely a specialized task but also a form of cultural awareness and a code of conduct.

4. Results

1). Staffing Control in Tianli's Schools

1.1). In September 2019, there were 152 teaching positions at 14 of the 23 schools according to statistics provided by the group's financial center. Nine schools had staff numbers below designated size. In total, there were 62 teaching positions, or one more than the designated level, accounting for an extra 2.07%.

1.2). By March 2020 after the launch of "trimming staff and streamlining administration," only one school in Ziyang out of the 23 schools under the group had a temporary overstaffing of 15 teachers holding one position each. The other 22 schools had 162 positions less than the designated level, including 147 fewer teachers with one position (209 fewer if compared with data from September). There were a total of 471 positions less than the designated level in 23 schools.

By April 30, 2020, there were 19,879 students in the pilot schools, with 2,796 designated staff (1,481 teachers and 1,315 other staff) and 2,569 actual staff (1,392 teachers and 1,177 other staff), for a total of 227 positions less than the designated amount, or 8.12% below the designated total.

Among the number of positions below the designated level, there were 95 fewer teaching positions held by one position only (teachers in kindergartens excluded), accounting for 6.80%, and there were 138 fewer teaching positions held concurrently with other positions, accounting for 9.32%. The ratio of students to teachers was 14.28:1.

2). Staffing Control of the Group's Headquarters

Based on measures taken by Tianli's schools in "trimming staff and streamlining administration," all centers facilitated cost controls by clarifying departmental functions, optimizing processes and practicing "one person, multiple positions." By March 30, 2020, the "implementation plan for cost control at centers" was approved, with 14 staff positions eliminated.

In summary, the number of posts was 485 less than the designated total for the group.

## 5.2 Future research

(1) The IoT-empowered intelligent campus perception used in this study will be improved to carry out data collection and the analysis of student diets and nutrition. Via the development and introduction of smart devices, it will be possible to analyze students' daily, weekly and monthly intake of major nutritional components by referencing the schools' "three meals per day" menu and measuring how much food each student eats at school. Based on this and other nutrition-related knowledge, more scientific meal plans and advice can be provided for students of various ages according to their individual physiques so that the schools can comprehensively improve their logistical services and improve their brand image.

(2) This researcher will continue to verify the results of the correlation analysis on behavioral data and academic performance, as mentioned in 4.1, and will implement and verify more correlation analyses on academic performance and other aspects of student behavior, such as library borrowing habits and meal times, thus serving as a reference for the subsequent change of educational and teaching modes.

(3) This researcher will conduct further, more detailed big data-based analyses on teacher behavior at school and will expand the scope of this study beyond pilot schools to all faculty. This way, this researcher will be able to analyze the schools' human resource system more systematically based on bigger samples from a macro level. In addition, it will be able to explore more efficient organizational structures and personnel distribution schemes, thus fostering outstanding human resources to fuel the sustainable and sound development of the organization.

(4) Based on this behavioral analysis of teachers, the behavior of school logistics staff (including security staff, cleaners, cafeteria workers and dorm management personnel) at school will be digitized. By analyzing such data, the work routines or behavioral tendencies of such staff will be comprehensively presented so that new standard processes and job responsibilities can be established. Thus, such employees can be led to work more efficiently with appropriately distributed workloads, reducing redundant and ineffective work. Ultimate-

ly, the organization will generate larger profits with fewer staff; in turn, its logistical staff will earn more.

(5) The importance of educational science and technology should be improved. In particular, it should be improved throughout the research and development of smart teaching tools, such as standardized teaching and research platforms and automatic assessment systems for in-class exercises. This, in addition to changes to teaching methods, will establish a new education and teaching mode for advanced basic education in this intelligent era. Finally, we can really effectively reduce the working hours of teaching staff and improve their sense of work happiness

(6) This researcher will actively study the business models and business logic of the education and education-related industries, as well as policy guides from the Chinese government for private education. This way, the business models of private schools run by business groups can be upgraded, and their business transformation from educational service providers to suppliers of comprehensive and integrated services regarding education and life can be attempted.

(7) This researcher will study the organizational empowerment of process reengineering in private schools. By clarifying the currently working organizational structure and processes of the group's headquarters and schools with SOP (standard operation process) reengineering, the group will standardize its organizational structure, plan organizational process nodes and approval authorities, and systematically identify the functions of each center. This researcher will also attempt to explore the value and significance of remodeling the process architecture of the organization.

# Bibliography

Amarasuriya, S. D., Jorm, A. F., & Reavley, N. J. (2018). Predicting intentions to seek help for depression among undergraduates in Sri Lanka. *Bmc Psychiatry*, *18*(1), 122.

Bai, S. T., Yuan, S., Cheng, L., & Zhu, T. S. (2014). 多任务回归在社交媒体挖掘中的应用 [Application of multi-task regression in social media mining]. *Journal of Harbin Institute of Technology*(9), 100-104.

Barnard, C. I. (1948). *Organization and management*. Harvard University Press.

Barros, E. P., & Osório, A. J. (2017, March 18-20). *Open and Networked Education: Learning the future of learning*. The 2017 International Conference on Advanced Technologies Enhancing Education (ICAT2E 2017), Qingdao, China.

Bengü, Y., & Ahmet, ü. (2018). The Relationship Between Internet Addiction, Social Anxiety, Impulsivity, Self-esteem, and Depression in a Sample of Turkish Undergraduate Medical Students. *Psychiatry Research*, *267*, 313.

Bo, C. X. (2015). *当代中国中小学校组织变革的价值范式研究* [Doctoral dissertation]. Wuhan University.

Cao, Y. (2016). *基于大数据和性格模型的大学生校园行为模式的研究及其应用* [Master's thesis]. University of Electronic Science and Technology of China.

Cao, Y., Gao, J., Lian, D. F., Rong, Z. H., Shi, J. T., Wang, Q., . . . Zhou, T. (2018). Orderness Predicts Academic Performance: Behavioral Analysis on Campus Lifestyle. *Journal of The Royal Society Interface*, *15*(146), 125-137.

Chang, L., & Fu, Z. P. (2019). 数字经济转型下传统企业的双平台战略与组织变革——以广新集团为例 [The dual platform strategy and organizational change of traditional enterprises under the digital economy transformation—taking Guangxin Group as an example]. *Enterprise Economy*(9), 69-76.

Chen, C. L. P., & Zhang, C. Y. (2014). Data-intensive applications, challenges, techniques and technologies: A survey on Big Data. *Information Sciences: An International Journal*, *275*, 314-347.

Chen, F. F., & He, X. B. (2018). 大数据技术在高校学生心理危机预防中的应用 [Application of big data technology in psychological crisis prevention for university students]. *Education Modernization*, *5*(18), 119-120.

Chen, G. X. (2017). *大数据对我国高校教育管理的影响及对策研究* [Doctoral dissertation]. Wuhan University.

Chen, R., & Sharma, S. K. (2015). Learning and self-disclosure behavior on social networking sites: the case of Facebook users. *European Journal of Information Systems*, *24*(1), 93-106.

Chen, Y., Liu, H., & Zhou, W. H. (2015). 大数据在淘宝网电子商务模式创新中的应用研究 [Study on the application of big data in Taobao's e-commerce mode innovation]. *Value Engineering*, *34*(35), 1-5.

Chen, Y. P. (2015). 大数据对于消费者行为研究的影响 [Impact of big data analysis on consumer behavior]. *China Business*(51), 38-41.

China, T. G. O. o. t. M. o. E. o. t. P. s. R. o. (2014). *Key points of education informatization work in 2014*. (Report No. 2014 No. 1). The General Office of the Ministry of Education of the People's Republic of China

Christensen, C. M., Horn, M. B., & Johnson, C. W. (2008). *Disrupting class how disruptive innovation will change the way the world learns*. McGraw-Hill, New York.

Cios, K. J., & Moore, G. W. (2002). Uniqueness of medical data mining. *Artificial Intelligence in Medicine*, *26*(1-2), 1-24.

Dewey, B. J. (1916). Democracy and education : an introduction to the philosophy of education. *American Journal of Sociology*, *10*(1), 40–49.

Dewey, B. J. (1948). Common Sense and Science: Their Respective Frames of Reference. *Journal of Philosophy*, *45*(8), 197-208.

Ding, B. T. (2019). 大数据领导力的"五力"模型研究 [A study on 5-Capability Model of Big Data Leadership]. *Shanghai Urban Management*(4), 40-45.

Du, J. M., Fang, H. G., Li, W. Y., & Tong, S. S. (2016). 教育大数据研究综述 [Literature review on big data in education]. *The Chinese Journal of ICT in Education*, *382*(19), 1-4.

Elbadrawy, A., Polyzou, A., Ren, Z., Sweeney, M., Karypis, G., & Rangwala, H. (2016). Predicting Student Performance Using Personalized Analytics. *Computer*, *49*(4), 61-69.

Feng, J. J. (2004). On the concept of personalized education. *Education Science*, *20*(2), 11-14.

Feng, P. C. (2018). 大数据时代的组织演化研究 [Research on organizational evolution in the big data era]. *Economist*, *3*(3), 57-62.

Freeman, R. E. (2010). *Strategic management: a stakeholder approach*. Cambridge University Press.

Fuxa, A. J., & Fulkerson, J. A. (2011). Adolescent Obesity and School Performance and Perceptions of the School Environment Among Minnesota High School Students. *School Mental Health*, *3*(2), 102-110.

Gao, S. L. (2015). 大数据背景下国外数据素养教育及启示 [Data literacy education abroad and its inspiration under the background of big data]. *Library Research*, *45*(006), 108-111.

Greiner, L. E. (1997). Evolution and Revolution as Organizations Grow: A company's past has clues for management that are critical to future success. *Family Business Review*, *10*, 397-409.

Grivokostopoulou, F., Perikos, I., & Hatzilygeroudis, I. (2014, December 8-10). *Utilizing semantic web technologies and data mining techniques to analyze students learning and predict final performance*. IEEE International Conference on Teaching, Assessment and Learning (TALE) 2014, Te Papa Tongarewa National Museum of New Zealand, Wellington, New Zealand.

Guan, J., & Li, Q. T. (2014). 中国在线教育发展现状,趋势及经验借鉴 [China's online education current situation, trend and experience for reference]. *China Educational Technology*(08), 62-66.

Guan, Y. J., & He, M. (2019). 基于用户行为的立体车库车辆停放调度研究 [Research on parking scheduling of stereo garage based on user behavior]. *Journal of North China University of Science and Technology (Natural Science Edition)*(1), 112-117.

Gulati, R., Mayo, A. J., & Nohria, N. (2016). *Management: an integrated approach (2nd edition)*. Cengage Learning.

Gupta, M., Mittal, H., Singla, P., & Bagchi, A. (2017). Analysis and characterization of comparison shopping behavior in the mobile handset domain. *Electronic Commerce Research*, *17*(3), 1-31.

Han, J. W. (2005). *数据挖掘: 概念与技术* [Data mining: concepts and techniques]. China Machine Press.

Han, Y. (2017). 掌握互联网思维 有效提升领导力 [Master the Internet thinking: effective leadership improvement]. *The Forum of Leadership Science*(3), 32-34.

Hao, Y. ( 2017). 略谈管理学在教育教学中的应用 [Application of management in education and teaching]. *KaoShi ZhouKan*(A4), 12.

He, C. K., & Wu, M. (2016). edX 平台教育大数据的学习行为分析与预测 [Education big data analysis and forecast on study behavior on edX platform]. *Distance Education in China*(06), 54-59.

He, H., & Luo, Y. (2015). Analysis on depression status and influence factors of university students in Beijing. *Modern Preventive Medicine*(07), 115-118,153.

He, X. X. (2017). *基于课堂教学改革的学校组织变革研究* [Doctoral dissertation]. East China Normal University.

Helbing, D., & Balietti, S. (2011). From Social Data Mining to Forecasting Socio-Economic Crisis. *European Physical Journal Special Topics*, *195*, 3-68.

Horn, M. B. (2016a). Moving Edtech Forward: Upstart School Networks Are Betting on a Breakthrough. *Education Next*, *16*(1), 82-83.

Horn, M. B. (2016b). The Rise of AltSchools and Other Micro-Schools. *Education Next*, *15*(3), 77-78.

Hou, H. D. (2019). "互联网+"时代下人力资源管理的优劣势分析 [Analysis on advantages and disadvantages of human resource management in the "Internet+" age]. *Human Resources*(12), 33.

Hu, B. C., & Wang, Z. L. (2015). "大数据"对教育的作用,挑战及教育变革趋势——大数据时代教育变革的最新研究进展综述 [The role and challenge of "big data" in education and the trend of change in education—review on the latest research on educational change in the big data times]. *Modern University Education*(004), 98-104.

Hu, Q., Li, A., Heng, F., Li, J. P., & Zhu, T. S. (2016, February 4). *Predicting Depression of Social Media User on Different Observation Windows*. 2015 IEEE/WIC/ACM International Conference on Web Intelligence and Intelligent Agent Technology (WI-IAT), Singapore.

Huang, S. L., & Xiang, J. (2013). "大数据"点亮人力资源管理系统的"大智慧"——结合新华社人力资源大数据实践探析 ["Big data" inspires "big wisdom" in human resource management system]. *Science & Technology for China's Mass Media*(023), 76-78.

Huang, X. B. (2009). Application of the IOT. *Information Construction*(11), 21-22.

Jackson, P. W. (1986). The Practice of Teaching. *Journal of Higher Education*, *58*(6), 159.

Jia, T. (2015). *大数据对高等教育发展的推动研究* [Master's thesis]. Southwest University.

Jia, Y., Zhang, Q. M., Jian, G., Zhang, L., & Tao, Z. (2015). Promotion and resignation in employee networks. *Physica A: Statistical Mechanics and its Applications*, *444*, 442-447.

Jiang, Z. X., Zhang, Y., & Li, X. M. (2015). 基于 MOOC 数据的学习行为分析与预测 [Learning behavior analysis and prediction based on MOOC data]. *Journal of Computer Research and Development*(03), 614-628.

Jie, X., Moon, K. H., & Schaar, M. (2017). A Machine Learning Approach for Tracking and Predicting Student Performance in Degree Programs. *IEEE Journal of Selected Topics in Signal Processing*, *11*(5), 742-753.

Jin, Q. K. (2018). 大数据时代企业领导力提升策略 [On leadership promotion strategies of enterprises in the big data era]. *Heilongjiang Science*, *9*(23), 152-153.

Johnson, R. A., Kast, F. E., & Rosenzweig, J. E. (Eds.). (1973). *The theory and management of systems*. McGraw-Hill.

Keefe, J. W. (Ed.). (1979). *Learning style: An overview*. National Association of Secondary School Principals.

Khan, M. L. (2017). Social media engagement: What motivates user participation and consumption on YouTube? *Computers in Human Behavior*, *66*, 236–247.

Kotter, J. P. (1995). Why transformation efforts fail. *Harvard Business Review*, *13*(2), 59-67.

Kotter, J. P., & Cohen, D. S. (2012). *Heart of change: real-life stories of how people change their organizations*. Harvard Business Review Press.

Krähe, A. D. (1950). *Unternehmungsorganisation*. VS Verlag für Sozialwissenschaften.

Lan, Y. (2002). Realizing transformation: trends of school transformation in China at the beginning of the 21st century. *Exploration and Free Views*, *1*(007), 10-14.

Lay, W. A. (1912). *Experimentelle pädagogik: mit besonderer rücksicht auf die erziehung durch die tat*. Benedictus Gotthelf Teubner.

Lee, S., Wang, T., & Ren, X. (2019). Inner speech in the learning context and the prediction of students' learning strategy and academic performance. *Educational Psychology*(1), 1-15.

Lewin, K. (1951). Field Theory in Social Science. *American Catholic Sociological Review*, *12*(2), 103.

Li, K. (2016). *大数据背景下商业银行人力资源信息化创新应用研究* [Master's thesis]. Soochow University.

Li, K. S., Nian, J. Q., Li, Q., Yang, C., & Deng, W. (2019). "互联网+"心理平台:大数据时代心理健康循证实践的新途径 ["Internet+" psychological platform: a new approach to the evidence-based practice of psychological healthy in big-data age]. *Chinese Journal of Clinical Psychology*, *27*(1), 210-214.

Li, L., & Liu, J. (2014). 面向舆情主题的微博用户行为聚类实证分析 [Empirical Analysis of Micro-blogger Behavior Clustering on Public Opinion Topics]. *Journal of Intelligence*, *33*(3), 4.

Li, S. S., & Duan, C. Y. (2018). 北美地区校长领导力的发展演进及研究热点——基于 Citespace 知识图谱的元研究 [Development evolution of and research focus on principals' leadership in North America study based on Citespace knowledge graph]. *Education Exploration*(003), 117-122.

Li, Y. (2017). *大数据环境下在线学习行为分析模型研究* [Master's thesis]. Harbin University of Science and Technology.

Liang, J., & Luo, H. J. (2018). 大数据挖掘方法在大学生心理预警系统中的应用 [Big data mining in the application of the psychological early-warning system of college student]. *Chinese Journal of School Health*, *039*(012), 1821-1824,1827.

Lin, & Chih-Che. (2015). The relationships among gratitude, self-esteem, depression, and suicidal ideation among undergraduate students. *Scand J Psychol*, *56*(6), 700-707.

Liu, F. J. (2014). 大数据的教育应用研究综述 [Research overview of the big data's application in education]. *Modern Educational Technology*, *24*(8), 13-19.

Liu, S., Li, F., Li, C. F., Yan, Y. Q., Jin, W. P., Ke, S. S., . . . Gong, J. (2019). 青少年健康行为和学习压力对学习成绩的影响 [Influence of health behaviors and learning pressure on academic performance among teenagers]. *Chinese Journal of Health Education*(03), 239-242.

Liu, W., Duan, H. X., Ren, P., Li, X., & Wu, J. P. (2003, November 5-5). *Wavelet based data mining and querying in network security databases.* 2003 International Conference on Machine Learning and Cybernetics, Xi'an China.

Liu, W. C., Tang, J., & Wu, C. (2019). 人工智能与领导力:基于复杂大数据支撑的政府决策机制研究 [AI and leadership: research on decision-making mechanisms of the government based on the complex big data support]. *Reform & Openning*(011), 42-46.

Liu, X., & Xu, H. B. (2002). 医学生学习动机、学习行为对学业成绩影响的调查研究 [Investigation on the influence of medical students' learning motivation and learning behavior on their academic performance]. *China high medical education*(6), 2.

Liu, X. J. (2012). *Exploration on individuality education in higher education institutions.* Huazhong University of Science & Technology Press.

Liu, Y., Tan, X., Li, Y., Xu, F., Zhang, J., & Kong, J. H. (2015). A survey on depression in college students and influencing factors. *Chinese Journal of General Practice*, *13*(001), 91-93.

Liu, Y. J. (2014). *社会物理学:社会治理* [Social physics: social governance]. China Science Publishing.

Lu, J. (2013). 大数据及其在教育中的应用 [Big data and its application in education]. *Journal of Shanghai Education Research*(009), 5-8.

Lu, Y. Q. (2013). 以教学方式变革为导向的学校组织变革的策略选择 [Strategy selection of organizational change in schools based on change in teaching methods]. *Secondary and Primary School Management*(009), 14-16.

Ma, Z. K. (2009). *Organizational change (organizational operation and management series).* China Economic Publishing House.

Mayer-Schonberger, V., & Cukier, K. (2013). Big Data: A Revolution That Will Transform How We Live, Work, and Think. *Smart Business Cincinnati/Northern Kentucky*, *179*(9), 1143-1144.

Meng, L. (2005). Literatures on western organization change model. *Journal of Capital University of Economics and Business*, *7*(1), 90-92.

Michael, H., & James, C. (1993). *Reengineering the corporation* (Vol. 35). Nicholas Brealey Publishing.

Mills, D. Q. (1991). *Rebirth of the corporation*. J. Wiley & Sons.

Mintzberg, H. (1992). *Structure in fives: designing effective organizations (1st edition)*. Pearson.

Mo-Suwan, L., Lebel, L., Puetpaiboon, A., & Junjana, C. (1999). School performance and weight status of children and young adolescents in a transitional society in Thailand. *Int J Obes Relat Metab Disord*, *23*(3), 272-277.

Mosher, F. C. (1967). *Governmental reorganization: case and commentary*. The Bobbs-Merrill Company.

Na, G. Y. (2006). 管理的终极之善是改变他人的生活 [The ultimate good of management is to change others' live]. *IT Times*(2), 1.

Naisbitt, J. (1982). *Megatrends: Ten New Directions Transforming Our Lives*. Warner Books.

Odai, R. O. (2018). *Big data, empowerment leadership, decisions, performance—evidence from Ghana* [Master's thesis]. University of Electronic Science and Technology of China.

Okbay, A., Beauchamp, J. P., Fontana, M. A., Lee, J. J., & Pers, T. H. (2016). Genome-wide association study identifies 74 loci associated with educational attainment. *Nature*, *533*(7604), 539-542.

Pan, Y., Zhang, Y. Q., & Liu, L. (2019). Research on the characteristic service strategies of comprehensive university libraries: from the perspective of disciplinary differences between undergraduate course achievements and loan behavior. *Journal of Academic Library and Information Science*, *37*(02), 85-93.

Pentland, A. (2015). *Social physics: how social networks can make us smarter*. Penguin Books.

Pu, R. (2005). 应用学习型组织理论实现学校组织变革 [Realizing the school organizational change by adopting study-oriented organization theories]. *Journal of Teaching and Management*(10), 7-9.

Qiu, J. Z., Tang, J., Liu, T. X., Gong, J., Zhang, C. H., Zhang, Q., & Xue, Y. F. (2016, February 22-25). *Modeling and Predicting Learning Behavior in MOOCs*. WSDM '16: Proceedings of the Ninth ACM International Conference on Web Search and Data Mining, San Francisco, California, USA.

Qu, S., Li, K., Zhang, S., & Wang, Y. (2018). Predicting Achievement of Students in Smart Campus. *IEEE Access*, *6*, 60264-60273.

Rong, H. T., Wang, R. L., Wu, J., & Yang, Q. B. (2016). 学生行为对学生成绩的影响探究 [On influence of students' behavior on academic performance]. *Modern Business Trade Industry*, *37*(023), 185-186.

Salamon, L. M. (1981). "The Question of Goals". In Szanton, P. (Ed.), *Federal Reorganization: What have we learned?* (pp. 58-84). Chatham House Publishers, Inc.

Schein, E. H. (1992). *Organizational culture and leadership*. Jossey-bass.

Schönberger, V. M., & Zhou, T. (2013). *Big data: a revolution that will transform how we live, work, and think*. Zhejiang People's Press.

Sergiovanni, T. J. (1984). Leadership and Excellence in Schooling. *Education Digest*, *41*(5), 4-13.

Severance, & Charles. (2012). Teaching the World: Daphne Koller and Coursera. *Computer*, *45*(8), 8-9.

Shang, J. (2019). 2018 年中国游客赴欧洲旅游大数据报告 [Big data report on Chinese visitors' trips to Europe 2018]. *Air Transport & Business*(003), 52-54.

Shi, L. (2020). 新式茶饮消费者的消费心理与行为研究——基于消费者评价语的情感分析 [A study on consumer psychology and behavior of new-style tea drinkers - Sentiment analysis based on consumer evaluation]. *Food*, *37*(2), 7.

Simon, H. A. (1976). *Administrative Behavior: A Study of Decision-Making Processes in Administrative Organization*. Macmillan.

Stabler, B., Clopper, R. R., Siegel, P. T., Stoppani, C., & Study, T. (1994). Academic achievement and psychological adjustment in short children. The National Cooperative Growth Study. *Journal of Developmental & Behavioral Pediatrics Jdbp*, *15*(1), 1.

Straton, N., Hansen, K., Mukkamala, R. R., Hussain, A., Grønli, T.-M., Langberg, H., & Vatrapu, R. (2016, September 14-17). *Big Social Data Analytics for Public Health: Facebook Engagement and Performance.* 18th International Conference on E-health, Networking, Application & Services (IEEE HealthCom 2016), Munich, Germany.

Su, Y. H. (2017). 远离"大"数据误区 [Avoid misunderstanding on big data]. *Human Resources*(10), 68-70.

Tan, H. J. (2016). 基于大数据时代的企业领导力提升 [Enterprise leadership improvement based on the big data era]. *Enterprise Management*(004), 110-112.

Tang, H. Q. (2017). *基于高校论坛数据的成绩预测和学生心理状况分析* [Master's thesis]. University of Electronic Science and Technology of China.

Tang, K. Y. (2014). 大数据时代人力资源管理的变革 [Change of human resource management in the big data era]. *Human Resources and Social Security of China*(003), 57.

Toffler, A. (1987). *The adaptive corporation*. China prospect publishing house.

Tsai, C. W., Lai, C., Chiang, M. C., & Yang, L. T. (2014). Data Mining for Internet of Things: A Survey. *Communications Surveys & Tutorials IEEE*, *16*(1 Partsupplement), 77-97.

Tyler, R. W. (1949). *Basic principles of curriculum and instruction*. University of Chicago Press.

UNESCO. (2017). Reflection on education: mindset change towards "globally shared interests". *Modern Distance Education Research*(05), 2.

Wan, H. (2018). 校长领导力的本质及自我修炼 [The nature and traits of principal leadership]. *People's Education*(012), 13-16.

Wang, B. (2017). 信息时代企业组织变革发展方向 [Development orientation of enterprise organizational change in the information era]. *Modern Management Science*(2), 106-108.

Wang, G. Q. (2017). *A study on key issues in China's informationization in the "13th Five Year Plan" period: Analysis and Vision of China's Economy.* Social Sciences Academic Press (China), Beijing.

Wang, H. Y. (2013). *课堂改革推进中的学校组织变革研究* [Research on organizational change of school with the teaching reform]. Jilin People's Press.

Wang, J. J., Zhu, B. P., & Wang, Z. E. (2020). 大数据时代企业领导力提升策略探究 [A study on strategies to improve leadership in enterprises in the big data era]. *Technology & Management*, *669*(01), 28-28.

Wang, J. T. (2016). *数据驱动的大学生心理跟踪及危机预警研究* [Master Thesis]. South China Agricultural University.

Wang, K. L., & Deng, F. Q. (2018). 基于阿里巴巴大数据重复购买预测的实证研究 [An empirical study on predicting repurchasing based on Alibaba big data]. *Times Finance*(3), 237-239.

Wang, L. C., Yan, C. X., & Li, W. (2017). 基于新浪微博大数据的旅游流时空特征研究——以兰州市为例 [Research on spatial—temporal characteristics of tourist flow based on Sina Microblog LBS data: a case study of Lanzhou]. *Tourism Tribune*, *32*(005), 94-105.

Wang, X. (2019). *基于数据挖掘的学生行为习惯与学习成绩的关联性研究* [Master's thesis]. Shanghai Normal University.

Wang, Y., & Zhao, H. C. (2017). 美国校长信息化领导力评价研究及启示——基于评价标准的思考 [Research and implications of the American principal technology leadership Assessment—based on the thoughts of evaluation criterion]. *Digital Education*(02), 86-92.

Wang, Y. Y. (2017). *大数据时代互联网企业人力资源管理研究* [Master's thesis]. Minzu University of China.

Wang, Z. (2013). 学校组织结构变革:助力学生多元自主发展 [Structural change in school organization: promote diversified independent development of students]. *Secondary and Primary School Management*(009), 4-9.

Wang, Z., & Li, M. X. (2013). *学校组织变革实践:校长的探索* [Practices of school organizational change: the principals' trials]. Educational Science Publishing House.

Weber, M. (1947). *The theory of social and economic organization*. Free Press.

Wei, Z., & Lin, F. (2006). Behavior Analysis in Distance Education by Boosting Algorithms. *International Journal of Distance Education Technologies*, *4*(2), 57-71.

Wu, S., & Li, X. D. (2016). 基于大数据时代的企业领导力提升 [On leadership improvement of enterprises in the big data era]. *Management & Technology of SME*(7), 16-17.

Wu, W. H., Yang, Q., Shen, X. Y., Wang, H. Z., Wu, L., & Zhang, P. Y. (2011). 智能实验室管理系统下的实验室开放管理 [The laboratory open management under the intelligent management system]. *Experimental Technology and Management*, *28*(002), 172-176.

Wu, Y. F. (2018). *eduExplorer:基于校园行为数据的可视分析系统* [Master's thesis]. University of Electronic Science and Technology of China.

Xie, K. Y., & Tu, H. W. (2016). 如何推动组织的变革?——基于扎根理论的组织变革动力研究 [How to promote organization change? A grounded theory research on change dynamics]. *Human Resources Development of China*(008), 71-79.

Xu, D., & Xiao, Y. H. (2019). 基于机器学习技术的网站用户行为预测 [Prediction of website users' behavior based on machine learning technology]. *Modern Electronics Technique*(04), 94-96,100.

Xu, H. (2012). *民办学校师资管理问题及对策研究* [Doctorial Thesis]. Northeast Normal University.

Xu, J., & Wang, B. (2019). 基于互联网+的企业人力资源管理策略分析——以国防职教集团中化工企业为例 [Strategy analysis of enterprise human resource management based on Internet—take chemical enterprises in national defense vocational education group]. *Adhesion*(7), 153-156.

Xu, K. (2019). *珠三角 S 镇义务教育阶段民办学校教育管理问题及对策研究* [Master's thesis]. Qinghai Normal University.

Xu, M. Y., Liu, G. Q., & Li, R. (2013). 大数据对组织变革的影响 [A study on influence of big data on organizational change]. *Enterprise Management*(009), 106-107.

Yang, C. (2018). *云环境下基于 Petri 网的用户行为分析研究* [Master's thesis]. Nanjing University of Posts and Telecommunications.

Yang, J., Qiao, Y., Zhang, X., He, H., Liu, F., & Cheng, G. (2017). Characterizing User Behavior in Mobile Internet. *IEEE Transactions on Emerging Topics in Computing*, *3*(1), 95-106.

Yang, J. Y., Wei, X. R., Wu, A., Liu, Y. J., & Wu, D. (2018). 中美两国中小学校长信息化领导力比较研究 [A comparative study on ICT leadership of principals in primary and secondary schools in China and the U.S]. *e-Education Research*, *039*(005), 122-128.

Yang, L. C. (1987). 谈谈管理理论在学校教育管理中的应用 [On application of management theories in school education management]. *Journal of Guangxi University of Finance and Economics*(02), 25-27.

Yang, X. M. (2016). 试论数字时代民办高校校长领导力的提升 [On principals' leadership improvement in privately-run universities in the digital age]. *China Adult Education*, *No.387*(02), 65-68.

Yang, Y. J. (2010). 组织文化与组织变革 [Organizational culture and organizational change]. *Friend of Science Amateurs*(13), 113-114.

Yao, J. L. (2017). *Research on safety risk prevention and control mechanism in primary and secondary schools*. China University of political science and Law Press.

Yao, W. H. (2010). Definitions and content of the IOT. *Information China*(05), 22-23.

Ye, X., Lian, Z., She, B., & Kudva, S. (2019). Spatial and big data analytics of E-market transaction in China. *GeoJournal*, *85*, 329-341.

Ye, Z., Zheng, J. Z., & Tu, R. Y. (2018). Network evolution analysis of e-business entrepreneurship: big data analysis based on taobao intelligent information system. *Information Systems and e-Business Management*, *18*, 665–679.

Yi, L. Y., & Zou, T. L. (2019). 大数据驱动下的高校平安校园建设研究 [Study on peaceful campus construction in universities and colleges driven by big data]. *China Educational Technology*(8), 57-62.

Yu, F., Peng, K. P., & Zheng, J. X. (2015). 大数据背景下的心理学:中国心理学的学科体系重构及特征 [Big data and psychology in China]. *Chinese Science Bulletin*, *60*(5), 520-533.

Yu, X. Y. (2009). *学校组织变革研究* [Doctoral dissertation]. Beijing Normal University.

Zeng, H., & Wu, S. N. (2016). 基于微博的大数据用户画像与精准营销 [User image and precision marketing on account of big data in Weibo]. *Modern Economic Information*(024), 306-308.

Zeng, Z. H., Chen, Z. W., & Huang, T. (2016). 基于大数据的高校个性化画像教学模型构建研究 [Research on establishing big data-based teaching model featuring personalized portraits in universities]. *Journal of Chifeng University (Natural Science Edition)*, *32*(020), 233-235.

Zhang, C. (2018). 学生自杀事件的原因分析及应对策略 [Cause analysis on students'suicide and solutions]. *Jiangsu Education*(16), 33-35.

Zhang, J. M., & Wang, C. J. (2015). 基于大数据技术的大学生心理危机预警研究 [Psychological crisis warning of university students based on big data technology]. *Education and Vocation*(030), 75-77.

Zhang, L., Huang, X. L., Liu, T. L., Chen, Z. X., & Zhu, T. S. (2014, November 27-29). *Using Linguistic Features to Estimate Suicide Probability of Chinese Microblog Users.* International Conference on Human Centered Computing, Phnom Penh, Cambodia.

Zhang, L. Y., Gao, J., Hong, X., & Zhou, T. (2015). 大数据导航人力资源管理 [Big data guides the human resource management]. *Big Data Research*(1), 121-123.

Zhang, X., Yu, P., & Pan, D. Z. (2018). 智慧型人力资源管理平台 [Intelligent human resource management platform]. *Human Resource Management*(003), 17-18.

Zhang, X. R., Fan, Z. F., & Tao, X. B. (2015). 大数据在人力资源管理中的应用空间与挑战——基于谷歌与腾讯的对比分析 [The application potential and challenge of using big data in human resource management—a comparative analysis based on Google and Tencent]. *Human Resources Development of China*, *No.340*(22), 52-57.

Zhang, Y., & Xia, Y. (2006). 组织变革--现代组织发展的推动力 [Organizational change—driving force for modern organizational development]. *Journal of Hebei Tourism Vocational College*, *11*(001), 32-34.

Zhao, L. L., & Dai, R. H. (2016). 校长的信息化领导力与领导效能:内涵,特征及启示 [Informationization leadership and leadership effectiveness of the principal: connotation, features and implications]. *Teacher Education Research*, *28*(005), 49-56.

Zhao, L. L., & Liang, Q. (2018). 技术整合:校长信息化领导力建设的新视角 [Technology integration: a new perspective of principal's technology leadership construction]. *Teacher Education Research*, *030*(005), 104-110.

Zhao, M. R. (2009). 论校长领导力 [On the leadership of principals]. *Education Science Research*(01), 40-42.

Zhao, Z. Y., Zhang, K., & Wu, Q. J. (2014). 复旦大学:数据管理支撑信息化一站式服务 [Fudan University: information-base one-stop service supported by digital management]. *China Education Network*(12), 53-56.

Zhi, T. J., & Zhao, L. L. (2016). 校长的信息化领导力如何影响学校的信息化效能——基于结构方程模型的实证分析 [How the Secondary School Principals' Informationization Leadership can Influence the School Informationization Efficiency—An empirical analysis based on structural equation model]. *Modern Distance Education*(02), 63-69.

Zhou, X. L. (2014). 大数据时代的教育管理变革 [Management change in education in the big data era]. *Journal of the Chinese Society of Education*(010), 25-30.

Zhu, K. Y. (2017). *巴纳德职业经理人责任道德研究* [Master's thesis]. Zhengzhou University.

Zhu, R. X. (2016). 基于互联网思维的政府领导力研究 [A study on government leadership based on the Internet thinking]. *E-Government*(002), 60-66.

Zhu, Y. X. (2016). 未来学校的曙光 [The dawn of future schools]. *Journal of the Chinese Society of Education*(2), 1-1.

Zollanvari, A., Kizilirmak, R. C., Kho, Y. H., & Hernandez-Torrano, D. (2017). Predicting Students' GPA and Developing Intervention Strategies Based on Self-Regulatory Learning Behaviors. *IEEE Access*, *5*, 23792-23802.

# Annex A

Table A.1 Student Bracelet-Wearing Data

| Field No. | Field Name | Field Type | Field Description |
|---|---|---|---|
| 1 | Student_Name | varchar | Student's name |
| 2 | Student_Id | varchar | Student's ID |
| 3 | Start_End_Date | date | Statistical Period |
| 4 | Wearing_Times | int | Number of times the bracelet was worn |
| 5 | Wearing_Percent | double | Frequency of wearing the bracelet |

Table A.2 Student Academic Achievement Data

| Field No. | Field Name | Field Type | Field Description |
|---|---|---|---|
| 1 | Student_Name | varchar | Student's name |
| 2 | Student_Id | varchar | Student's ID |
| 3 | Exam_Date | date | Examination date |
| 4 | Subject | varchar | Subject |
| 5 | Subject_Score | double | Subject score |
| 6 | Total_Score | double | Total score |
| 7 | Subject_Rank | int | Subject ranking |
| 8 | Total_Rank | int | Overall ranking |

Table A.3 Sunday Attendance

| Field No. | Field Name | Field Type | Field Description |
|---|---|---|---|
| 1 | Student_Name | varchar | Student's name |
| 2 | Student_Id | varchar | Student's ID |
| 3 | Attendance | bool | Sunday attendance |

# Annex B

Table B.1 Student Bracelet Statistics in Phase I

| Wearing Frequency | Times Worn | Number of Students | Proportion | Wearing Habits |
|---|---|---|---|---|
| 80%-100% | 32-40 | 99 | 38% | Excellent |
| 60-79% | 24-31 | 44 | 17% | Good |
| 40-59% | 12-23 | 42 | 16% | Fair |
| 10-39% | 4-11 | 24 | 9% | Poor |
| 0-9% | 0-3 | 51 | 20% | Abysmal |

Table B.2 Student Bracelet Statistics in Phase II

| Wearing Frequency | Times Worn | Number of Students | Proportion | Wearing Habit |
|---|---|---|---|---|
| 80%-100% | 97-122 | 43 | 17% | Excellent |
| 60-79% | 73-96 | 23 | 9% | Good |
| 40-59% | 48-72 | 14 | 5% | Fair |
| 10-39% | 12-47 | 37 | 14% | Poor |
| 0-9% | 0-11 | 143 | 55% | Abysmal |

Table B.3 Statistics on Daily Steps in Phase I

| Compared with the Average | Step Count Range | Number of Students | Proportion |
|---|---|---|---|
| >20% | > 9967 | 44 | 21% |
| (10%, 20%] | 9137-9967 | 30 | 14% |
| (0, 10%] | 8306-9136 | 42 | 20% |
| (-10%, 0] | 7475-8305 | 27 | 13% |
| (-20%, 10%] | 6644-7474 | 24 | 11% |
| <-20% | < 6644 | 42 | 20% |

Table B.4 Statistics on Daily Steps in Phase II

| Compared with the Average | Step Count Range | Number of Students | Proportion |
|---|---|---|---|
| >20% | > 7050 | 31 | 29% |
| (10%, 20%] | 6463-7050 | 16 | 15% |
| (0, 10%] | 5876-6462 | 18 | 17% |
| (-10%, 0] | 5288-5875 | 8 | 7% |
| (-20%, 10%] | 4700-5287 | 5 | 4% |
| <-20% | < 4700 | 30 | 28% |

Table B.5 Statistics on Students Returning to School on Time

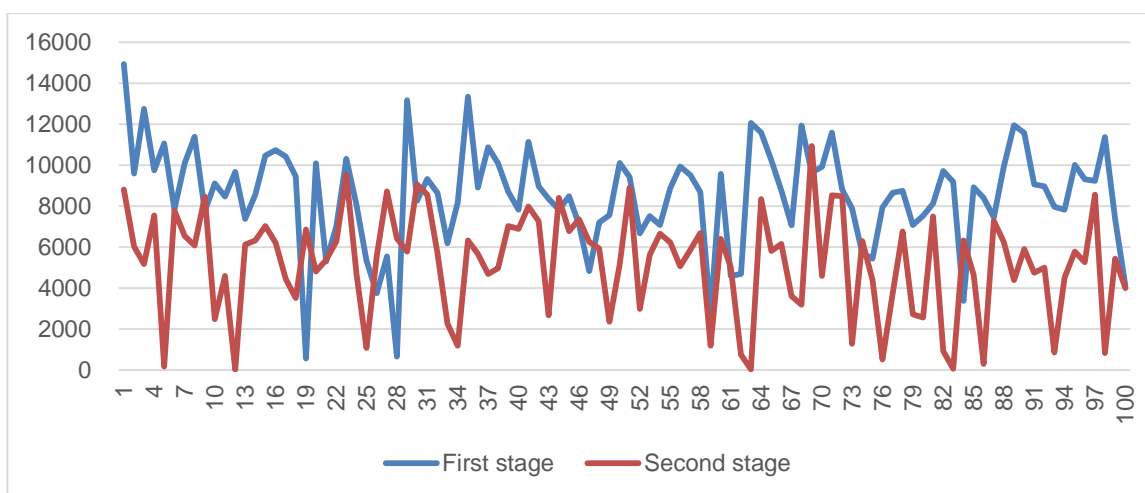| Returning to School on Time Rate | Number of Times the Students Returned to School on Time | Number of Students | Proportion |
|---|---|---|---|
| ≥ 75% | 12-16 | 9 | 7% |
| 50%-75% | 8-11 | 36 | 27% |
| 25%-50% | 4-7 | 28 | 21% |
| < 25% | 0-3 | 60 | 45% |

Figure B.1 Distribution table of exercise steps and grade ranking in two stages (top 100 with steps records)
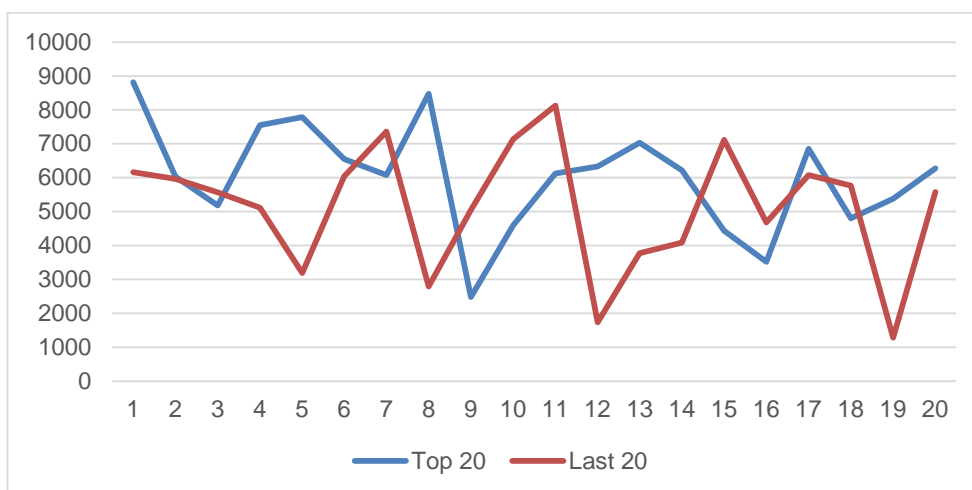


Figure B.2 Comparison of daily average steps of top 20 and last 20 students (with steps recorded) during the second stage
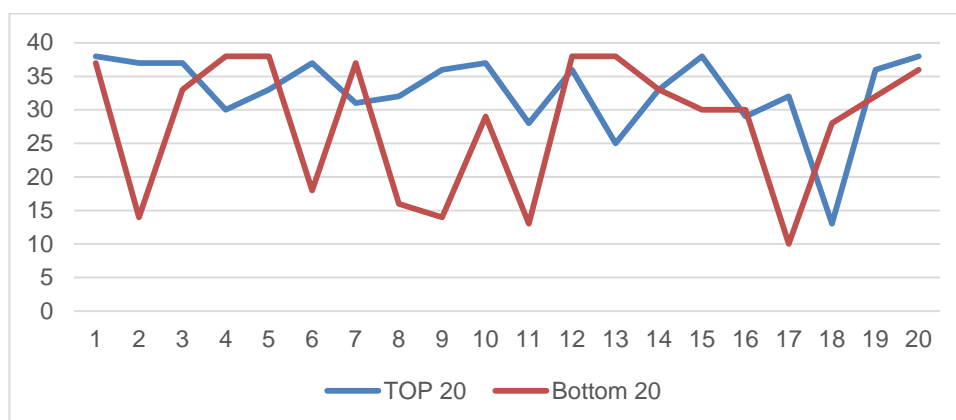


Figure B.3 Comparison of wearing days of top 20 and last 20 students (with wearing records) bracelets during the first stage
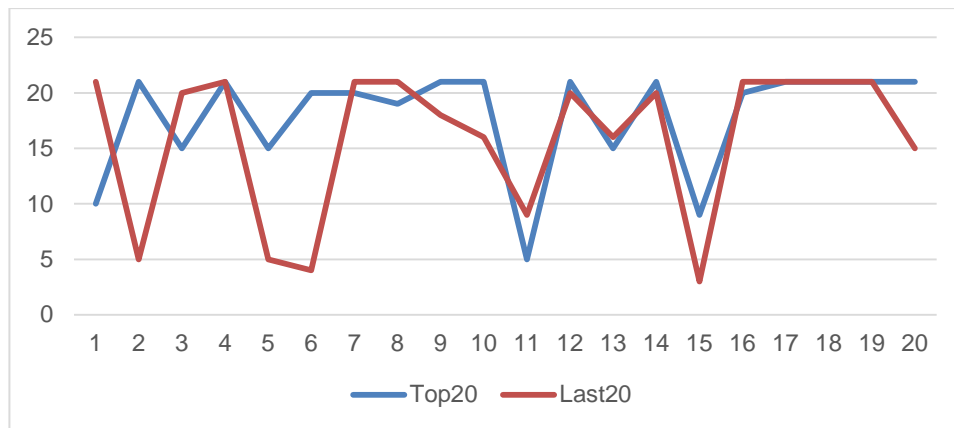
Figure B.4 Comparison of wearing days of top 20 and last 20 students (with wearing records) bracelets during the second stage

# Annex C

Table C.1 Work Hours at Five Tianli Schools Before the Epidemic

| Schoo l Dis- tricts | Par- tici- pants | Log Day s | Total Du- ration (minutes) | Per Capita Daily Hours | | | | Per Capita Daily Hours at Tianli's Schools |
|---|---|---|---|---|---|---|---|---|
| | | | | Kin- dergar- ten | Prima- ry School | Junior High School | High School | |
| LZ | 42 | 849 | 512,148 | 10.21 | 9.66 | 9.35 | 10.91/10.51 | 10.05 |
| YB | 24 | 415 | 225,872 | 9.32 | 8.03 | 9.24 | 9.61/9.34 | 9.07 |
| GY | 26 | 291 | 191,456 | - | 11.07 | 9.96 | 11.02/10.79 | 10.60 |
| DY | 27 | 478 | 290,930 | - | 10.03 | 9.95 | 10.09/9.71 | 10.09 |
| ZY | 24 | 310 | 166,005 | - | 8.14 | 8.85 | 9.63/9.06 | 8.93 |
| Total | 143 | 2343 | 1,386,501 | 9.76 | 9.39 | 9.47 | 10.25/9.86 | 9.86 |

Note: Statistics for subjects taught on Saturday and Sunday are excluded (statistics after slashes indicate hours for teachers in senior high schools with weekends included.)

Table C.2 Work Hours at Five Tianli Schools After the Epidemic

| School Districts | Partic- ipants | Log Days | Total Du- ration (minutes) | Per Capita Daily Hours | | | | Per Capita Daily Hours at Tianli's Schools |
|---|---|---|---|---|---|---|---|---|
| | | | | Kin- dergar- ten | Prima- ry School | Junior High School | High School | |
| LZ | 40 | 901 | 388,796 | 6.70 | 6.98 | 9.34 | 10.01/9.69 | 7.19 |
| YB | 22 | 177 | 69,007 | 4.77 | 7.10 | 6.08 | 8.45/8.19 | 6.50 |
| GY | 26 | 33 | 20,267 | - | 10.64 | 9.44 | 10.48/10.29 | 10.24 |
| DY | 23 | 107 | 49,987 | - | 5.43 | 6.32 | 7.91/7.63 | 7.78 |
| ZY | 24 | 242 | 121,956 | - | 6.51 | 8.52 | 8.39/8.02 | 8.40 |
| Total | 135 | 1460 | 650,013 | 5.74 | 7.33 | 7.94 | 9.05/8.74 | 7.42 |

Note: Numbers after slashes refer to hours at high schools with weekends included.

# Annex D

Table D.1 The Tasks of Teachers Focused Only on Teaching in Primary Schools

| School District | Average Teaching Experience (years) | Teaching Hours Per Week | Top Three Tasks (%) | | | Average Work Hours Per Day |
|---|---|---|---|---|---|---|
| Luzhou | 10 | 25.6 | Teaching Classes 28.88 | Homework Grading 16.79 | Meetings 14.02 | 7.63 |
| Yibin | 12 | 24 | Lesson Planning 36.25 | Teaching Classes 24.01 | Meetings 8.23 | 6.61 |

Table D.2 The Tasks of Teachers Focused Only on Teaching in Junior High Schools

| School District | Average Teaching Experience (years) | Teaching Hours Per Week | Top Three Tasks (%) | | | Average Work Hours Per Day |
|---|---|---|---|---|---|---|
| Yibin | 21 | 28 | Teaching Classes 33.07 | Lesson Planning 18.62 | Homework Grading 15.95 | 7.73 |
| Guangyuan | 5 | 20 | Teaching Classes 34.3 | Lesson Planning 15.02 | Homework Grading 13.05 | 8.73 |
| Zunyi | 7.5 | 16.25 | Monitoring Independent Study 22.50 | Lesson Planning 18.27 | Teaching Classes 16.95 | 9.09 |

Table D.3 The Tasks of Teachers Focused Only on Teaching in High Schools

| School District | Average Teaching Experience (years) | Teaching Hours Per Week | Top Three Tasks (%) | | | Average Work Hours Per Day |
|---|---|---|---|---|---|---|
| Guangyuan | 6 | 16 | Teaching Classes 35.06 | Lesson Planning 21.16 | Homework Grading 12.5 | 8.6 |
| Zunyi | 10 | 15.25 | Lesson Planning 27.94 | Teaching Classes 18.76 | Supervising Exams 15.56 | 7.9 |

Table D.4 The Faculty Structure at Pilot High Schools

| School District | New Teachers | Experienced Teachers | Veteran Teachers | PT-Teachers |
|---|---|---|---|---|
| Luzhou | 10.03 | 55.26 | 11.40 | 22.81 |
| Yibin | 3.90 | 40.26 | 31.17 | 24.68 |
| Guang-yuan | 22.37 | 31.58 | 5.26 | 40.79 |
| Deyang | 24.59 | 32.79 | 14.75 | 27.87 |
| Zunyi | 7.70 | 57.70 | - | 34.60 |

Table D.4 The Faculty Structure at Pilot High Schools
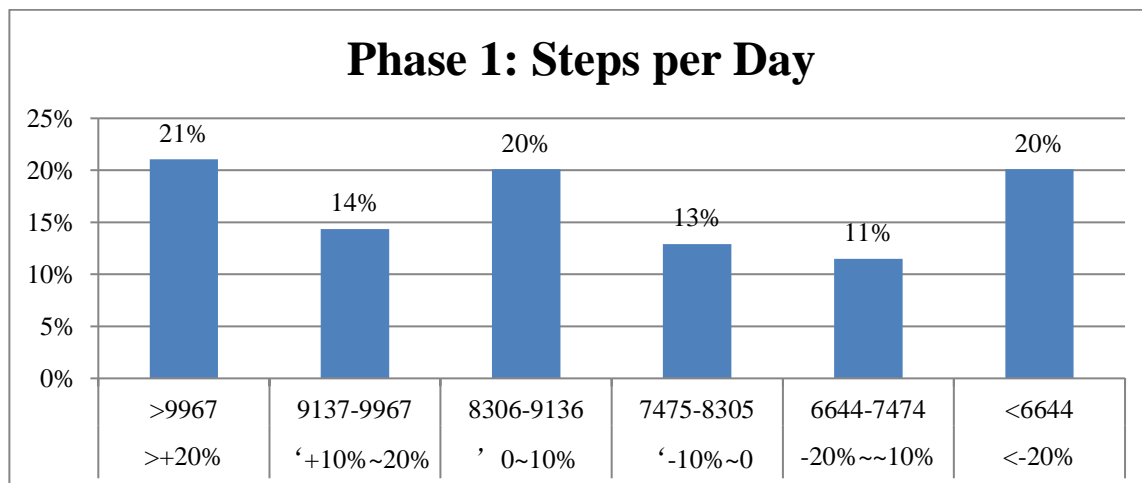
# Annex E



Figure E.1 The Distribution of Daily Steps in Phase I

Source: Experimental Statistics (See Table B.3 for more information)



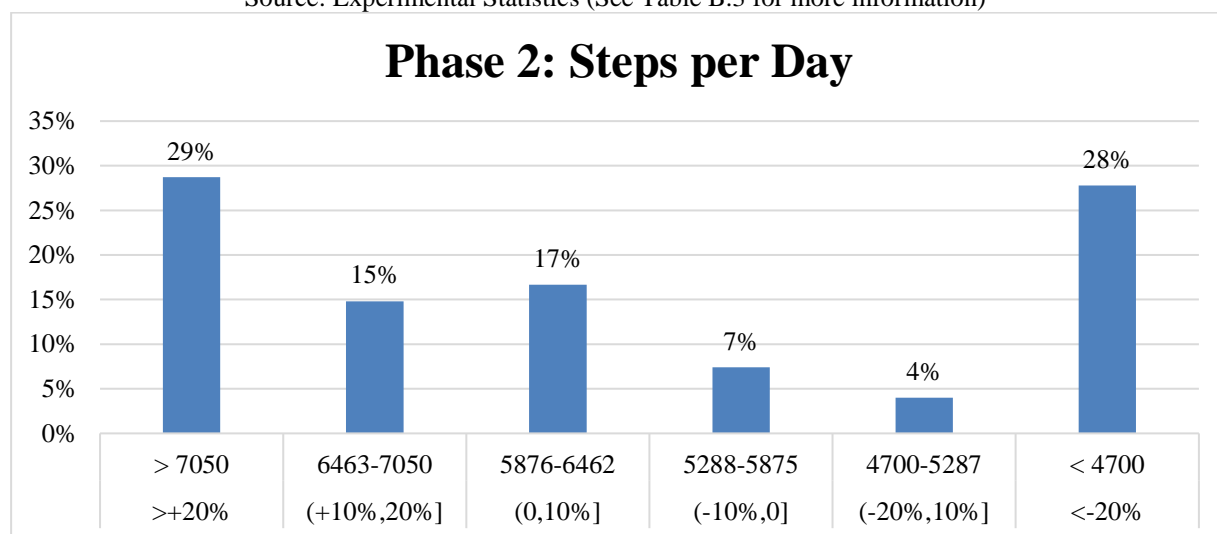Figure E.2 The Distribution of Daily Steps in Phase II

Source: Experimental Statistics (See Table B.4 for more information)

Figure E.3 The App Interface for Raw Teacher Work Log Data

# Annex F

Table F.1 The Members and Duties of the Job Structure Optimization and Innovation Group

| Assignment | Member | Duty |
|---|---|---|
| Team Chief | CEO & Chief Schoolmaster | Carry out overall management, provide guidance to the project innovation team and approve of and make decisions on projects |
| Vice Team Chief | Vice Chief Schoolmaster | Evaluate the standards and results of projects |
| Executive Team Chief | HRO | Implement work plans, assist the team leader in carrying out project innovation team tasks, organize regular team meetings, carry out investigations at schools and evaluate projects |
| Members | Group HR and HR Principals at Pilot Schools | Based on the specific conditions of the schools, support the executive team leader in investigating schools, participate in project research, be responsible for the collection, analysis and summary of HR data at schools, collect suggestions for projects, provide suggestions and solutions for the optimization of job arrangements according to group strategies, work goals and the duties of various positions at the relevant schools |