北京师范大学智慧学习研究院
Smart Learning Institute of Beijing Normal University

2018 Technology Outlook for Chinese Vocational Education

A Horizon Project Report

Key Trends Accelerating Technology Adoption in Chinese Vocational Education

Short-Term Trends: Driving technology adoption in Chinese Vocational Education over the next one to two years

- Promoting Informatization in Vocational Education
- Increasing Use of Blended Learning Designs
- Proliferation of Open Educational Resources

Mid-Term Trends: Driving technology adoption in Chinese Vocational Education over the next three to five years

- Shift to Deep Learning Approaches
- Redesigning Learning Spaces
- Rise of New Forms of Interdisciplinary Studies

Long-Term Trends: Driving technology adoption in Chinese Vocational Education for five or more years

- Shift from Students as Consumers to Creators
- Advancing Cultures of Change and Innovation
- Rethinking How Schools Work

Significant Challenges Impeding Technology Adoption in Chinese Vocational Education

Solvable Challenges: Those which we both understand and know how to solve

- Discrimination against China Vocational Education in Society
- EdTech and Evolving Roles of Faculty
- Creating Authentic Learning Opportunities

Difficult Challenges: Those we understand but for which solutions are elusive

- Keeping Formal Education Relevant
- Blending Formal and Informal Learning
- Personalizing Learning

Wicked Challenges: Those that are complex to even define, much less address

- Sustaining Innovation through Leadership Changes
- Scaling Evidence-Based Methods Across Disciplines
- Facilitating Discovery of Effective Learning Technologies

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Time-to-Adoption Horizon: One Year or Less

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- Flipped Classroom
- Micro Lessons
- Online Learning

Time-to-Adoption Horizon: Two to Three Years

- Virtual Reality, Augmented Reality & Mixed Reality
- Mobile Learning
- Cloud Computing
- Learning Analytics & Adaptive Learning

Time-to-Adoption Horizon: Four to Five Years

- Next Generation LMS
- Artificial Intelligence
- Virtual and Remote Laboratories
- Information Visualization

2018 2019 2020 2021 2022

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Executive Summary

The *2018 Technology Outlook for Chinese Vocational Education: A Horizon Project Report* reflects a collaborative research effort between the New Media Consortium (NMC) and the Smart Learning Institute (SLI) of Beijing Normal University to inform Chinese vocational college leaders and decision-makers about the significant developments in technologies supporting teaching, learning, and creative inquiry in higher education institutions across the country. Due to unexpected changes in leadership and funding at NMC, the report writing process is completed solely by SLI. Nevertheless, this project adheres to the research design as advanced by NMC and the data collection process is a joint effort of NMC and SLI.

The research underpinning the report makes use of the rigorous Delphi-based process for bringing groups of experts to a consensus, in this case around the impact of emerging technologies on Chinese vocational education over the next five years. The same process underlies the well-known NMC Horizon Report series, which is the most visible product of an on-going research effort begun more than 15 years ago to systematically identify and describe emerging technologies likely to have a large impact on education around the globe.

The 2018 Technology Outlook for Chinese Vocational Education was produced to explore emerging developments in technology and forecast their potential impact expressly in a Chinese vocational education context. In the effort that took place from August through October 2017, a selected panel of esteemed experts was asked to consider a host of relevant articles, news, blog posts, research, and project examples and ultimately pinpointed the most notable technology topics, trends, and challenges for Chinese vocational colleges over the next five years.

Known as the 2018 Horizon Project China Expert Panel, that group of thought leaders consists of knowledgeable individuals, all highly regarded in their fields. Collectively, the panel represents a range of diverse perspectives across the higher education sector. The project has been conducted under an open data philosophy, and all the interim products, secondary research, discussions, and ranking instrumentation can be viewed at china.nmc.org. The precise research methodology employed in producing the report is detailed in a special section found at the end of this report.

Nine key trends, nine significant challenges, and twelve important developments in educational technology were identified by the expert panel. The trends and challenges are intended to frame technology adoption in terms of the positive paradigm shifts advancing it and the obstacles impeding it. These influential discussions acknowledge that technology by itself is not a sufficient solution but instead an enabler of more effective teaching and learning approaches. Technology use must be grounded in progressive pedagogies and models that foster greater student engagement and performance. Both the trends and the challenges are placed into horizons; the trends range from long- to short-term while the challenges are classified by scope of difficulty (solvable, difficult, and wicked).

Each of the twelve developments in technology is profiled on a single page that describes the topic and categorises it as very important for Chinese vocational colleges over the next year, two to three years, or four to five years. Every page opens with a carefully crafted definition of the highlighted development, outlines its educational relevance, points to some real-life examples of its current use, and ends with a short list of additional readings for those who wish to find out more.

Taken together, the three key sections of this report constitute a reference and straightforward technology planning guide for educators, vocational college leaders, administrators, policymakers, and technologists. It is our hope that this research will inform the choices that colleges are making about technology to improve, support, or extend teaching, learning, and creative inquiry in China.

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Introduction

The *2018 Technology Outlook for Chinese Vocational Education: A Horizon Project Report*, although similar in term of research design, this project is exclusive from previous NMC Horizon Project series. The previous projects mainly focused on the context of higher education, K-12 education, museum, and library. This is the first horizon research project that specifically explores emerging educational technology trends and uptakes in vocational education using systematic and rigorous research method.

China's vocational education has a unique system consists of junior, secondary and higher vocational education which functions as a linked educational pathway, and connects to general and adult education, providing both school education and vocational trainings. Junior vocational education refers to three or four years of basic vocational and technical training after primary education. It is equivalent to lower secondary education, and is a part of the 9-year compulsory education. In order to meet the demand of labour forces for the development of rural economy, junior vocational schools are mainly located in rural areas. Secondary vocational education is a three-year vocational schooling system similar to the senior high school stage. Students enrolled in secondary vocational schools are junior high school graduates or equivalent. Higher vocational education is a two- to four-year schooling system that teach professional knowledge and provide vocational trainings. Higher vocational schools or vocational colleges (use interchangeably) usually recruit high school and secondary vocational graduates.

In August 2017, the statistics released by the Ministry of Education of the People's Republic of China showed that there are a total of 12,300 of vocational colleges and schools, 9,307,800 new enrolments, and 26,802,100 students[1] in which (i) 1,359 of them are higher vocational schools with 3,432,100 new enrolments, 10,828,900 students and 3,298,100 graduates; (ii) 10,893 of them are secondary vocational schools with 5,933,400 new enrolments, 15,990,100 students and 5,336,200 graduates.[2] [3] Vocational graduates have a high employment rate in which the employment rate of higher vocational graduates is more than 90% and the employment rate of secondary vocational graduates is more than 95% for ten consecutive years. They are highly skilled workforce contributing to China's economic growth. Approximately 70% of the graduates are employed to support the development of small and medium-sized enterprises, regional industries, manufacturing industries, emerging industries and service industries.[4] [5]

In response to China's national policies for vocational education – "National Model Vocational College Construction Plan" and "Construction Plan for Reform and Development of National Secondary Vocational Education" – the central government provided support in establishing 200 vocational colleges and 1000 secondary vocational schools. Additionally, the Ministry of Education will be supporting local establishment of 200 quality vocational colleges in 2018. Despite the construction plans, vocational education informatization is also emphasized in China's policies. According to "Education Informatizaton 13th Five Year Plan", "Vocational College Digital Campus Construction Regulations" and "Guidelines on Promoting ICT Development of Vocational Education", vocational education informatization needs to take into account the economic and social development in China, as well as industry and regional characteristics; using these considerations to develop appropriate information technology integrated teaching model and improve the education system to realize modernization of vocational education in China.

Due to the unique features of Chinese vocational education, the terms "vocational college" and "vocational school" are often used in association to different level of vocational education. Despite the name of vocational colleges and schools, the term "vocational college(s)" is used in general to indicate both college(s) and school(s).

Nine key trends, nine significant challenges, and twelve developments in educational technology profiled in this report are poised to impact Chinese vocational education. The topics converge in ways that tell a larger story about the state of teaching and learning across the country. These ten highlights capture the big picture themes of educational change that are unique to Chinese Vocational Education:

1. Holo-media materials, online learning, micro lesson and flipped classroom are expected to popularize in vocational education within one year. This trend indicates that vocational colleges give more emphasis to the development of digital teaching resources, diverse forms of teaching and learning resources, and continuous exploration of ICT-based teaching approach. These are associated with substantial support on program and course development in vocational colleges.

2. Technologies such as virtual, augmented and mixed reality and cloud computing are bound to become pervasive in vocational colleges in the next two to three years. Intelligent technologies such as artificial intelligence and information visualization would be adopted over the next four to five years. The findings are consistent with the development trends of artificial intelligence technology and smart era.

3. Promoting informatization in vocational education, proliferation of open educational resources, and increasing use of blended learning design are short-term trends of educational technology adoption in vocational education. These outcomes are in line with the 13th Five-Year development plan for the informatization of vocational education which indicates that the associated policies and strategies have been effectively promoted.

4. Redesigning learning spaces, shifting to deep learning approaches and rise of new forms of interdisciplinary studies are the trends driving vocational education informatization over the next three- to five- year trends, while the shift of students as consumers to creators, advancing culture of change and innovation, and rethinking how schools work would gradually become the trends for vocational education informatization over the next five years or more. These trends are consistent with the trends of education informatization for the K-12 sector and higher education.

5. Creating authentic learning opportunities, edTech and evolving roles of faculty, and discrimination against China vocational education in society are considered as solvable challenges for educational technology adoption in Chines vocational education. Based on the future directions and strategies for the development of vocational education, the former is consistent with the actual situation of vocational education while the latter two are considered as conflicting with the actual situation of vocational education which deserves further study.

6. Since the "13th Five-Year Plan" was put into practice, digital campuses and smart campuses for vocational education are gradually spreading across China. In addition, information technology and digital resources have also been employed more frequently. These aid in improving technology skills and technology integrated teaching skills.

7. Over the past thirty years, penetration of the concept of "work-integrated learning" and the accumulated experience in "school-enterprise cooperation" have driven the "integration of industry with vocational schools" in some areas in China, especially in the industry associated with information and communication technology such as electronics and computer, networking and communications, and intelligent manufacturing. The development of regional economy and vocational colleges are complementary to each other, leading to mutual benefits.

8. Following the progress of 13th Five-Year Plan for education informatization, the strategic arrangement for vocational education informatization is taking its initial shape. The proliferation of digital resources and the popularization of online learning spaces, to some extent, have promoted the development of vocational education as well as the shift in learning approaches.

9. The disparities of the regional economic and social growth have led to imbalanced development of vocational colleges. Informatization facilitates the sharing of and staying informed with the vocational education philosophy, promoting the co-construction and sharing of quality educational resources and innovative teaching model which in turn, to some extent, promoting a much more balanced regional development.

10. As proposed by "European Industry 4.0" and "Made in China 2025", technology such as VR and artificial intelligence would develop faster in technical and vocational education training in comparison to K-12 education and higher education to meet the needs of emerging industrial development.

The work of the 2018 Horizon Project China Expert Panel acknowledges that technology adoption in vocational colleges across the country can be accelerated by trends in policy, practice, and leadership. Similarly, a number of challenges are impeding the proliferation of digital tools, and the panel identified a set of significant challenges that reflects the current obstacles facing Chinese vocational education over the next five years. The top-selected trends and challenges are included in the related tables in this summary, and are organized by categories described in the next sections of this report.

The tables illustrate the choices of the Chinese experts in the field of vocational education compared with those who contributed to the *2017 NMC Technology Outlook for Chinese Higher Education* with perspectives on technology impact in Chinese universities, and the *NMC Horizon Report > 2017 Higher Education Edition*, which looked at technology uptake from a global perspective. As vocational education and higher education both offer qualifications that are nationally and often internationally recognized, the comparison of these reports provide interesting perspectives within China and beyond China. Altogether, the three reports encompass a group of 276 acknowledged experts, with 112 Chinese vocational education experts, 85 Chinese higher education experts, and 79 international experts.

Overall, there are certain similarities or overlaps in key trends in Chinese Vocational Education and Chinese Higher Education that are as expected. Substantial similarities are also found between trends in Chinese Vocational Education and the Higher Education. Table 1 depicts the top ranked trends in those three reports. When one examines all the key trends, the similarities increase. For example, blended learning designs is a key short-term trend in all three reports. Moreover, advancing cultures of innovation and students as creators are also very similar in terms of emphasis. It is also interesting to note differences in time horizons among the common trends found in these three reports. Open educational resources appears as a short term trend in all three reports, although ranked differently. On the other hand, deep learning approaches is a top-ranked mid-term trend in this report but emphasized differently in the other reports – for example, it is a lower-ranked long-term priority in the 2017 Chinese Higher Education Report.

Table 1: Top-Selected Trends across Three Horizon Research Projects

2017 Technology Outlook Higher Education Edition	2017 Technology Outlook Chinese Higher Education	2018 Technology Outlook Chinese Vocational Education
Short-Term Trend		
Blended Learning Designs	Increasing Use of Blended Learning Designs	Promoting Informatization in Vocational Education
Collaborative Learning	Proliferation of Open Educational Resources	Increasing Use of Blended Learning Designs
	Rise of STEAM Learning	Proliferation of Open Educational Resources
Mid-Term Trend		
Growing Focus on Measuring Learning	Increasing Cross-Institution Collaboration	Shift to Deep Learning Approaches
Redesigning Learning Spaces	Redesigning Learning Spaces	Redesigning Learning Spaces
	Rethinking How Institutions Work	Rise of New Forms of Interdisciplinary Studies
Long-Term Trend		
Advancing Cultures of Innovation	Advancing Cultures of Innovation	Shift from Students as Consumers to Creators
Deeper Learning Approaches	The Rise of Coding as Literacy	Advancing Cultures of Change and Innovation
	Shift to Deep Learning Approaches	Rethinking How Schools Work

In addition, it is worth noting internal consistency within the Chinese Report on Vocational Education across the time horizons. For example, the long-term trend emphasizing students as creators rather than as consumers builds on and is consistent with the mid-term trends of redesigning learning spaces and emphasizing interdisciplinary studies, which in turn build on and are consistent with promoting informatization, increasing use of blended learning designs, and the proliferation of open education resources.

Similarities in challenges among the three reports is not immediately evident in Table 2. However, a closer look does reveal some similarities as well as differences. For example, blending formal and non-formal learning is a top-ranked priority in terms of a solvable challenge in the Chinese Higher Education report but appears as a top-ranked priority as a difficult challenge in this report.

With regard to challenges, it is perhaps the differences that are mostly striking among these three reports. The wicked challenges in Chinese vocational education are (a) sustaining innovation, (b) scaling evidence-based methods, and (c) facilitating discovery of effective learning technologies. These wicked challenges build upon the difficult challenges (keeping formal education relevant, blending formal and non-formal learning, and personalizing learning), which in turn build upon the solvable challenges (discrimination against Chinese vocational education, evolving roles of faculty, and creating authentic learning environments). That internal consistency lends a fair amount of credence to the findings in this report. In addition, one can easily find similar challenges in other NMC reports and other regions and domains. The changing roles of faculty, for example, has been cited in many NMC reports.

Table 2: Top-Selected Challenges across Three Horizon Research Projects

2017 Technology Outlook Higher Education Edition	2017 Technology Outlook Chinese Higher Education	2018 Technology Outlook Chinese Vocational Education
Solvable Challenge		
Improving Digital Literacy	Blending Formal and Non-formal Learning	Discrimination against China Vocational Education in Society
Integrating Formal and Informal Learning	Improving Digital Literacy	EdTech and Evolving Roles of Faculty
	Integrating Technology in Teacher Education	Creating Authentic Learning Opportunities
Difficult Challenge		
Achievement Gap	Managing Big Data in Education	Keeping Formal Education Relevant
Advancing Digital Equity	Personalizing Learning	Blending Formal and Informal Learning
	Scaling Teaching Innovations	Personalized Learning
Wicked Challenge		
Managing Knowledge Obsolescence	Balancing Connected and Unconnected Life	Sustaining Innovation through Leadership Changes
Rethinking the Roles of Educators	Rethinking the Roles of Educators	Scaling Evidence-Based Methods Across Disciplines
	Teaching Complex Thinking	Facilitating Discovery of Effective Learning Technologies

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Fuelled by the key trends and impeded by significant challenges selected by the panel, the 12 important developments in technology presented in the body of this report reflect the experts' opinions as to which of the nearly 50 technology developments considered will be most important to Chinese vocational education over the five years following the publication of the report.

Table 3: Comparison of Top-Selected Technology Topics across Three Horizon Research Projects

2017 Technology Outlook Higher Education Edition	2017 Technology Outlook Chinese Higher Education	2018 Technology Outlook Chinese Vocational Education
Time-to-Adoption Horizon: One Year or Less		
Adaptive Learning Technologies	Flipped Classroom	Holo-media Materials
Mobile Learning	Makerspaces	Flipped Classroom
	Massive Open Online Courses	Micro Lessons
	Mobile Learning	Online Learning
Time-to-Adoption Horizon: Two to Three Years		
The Internet of Things	Augmented & Virtual Reality	VR, AR & MR
Next Generation LMS	Learning Analytics & Adaptive Learning	Mobile Learning
	Quantified Self	Cloud Computing
	Virtual & Remote Laboratories	Learning Analytics & Adaptive Learning
Time-to-Adoption Horizon: Four to Five Years		
Artificial Intelligence	Affective Computing	Next Generation LMS
Natural User Interfaces	Machine Learning	Artificial Intelligence
	Robotics	Virtual and Remote Laboratories
	Volumetric & Holographic Displays	Information Visualization

A comparison of the top technology topics across these three reports is also revealing. Again one can find similarities and differences among topics/technologies and time horizon. For example, flipped classroom shows up as a top–ranked one-year or less horizon topic/technology in this report as well as in Chinese Higher Education Report. One then expects see emphasis on changing roles of instructors in those reports to establish the consistency of the report, which is the case with Chinese Vocational Education report. Not surprisingly, all of the reports emphasize emerging technologies such as artificial intelligence, AR, VR, mobile technologies and so on, although not always in the same time horizon.

Finally, it is worth examining the internal consistency of this and other NMC reports as well as revisiting these report over time as technologies, practices, and policies do change. One truth to keep in mind is that technologies change – they change what people do, what people can do, what people will want to do, and in some cases what people will want to avoid doing. Technologies change and the hope is that the changes are progressing in positive and productive directions, which is why these Horizon Reports are valued so highly.

Key Trends Accelerating Technology Adoption

The technology developments featured in the Horizon Project are embedded within a contemporary context that reflects the realities of the time, both in the sphere of education and in the world at large. To assure this perspective, each panel member has researched, identified, and ranked key trends that are currently affecting teaching, learning, and creative inquiry in Chinese vocational education, and used these as a lens for the work of predicting the uptake of emerging technologies. These nine trends, which the panel agreed are very likely to drive technology planning and decision-making over the next five years, are sorted into three time-related categories: short-term trends that will last for the next one to two years and are bound to become pervasive in institutions, and two categories of slower trends that are growing more incrementally.

Short-Term Trends

Driving technology adoption in Chinese Vocational Education over the next 1-2 years

Promoting Informatization in Vocational Education. The advent of computers, multimedia, and the Internet have ushered in the information era, leading to the widespread use of information technology. Education informatization has a significant role in promoting vocational education reform.[6] The use of information technology could facilitate the transformation of traditional education methods, improve the quality of vocational education, and realize vocational education modernization. The official document – Guidelines on Promoting the Development of Vocational Education Informatization – released by China's Ministry of Education indicates the need to increase the application of new technologies (e.g., big data, Internet of Things) in vocational education.[7] Shanghai Electric Power Industrial School strives to establish a "smart campus" that utilizes technology to create systems, services and school structures that will enhance students' learning and campus life.[8]

Increasing Use of Blended Learning Designs. Perceptions of online learning have been shifting in its favor as more learners and educators see it as a supplement to some forms of face-to-face learning. Drawing from best practices in both online and face-to-face methods, blended learning is on the rise at Chinese vocational colleges. The Road and Bridge profession of Hunan Communication Polytechnic combines classroom teaching with live teaching to achieve real-time interaction between classroom and the construction site.[9]

Proliferation of Open Education Resources. Defined by UNESCO, open educational resources (OER) are "teaching, learning and research materials in any medium – digital or otherwise – that reside in the public domain or have been released under an open license that permits no-cost access, use, adaptation and redistribution by others with no or limited restrictions."[10] OER open up opportunities for knowledge sharing and creation in Chinese vocational colleges, promoting pedagogical innovation and access to quality education. The Higher Education Press is operating "Smart Vocational Education", an online platform which shares digital educational resources and combines Massive Open Online Course (MOOC) and Small Private Online Course (SPOC) to support teaching and learning in vocational education.[11]

Mid-Term Trends

Driving technology adoption in Chinese Vocational Education over the next 3-5 years

Shift to Deep Learning Approaches. There is a growing emphasis in vocational education on deep learning approaches,[12] defined by the William and Flora Hewlett Foundation as the mastery of content that engages students in critical thinking, problem-solving, collaboration, and self-directed learning. Deep learning methods aim to foster active learning experience, ensuring students are able to make clear connections between the curriculum and the real world. Nanjing Jiaotong Vocational and Technical College employs the CRH vehicle simulation system which utilizes the 3D virtual technology to inspire students' enthusiasm in learning, engage them in deeper learning.[13]

Redesigning Learning Spaces. It is believed that new forms of teaching and learning require new spaces. As Chinese vocational education continues to move away from traditional, lecture-based lessons toward more hands-on, active learning methods, rearranging learning environment is necessary to facilitate organic interactions and cross-disciplinary work. WorldUC employs cloud computing technology to create a learning space where vocational colleges can utilize this learning space to carry out teaching and learning activities.[14]

Rise of New Forms of Interdisciplinary Studies. The continuous evolvement of technology opens up the opportunities for interdisciplinary collaboration and serves as a catalyst for innovation in Chinese vocational education. Interdisciplinary studies aim to synthesize knowledge, skills, and perspectives of two or more academic disciplines to foster learners' creativity, critical thinking skills, and communication skills. Nanning Vocational and Technical College strengthens the development of its teaching team to promote a multidisciplinary education model for ideological and political course.[15]

Long-Term Trends

Driving technology adoption in Chinese Vocational Education over the next 5 or more years

Shift from Students as Consumers to Creators. Following the concepts and practice of innovation and entrepreneurship in China, the role of students as a creator is being emphasized. Chinese vocational colleges should embrace maker education which stresses learner-driven experience in association to authentic problems, leading to independence, creative problem solving and connections to real world settings. The maker education is a shift from spoon-fed education to constructivist pedagogical approach, encouraging students to create and innovate. Integration of multi-disciplinary knowledge is necessary in maker education to realize the transformation of students from consumers to creators. Nanjing Electromechanical Vocational and Technical College is exploring a new model for talent training which is capable of integrating both maker education and vocational education.[16]

Advancing Cultures of Change and Innovation. Chinese vocational colleges play an increasingly important role in the growth of national economies. In order to promote innovation and support the economic development, vocational colleges must be structured in ways that allow for flexibility while spurring creativity and entrepreneurial thinking. As vocational education is closely related to the industrial development, continuous development in vocational education is important to adapt to the constantly changing industry, and meet the needs for economic and social development. Thus, advancing culture of change and innovation are critical in vocational education to make contributions to the economic and social development.

Rethinking How Schools Work. The continuous development of innovative teaching and learning approaches in vocational education is driving the movement to reinvent vocational education system to foster talents who can meet the needs of changing society and industry. The Ministry of Education of People's of Republic of China has published "Guidelines for the Construction of Digital Campus in Vocational Colleges" to promote informatization in vocational education including high-speed networks, information and communication technology infrastructure, and resource sharing platform to close education gap.[17] Vocational colleges are responsible in generating graduates who are equipped with knowledge and skills which fulfil the society and industry demands.

Significant Challenges Impeding Technology Adoption

Along with the trends discussed in the preceding section, the expert panel noted a number of significant challenges faced in Chinese vocational education that are impeding the uptake of emerging technologies. Because not all challenges are of the same scope, the discussions here are sorted into three categories defined by the nature of the challenge. The Horizon Project defines solvable challenges as those that we both understand and know how to solve; difficult challenges are ones that are more or less well understood, but for which solutions remain elusive. Wicked challenges, the most difficult, are categorised as complex to even define, and thus require additional data and insights before solutions will be possible.

Solvable Challenges

Those that we both understand and know how to solve

Discrimination against China Vocational Education in Society. There has been long-standing discrimination against vocational education in Chinese society. The widespread stereotypes suggest that vocational students are underachievers or come from economically disadvantaged families. In fact, the assessment of vocational skills is as rigorous as academic assessment, and vocational graduates are in high demand in the job market. These obsolete conceptual barriers need to be addressed to recognize the value of vocational education. Yunnan Institute of Transportation created a "craftsman qualification" system with reference to the higher education system. This system is a new breakthrough which helps to enhance students' self-confidence while improving the quality of vocational education.[18]

EdTech and Evolving Roles of Faculty. The advancement of technology in education (e.g., adaptive technology platforms and online learning tools) is altering the traditional model of teaching and learning such as access to the learning materials, student-content-teacher interaction and instructional design. The adoption of educational technologies requires the transformation of teachers' role and associated technology skills. Despite learning and mastering educational technology skills, teachers need to continuously consider the effectiveness of technology integration in teaching that can optimize student learning and tailor to their learning needs.

Creating Authentic Learning Opportunities. Vocational education emphasizes the connection between students' learning in school/colleges and the real-life working situation. Authentic learning is a pedagogical approach which allows learners to explore, discuss and construct concepts in relation to the real-life context.[19] Authentic learning can help learners to establish such connection to better prepare them for future real-life working situation. Harbin Vocational and Technical College has established a VR integrated welding training environment which employs a variety of technologies to facilitate learning, and provide collaborative and personalized learning opportunities to enhance students' learning interest and outcome.[20]

Difficult Challenges

Those we understand but for which solutions are elusive

Keeping Formal Education Relevant. Chinese vocational graduates are still facing the challenges of meeting the employment criteria, as they are not prepared to cope with the work demand and employers often emphasizes academic qualifications in addition to professional skills. According to China's policy on the "Decision of the State Council on Accelerating the Development of Modern Vocational Education", there is need to link curriculum and pedagogy of vocational education to the employment requirements of relevant professions and industries.[21] E-campus Learning Platform, also known as the "Micro-Knowledge Database" consists of courses that can meet the industry standards and satisfy the job requirements while providing both academically and vocationally qualified certificate in order to strengthen graduates' employability.[22]

Blending Formal and Informal Learning. As the Internet has brought the ability to learn about almost anything to the palm of one's hand, there is an increasing interest in the kinds of self-directed, curiosity-based learning. These, along with life experience and other more serendipitous forms of learning, fall under the banner of informal learning, inspiring students to follow their own learning pathway. Vocational colleges have not yet been able to incorporate such experiences across their courses and programs at scale, though many experts believe that a blending of formal and informal methods of learning can create an environment that fosters experimentation, curiosity, and above all, creativity. In this sense, an overarching goal is to cultivate the pursuit of lifelong learning in all students and faculty. However, methods of formally acknowledging and rewarding skills both students and faculty master outside of the classroom are compounding this challenge. The National Open University has established an online learning platform for secondary vocational education, enabling students to learn without time and space constraints.[23]

Personalizing Learning. Personalized learning refers to the range of educational programs, learning experiences, instructional approaches, and academic support strategies intended to address the specific learning needs, interests, aspirations, or cultural backgrounds of individual students. Although technological advances in vocational education have made personalized learning possible, it is not adequately supported by current technology or practices especially many of them – such as adaptive learning artificial intelligent systems – have only recently begun to emerge. Compounding the challenge is the notion that technology is not the whole solution but personalized learning efforts must incorporate effective pedagogy and include faculty in the development process.

Wicked Challenges

Those that are too complex to even be defined, and much less addressed

Sustaining Innovation through Leadership Changes. Sustainability for long-term success is a vital consideration when developing a new program, especially as external factors such as funding and leadership are prone to change. Planning for and implementing innovative approaches to prepare student for success at vocational colleges requires dedication from leadership, faculty, and staff. Unfortunately, leadership vacancies or transitions can result in project delays or hinder the development and growth of programs to effectively meet student needs. Therefore, it is important to develop effective strategies that can ensure sustainable innovation through leadership change.

Scaling Evidence-Based Methods across Disciplines. Evidence-based methods for learning refer to practices that have fostered improved learning outcomes, as demonstrated in controlled trials, pilots and evaluations. Metrics and analytics that reflect greater student retention and performance across an entire course, program, or institution can illuminate the efficacies and obstacles of specific pedagogical and technological implementations. However, vocational colleges are challenged with scaling their successful practices as the process and evaluation of teaching and learning in one discipline does not always translate to others. For long-term success in implementation of evidence-based education, The Ministry of Education and Ministry of Finance are initiating a series of projects that are associated with evidence-based practices to improve a wider range of vocational educators' abilities and skills in research, teaching, teamwork, technology, and innovation.[24]

Facilitating Discovery of Effective Learning Technologies. In response to government's education informatization planning, Chinese vocational colleges are encouraging faculty to adopt learning technologies, but they cannot always find reputable information about technologies' impact on teaching and learning. Even multiple studies of a single tool can yield varying results due to differences in research conditions such as learner populations and technical implementation support. Compilation of learning technologies which take into the considerations of interoperability, affordability and the pedagogical needs of learners are vital to aid in discovering and selecting effective technologies.

Important Developments in Educational Technology

Time-to-Adoption: One Year or Less

Holo-Media Materials

Holo-media materials are a new form of teaching materials emerged following the rapid growing field of educational technologies and informatization in China. The holo-media materials involve integration of formal educational contents and educational resources – in the form of paper and digital – through sophisticated technologies such as AR, VR, internet, and multimedia to realize knowledge visualization. Particularly, in vocational education, the development of vocational skills involves apprenticeship and hands-on training in which mere reliance on reading paper-based educational materials is not enough to satisfy learners' needs. Chinese vocational colleges have adopted holo-media materials to provide simulated and interactive learning experiences to address the issues of teaching abstract concepts of vocational skills. The use of holo-media materials is a promising solution towards organic integration of "theory and practice", "knowledge and thinking", and "present and future" in vocational education.

Relevance for Teaching, Learning, or Creative Inquiry

- Holo-media materials consist comprehensive collections of paper- and digital-based teaching materials, online courses, learning exercises, test items, teaching tools and software to support effective teaching.[25]
- Educators can leverage technological tools from holo-media materials to address teaching of abstract concepts and vocational skills.
- The integration of sophisticated technologies into holo-media materials can facilitate interactive, interest-driven and active learning.

Holo-Media Textbook in Practice

- Changchun Automobile Industry Institute develops holo-media materials by reconstructing teaching contents and utilized augmented reality technologies and online learning platform to illustrate the knowledge and skills for the control system of hydraulic cylinder.[26]
- Northeast Normal University Ideal Software Co. Ltd. strengthens the design of holo-media materials based on logical reasoning process to resolve the incompatibility issues between content teaching order and students' skills training.[27]
- Changchun Machinery Industrial School draws from the advantages of holo-media materials including the use of modern technologies and learner-centered approaches to create a smart learning environment to reform its mechanical basic course.[28]

For Further Reading

Construction of Holo-media Materials in Henan Province[29]

(Guangming Net, 2017). Henan Provincial Department of Education takes the lead to establish standards for constructing vocational holo-media materials and public resource platform for holo-media materials to promote informatization in vocational education.

Development of Materials for Work-Integrated Learning[30]

(Min Li et al., 2017). School-enterprise cooperation is an effective way to develop holo-media materials for work-integrated learning as it ensures the practicability and advancement of the materials.

Time-to-Adoption: One Year or Less

Flipped Classroom

The flipped classroom refers to a model of learning that rearranges how time is spent both in and out of class to shift the ownership of learning from the educators to the students.[31] In the flipped classroom model, valuable class time is devoted to higher cognitive, more active, project-based learning where students work together to solve local or global challenges — or other real-world applications — to gain a deeper understanding of the subject.[32] Rather than the instructor using class time to dispense information, that work is done by each student after class, and could take the form of watching video lectures, listening to podcasts, perusing enhanced e-book content, or collaborating with peers in online communities.[33] Students access the online tools and resources any time they need them. Teachers can then devote more time to interacting with each individual. After class, students manage the content they use, the pace and style of learning, and the ways in which they demonstrate their knowledge; the instructor adapts instructional and collaborative approaches to suit their learning needs and personal learning journeys.[34]

Relevance for Teaching, Learning, or Creative Inquiry

- Flipped classroom concepts, as well as providing students with a more diverse set of learning resources, can support self-directed learning.
- More active learning is an important component of the flipped classroom: lectures can be watched with ensuing online discussions unfolding at home, while instructors can use class time for hands-on activities or trips outside of the building.
- The online component of the flipped classroom enables students to repeat vital learning activities such as re-watching video lectures and running virtual experiments as often as needed, in order for them to fully grasp the subject matter.

Flipped Classroom in Practice

- Hubei Technology and Science College uses flipped classroom in “Children and Family Education” course to stimulate students’ interest in learning, foster problem solving skills, improve independent learning ability and encourage collaborative learning.[35]
- Flipped classroom is combined with virtual and remote laboratories in Guangzhou Civil Aviation Vocational and Technical College to support learning of e-commerce in civil aviation.[36]
- Huai’an College of Information Technology incorporates flipped classroom with small private online course (SPOC) for computer network course to encourage self-directed and self-paced learning.[37]

For Further Reading

Model of Teaching for Higher Vocational based on the Flipped Classroom Approach[38]

(Hu Lei, 2015). Flipped classroom allows students to learn at their own pace. Task-based learning is one of the features of flipped classroom that could enhance learning outcomes and achieve learning goals.

Examination on the Applicability of Flipped Classroom in Vocational Education[39]

(Dong Qi et al., 2016). Flipped classroom can have effects on developing learning interest. Teachers have an especially important role in discovering and making effort to sustain students’ interest in learning.

Time-to-Adoption: One Year or Less

Micro Lessons

The concept of micro lesson is associated with small lesson designed to learn a specific topic. Micro lesson is mainly based on short, thematic teaching video created on the basis of traditional teaching materials.[40] The advancement of new technologies and new media, and the diverse learning models of the modern age (e.g., personalized learning, collaborative learning, mobile learning, online learning, distance learning and ubiquitous learning) have propelled the growth of micro lesson.[41] Learners can access micro lesson anywhere, anytime using their personal devices. Its unique features of short, simple, content-focused and interest-driven have provided effective solutions to teaching complex contents, especially complex vocational skills. Micro lesson is an innovative pedagogical approach which breaks through traditional classroom teaching approach, contributing towards targeted and effective learning.

Relevance for Teaching, Learning, or Creative Inquiry

- As micro lesson is short and content-focused, it promotes students' enthusiasm for learning and helps students to better engage in learning to achieve necessary outcome in reduced timeframe.
- Micro lesson makes use of internet and personal devices, providing easy access to learning and hence, supporting ubiquitous, self-directed learning.
- Complex topic can be broken down to several micro lessons which enables students to better process information and fully grasp each aspect of the topic.

Micro Lessons in Practice

- Jiangsu Provincial Department of Education organized provincial level micro lesson teaching competition to promote the integration of information technology into teaching and improve teaching and learning outcomes.[42]
- Teachers from Hunan Vocational Institute of Technology participated in professional training of online course and micro lesson development and design. They will apply the knowledge obtained together with the use of modern technologies to their teaching to foster the talent of their students.[43]
- Beijing Dongcheng Vocational College utilizes the advantage of micro lesson that is content-focused to address the issues of vocational education: the basic knowledge of students is relatively weak, the urgent need for quality vocational skills training, and the conflicts between theory and practice.[44]

For Further Reading

Investigation on the Development of Micro Lesson in Higher Vocational Education[45]

(Xiaohong Liao, 2017). Effective implementation of micro lesson in vocational colleges includes increasing teacher training in micro lesson, encouraging teacher to employ micro lesson approach in their teaching, and sharing resources for teaching micro lesson.

The Thoughts behind the Micro Lesson in Vocational Education[46]

(Li Song & Xingtang Fang, 2015). Well-designed micro lesson can help in developing self-directed learners. The design of a micro lesson needs to focus more on its content rather than the surface features of the micro lesson.

Time-to-Adoption: One Year or Less

Online Learning

Online learning refers to both formal and informal educational opportunities that take place through the web. This topic experienced a surge of interest with the rise of massive open online courses, and has since been garnering greater acceptance as a mode of learning that can complement face-to-face instruction in blended learning approaches — or stand on its own.[47] As leaders have gained a better understanding of this field, they have been conducting numerous related online learning experiments; educators are becoming more comfortable testing various levels of integration in their existing courses, and many believe that online learning can be an effective catalyst for thoughtful discussion on all pedagogical practice. Online learning is progressing towards the stage of maturity that at many Chinese vocational colleges, online learning is already commonplace. The current online learning model is experiencing various innovative reformations and taking into account the emerging business model.

Relevance for Teaching, Learning, or Creative Inquiry

- As new pedagogies emphasize personalized learning, there is a growing demand for learner-centerd online opportunities. Online learning environments, when designed effectively, have the potential to scale globally.
- Online learning makes creative use of educational technologies and emerging instructional approaches, including blended learning, video lectures, and badges.
- When placed online, a diverse set of learning resources is easily accessible to students and can support self-directed learning.

Online Learning in Practice

- Suzhou Construction Traffic Higher Vocational Technical School developed a “Chinese Literacy Discovery Tours” online learning platform to promote knowledge sharing as well as interactive teaching and learning for Chinese literacy.[48]
- The online learning platform of Changzhou Liuguojun Higher Vocational Technical School for classical Chinese poetry has beginner, intermediate and advance learning stages, advocating personalized learning and facilitating efficient learning.[49]

For Further Reading

Survey Shows Vocational Students Enjoy Online Learning[50]

(Xinhua Net, 2017). 2016 Chinese Vocational Education Information Blueprint indicates that sixty percent of vocational students enjoy online learning and believe that online learning can benefit learning.

The Solutions for Online Learning in Higher Vocational Education[51]

(Hua Xu, 2017). Online learning system needs to take into account the relationships between learners (ability level and learning style), learning tasks, learning strategies and learning evaluation.

Time-to-Adoption: Two to Three Years

Virtual Reality, Augmented Reality & Mixed Reality

Virtual reality (VR) describes computer-generated environments that simulate the physical presence of people and objects to generate realistic sensory experiences. Augmented reality (AR), the layering of data over 3D spaces to produce a new experience of the world, sometimes referred to as "blended reality," amplifies access to information, bringing new opportunities for learning. Mixed reality (MR) refers to the spectrum of situations that merge the actual reality and virtual reality through employing 3D and AR technologies to anchor virtual objects into users' real world space. VR, AR and MR are becoming increasingly viable in the vocational education sector. VR constructs provide contextual learning experiences that foster exploration of real-world data in virtual surroundings; [52] AR's responsive interactivity enables students to establish broader understandings based on interactions with virtual objects; and MR combines the best of VR and AR which allows students to interact with virtual objects in real world. These immersive technologies foster deeper levels of cognition as learners attain new perspectives on underlying data. Recent government support for the integration of internet technologies will help this development gain traction, including the Internet Plus action plan and China's first large data exchange.[53] Chinese vocational colleges are adopting AR, VR and MR technologies to enhance student learning experience and connecting them with relevant industries.[54]

Relevance for Teaching, Learning, or Creative Inquiry

- AR can help students learn by placing course content in rich contextual settings that more closely mirror real-world situations.
- VR can help institutions overcome shortcomings, including a reliance on theory and lack of concrete experiences, through experiential learning.
- VR, AR and MR can extend the walls of lecture halls, allowing students to explore and interact with environments and other people that may otherwise be inaccessible.

Virtual Reality, Augmented Reality & Mixed Reality in Practice

- Based on college-enterprise cooperation strategies, Quanzhou Overseas Chinese Vocational School and Netdragon Websoft have successfully integrated VR technology into practical training courses such as computer, environmental art and tourism.[55]
- Guangdong Food and Drug Vocational College developed "Virtual Factory" using VR technology (3Dmax, Quest 3D and Unity 3D) to assist practical training and teaching in pharmaceutical profession.[56]
- Hong Kong Vocational Training Council leverage VR and AR technologies to enhance students' learning motivation and efficiency in aircraft maintenance and risk management.[57]

For Further Reading

Cultivating the New Generation of VR Talent[58]

(www.eol.cn, 2017). Shandong College of Electronic Technology is cooperating with enterprises to incorporate VR technology into vocational teaching and training through building a VR innovation and collaboration center.

Time-to-Adoption: Two to Three Years

Mobile Learning

Learning happens all-the-time, everywhere, and is not place-bound.[59] With the proliferation of personal mobile devices, people increasingly expect to be connected to the internet and the rich tapestry of knowledge it contains wherever they go. According to the China Internet Network Information Center, in 2017, the number of Chinese people using the internet had reached 724 million (half the country's population), with 96.3% of them accessing the web through their smartphones. Currently China's Ministry of Education is challenged with finding solutions to lessen the disparity between urban and rural China, and mobile delivery is one method of reaching more low income citizens who might not have a computer at home, but will likely have a smartphone.[60] Mobile devices can break down institutional walls by extending the availability and accessibility of learning content and expertise, while allowing learners more flexibility and variety in how they share knowledge and collaborate. Chinese education researchers are finding that the effective use of mobiles can support learning across multiple environments,[61] while facilitating a shift from passive learning to more autonomous learning, where students actively seek out resources based on their personal interests.[62]

Relevance for Teaching, Learning, or Creative Inquiry

- Mobile apps with built-in social features enable learners to share questions or collaborate on creative projects instantaneously.
- Mobiles present an economic, flexible alternative to laptops and desktops due to the devices' lower cost, greater portability, and access to apps.
- Personal mobile devices can provide an entry point to customized learning content and the ability to generate data on related interactions.

Mobile Learning in Practice

- Wuxi Institute of Commerce creates a unique mobile learning space which integrates "Internet Plus Teaching" approach to promote ubiquitous, mobile, and personalized learning methods.[63]
- Fujian Business School links learning resources from Moodle platform with mobile app, taking advantages of mobile devices including convenient, user-friendly, and its communicative function which provide ubiquitous and interactive learning opportunities.[64]
- The Chinese Society of Vocational and Technical Education held an advanced training course for "Blended Learning Course Design and Mobile Learning Resource Development" to enhance vocational teachers' innovative teaching approach in the digital learning environment.[65]

For Further Reading

Mobile Learning in Vocational Colleges: Challenges and Recommendations[66]
(Jun Xie, 2018). The adoption of mobile learning in vocational colleges is facing challenges such as the need to improve teacher's flexibility in thinking and students' concentration. It is recommended to address these challenges from three levels: institution, teacher and student.

Vocational Teachers' Point of View: The Current State of Mobile Learning[67]
(Jiannan Qian & Xiao Liu, 2017). The authors suggest that cooperation from education departments, schools, teachers and students are required to lay a strong foundation for reformation of vocational education towards mobile learning.

Time-to-Adoption: Two to Three Years

Cloud Computing

Cloud computing refers to expandable, on-demand services and tools that are served to the user via the Internet from specialized data centers and consume almost no local processing or storage resources. Cloud computing resources support collaboration, file storage, virtualization, and access to computing cycles, and the number of available applications that rely on cloud technologies has grown to the point that almost every education institution makes some use of the cloud, whether as a matter of policy or not. Over the past few years, cloud computing has been firmly established as an efficient way for businesses to protect data, develop applications, deliver software and online platforms, and collaborate. China touts the world's largest Internet user base, with mobile being the preferred form of access. As such, cloud computing has become an important part of the national technology strategy. Major Chinese companies, including Alibaba, are challenging Amazon Web Services' position as leaders in this space.[68] Vocational colleges in China are well positioned to take advantage of cloud-based strategies to boost collaboration, productivity, and mobility in teaching and learning.

Relevance for Teaching, Learning, or Creative Inquiry

- At the institution level, flexible options for computing, bandwidth, and storage offered by providers can be reconfigured on the fly, and in most cases are considerably cheaper than the capital and operational costs of dedicated data centers.
- At the user level, secure cloud resources are less expensive than licensed products, and they increase access to storage, tools, media, and educational materials for learners.
- Cloud-based services support collaborative learning competencies, encouraging students to work simultaneously on a document in the same room or across continents.

Cloud Computing in Practice

- As vocational skills are receiving increasing attentions in the job market, the Cloud and Big Data Platform for Education created by HuaYun aims to reform vocational education and support online learning of big data technology.[69]
- HuaQin Education is implementing cloud software into the e-learning system as part of the vocational education informatization process.[70]
- Weidong Demos uses cloud computing technology to develop online learning platforms that meet diverse learning demands, improve teaching efficiency and optimize teaching management in vocational education.[71]

For Further Reading

Investigation on Regional Vocational Education Resources Cloud Platform[72]

(Yu Zhao & Zhihua Chen, 2017). The authors found that the cloud platform ca promote professional development of vocational teachers and sustainable development of regional vocational education.

Integration of Vocational Education Resources under the Cloud Computing Environment[73]

(Jing Li, 2017). Integrating education resources in vocational colleges under the cloud computing environment can reduce hardware and software costs, improve unequal resource distribution, etc.

Time-to-Adoption: Two to Three Years

Learning Analytics & Adaptive Learning

Learning analytics is an educational application of web analytics aimed at learner profiling, a process of gathering big data and analyzing details of individual student interactions in online learning activities. For educators and researchers, learning analytics has been crucial to gaining insights about students' learning behavior.[74] The goal is to build better pedagogies, empower active learning, target at-risk student populations, and assess factors affecting completion and student success.[75] Adaptive learning technologies apply analytics through software and online platforms, adjusting to individual students' needs.[76] Contemporary educational tools are now capable of learning the way people learn. Enabled by machine learning, they can adapt to each student in real time. As vocational education is unique that it emphasizes development of practical skills and knowledge needed for a specific trade or job function, researchers are conducting studies to better understand the impact of these applications on learner outcomes in the vocational education context.

Relevance for Teaching, Learning, or Creative Inquiry

- Adaptive learning technologies link specific concepts and skills from a course to how students are interacting with the material.
- Learning analytics and adaptive learning technologies can help surface early signals that indicate a student who is struggling, allowing faculty to address issues quickly.
- The science behind learning analytics in online environments can be used to create adaptive software that caters to a student's individual learning curve in real time.

Learning Analytics & Adaptive Learning in Practice

- Yancheng Mechanical and Electrical Higher Vocational Technical School employs adaptive learning platform to teach "C Language Programming", leveraging learning analytics technology to adjust teaching approaches according to student needs.[77]
- Magic Academy is building an adaptive learning platform to provide personalized learning service to students. Artificial intelligence technology is used to process and analyze learning data collected to accurately evaluate learners' learning ability and learning habits, as well as predict and recommend the subsequent learning contents.[78]

For Further Reading

A Study on Adaptive Learning of Students in Higher Vocational Colleges[79]

(Yuan Zhang & Guo Bing Hu, 2016). The findings of the study indicate that adaptive learning approach can unleash vocational students' learning potentials, help them to master knowledge efficiently and improve their learning outcomes.

Instructional Design for Project-Based Learning in Vocational Education using Learning Analytics Technology[80]

(Guoqing Xu, 2015). The instructional design for project-based learning is developed through in-depth analysis of learners' learning activities.

Time-to-Adoption: Four to Five Years

Next Generation LMS

Learning management systems (LMS), also referred to as Virtual Learning Environments, comprise a category of software and web applications that enable the online delivery of course materials as well as the tracking and reporting of student participation.[81] Viewed as a centralized location for the ephemera of learning experiences, LMS have long been adopted by vocational colleges to manage and administer online and blended courses. It is commonplace for students to access syllabi and readings, submit assignments, check grades, and contact peers and instructors through their college's LMS, while instructors monitor student engagement and performance at individual and course levels. However, some thought leaders believe current LMS are limited in capacity, too narrowly focused on the administration of learning rather than the learning itself.[82] Next-generation LMS, also called next-generation digital learning environments (NGDLE),[83] refers to the development of more flexible spaces that support personalization and collaborative learning, meet universal design standards, and play a larger role in formative learning assessment.[84] Rather than existing as single applications, they are a "confederation of IT systems and application components that adhere to common standards …that would enable diversity while fostering coherence."[85]

Relevance for Teaching, Learning, or Creative Inquiry

- The LMS is valuable as an administrative tool for planning, implementing and assessing learning processes.
- LMS has online interactive features for real time communication and collaboration, and hence capable of support live virtual classes and distance learning.
- LMS, when combines with learning analytic technology, is able to provide a holistic picture of learning progress and customize to learning needs for self-directed learning.

Next Generation LMS in Practice

- The teaching of fault diagnosis of power component in electric vehicle EV160 carries out in Changzhou Liuguojun Higher Vocational Technical School uses Microsoft OneNote and ZigBee Intelligent Training System to organize learning contents and provide feedback to students.[86]
- SchooIn is created by EEO that advances LMS as an administration tool to combines "teaching" and "learning" through a range of online learning tools such as reading according to level, adaptive testing, knowledge forum, and games.[87]

For Further Reading

Next Generation LMS: Content, Core Elements and Development[88]

(Zhenguo Xu et al., 2017). This paper discusses the core elements for LMS design that support students' learning needs and goals in digital learning environment.

Blended Learning and Moodle LMS[89]

(Bin Wei & Qingsong Zeng, 2017). Moodle is an open source online LMS which embraces the concept of student-centered learning. Third-party plugin offers additional functions to the Moodle LMS to further satisfy the teaching and learning needs.

Time-to-Adoption: Four to Five Years

Artificial Intelligence

In the field of artificial intelligence (AI), advances in computer science are being leveraged to create intelligent machines that more closely resemble humans in their functions.[90] The knowledge engineering that allows computers to simulate human perception, learning, and decision making is based on access to categories, properties, and relationships between various information sets. Machine learning (also called deep learning) is a subset of AI, providing computers the ability to learn without being explicitly programmed.[91] As another significant area of research, neural networks model the biological function of human brains to interpret and react to specific inputs such as words and tone of voice.[92] Neural networks are proving valuable for more sophisticated natural user interfaces through voice recognition and natural language processing, allowing humans to interact with machines similarly to how they interact with each other. As the underlying technologies continue to develop, AI has the potential to enhance online learning, adaptive learning software, and research processes in ways that more intuitively respond to and engage with students.

Relevance for Teaching, Learning, or Creative Inquiry

- Adaptive learning, featured earlier in this report, leverages basic AI algorithms to personalize learning, delivering content that best suits students' needs based on performance and engagement with the subject matter.
- Machine learning models which adopt AI technology can potentially sort through learner-contributed observations about the world around them and create visualizations that identify crucial patterns.
- Artificial intelligence will be able to use machine learning to act as a humanlike personalized coach for various pedagogical subjects.

Artificial Intelligence in Practice

- Epiphany is an intelligent learning platform for financial education that can link learning data to deliver contents according to students' learning interest and abilities.[93]
- Jiaxing Antong Driver Training Co. Ltd. combines AI technology with other technologies including VR, big data, smart sensor and internet plus to develop robot coach to train drivers.[94]

For Further Reading

New Generation of AI Development Plan[95]
(State Council of the People's Republic of China, 2017). In the AI development plan, the State Council is calling for strengthening AI training system to meet the needs for professional skills for AI development in China.

AI Challenges in Manufacturing Industry: From the Perspective of Vocational Education[96]
(Jian Xu, 2017). As advances in AI have made it possible to automate many tasks in China's manufacturing industry, vocational colleges should take lead in analyzing the impact of AI and foster talents who can adapt to the AI-based manufacturing industry in future.

Time-to-Adoption: Four to Five Years

Virtual and Remote Laboratories

Virtual and remote laboratories reflect a movement among education institutions to make the equipment and elements of a physical science laboratory more easily available to learners from any location, via the web. Virtual laboratories are web applications that emulate the operation of real laboratories and enable students to practice in a "safe" environment before using real, physical components. Students can typically access virtual labs anytime and anywhere. Some emerging virtual lab platforms also incorporate reporting templates that populate with the results of the experiments so that students and instructors can easily review the outcomes.[97] Remote laboratories, on the other hand, provide a virtual interface to a real, physical laboratory. Institutions that do not have access to high-caliber lab equipment can run experiments and perform lab work online, where users are able to manipulate the equipment and watch the activities unfold via a webcam. This provides students with a realistic view of system behavior and allows them to access professional laboratory tools from anywhere, whenever they need.[98] Additionally, remote labs alleviate some financial burden for institutions as they can forgo purchasing specific equipment and use the remote tools that are at their disposal.[99]

Relevance for Teaching, Learning, or Creative Inquiry

- As virtual laboratories do not involve real equipment or chemicals, learners have opportunities to run experiments more than once to improve understanding.
- Instructors play back videos of the experiments students have run online, pinpoint areas for improvement or further discussion, and acknowledge students who have excelled.
- Virtual and remote laboratories increase access to science tools without exposing students to potentially dangerous materials and processes.

Virtual and Remote Laboratories in Practice

- "Virtual Simulation System for Ancient Ceramic" and "Piecing Assistant" software are used in Dagang Secondary Specialized School to help students in learning the features of ceramics and historical culture of Chinese dynasties as well as mastering ancient ceramic repairing processes.[100]
- Virtual showroom is introduced in the arts and craft appreciation class in Jiangsu Yangzhou Tourism Commerce and Trade School. It is a digital exhibition hall that provides three-dimensional, interactive experiences of the traditional showrooms.[101]
- Guangzhou Institute of Technology has integrated virtual reality technologies into practical teaching of many vocational subjects to resolve the issues of high cost, high risk, high pollution and difficulties in observing, operating and reproducing.[102]

For Further Reading

The Application of Virtual Laboratory in Electrical Training[103]
(Weichao Ma, 2017). By investing a virtual laboratory for electrical training can reduce the cost of purchasing and maintaining traditional training equipment as well as provide an interactive learning environment.

Virtual Resources for Experiment and Practical Training in Vocational Education[104]
(The National Center for Digital Learning Resources, 2017). The center is collecting and indexing virtual resources to promote its application in vocational education.

Time-to-Adoption: Four to Five Years

Information Visualization

Information visualization is the graphical representation of technical, often complex data, designed to be quickly and easily understood. This type of media, also known as infographic, is highly valuable in the age of ubiquitous knowledge, and the skillset required to create infographic is in demand by organizations seeking to share messages that make an impact.[105] This is particularly compelling for vocational education as infographic can make complex data generated from information management systems and online learning systems more digestible. A well-crafted infographic can illuminate perspectives and relationships that would otherwise remain buried in databases and content repositories or interpret a detailed concept, such as data about student learning, and connect ideas to each other with clarity and simplicity. In the educational context, visualization of information covers skills associated with data analytic techniques, design thinking skill, contextual and inquiry-based research skills, and technical skills to put ideas into practice.

Relevance for Teaching, Learning, or Creative Inquiry

- Infographic can translate complex and massive amount of data into useful information that serve as a summarization and guidance to teaching and learning.
- Visualization of the data gathered through online learning platform can help faculty to understand the demographic composition of their students to make informed decisions.
- Expressive visualization will be able to make complex information and concepts more digestible and interesting, engaging students in learning process.

Information Visualization in Practice

- Jilin Vocational Technology College of Electronics and Information carries out studies on how to visually and intelligently demonstrate the application of next-generation communication technologies in future smart city settings.[106]
- LJC Soft partners with Beijing Normal University's Research Institute of VR and Visualization Technologies to research and promote related technologies. A range of technologies is developed for application in professional courses such as tourism management, hotel management, civil engineering and others.[107]

For Further Reading

Teaching Practice of 'Visualizing' Work Process[108]
(Zhuming Cao et al., 2016). The visualization of work process involves converting students' learning process into a work process and then creating an infographic which illustrates each stage of the work process, helping students to better understand their learning tasks (work) in each stage.

A Study on Visualization of Vocational Teachers' Practical Knowledge[109]
(Haili Yang, 2017). The visualization technology has made coding and visualizing the practical knowledge of vocational teachers possible which solve the issues of sharing, exchanging, and disseminating practical knowledge among teachers as well as aid in improving their practical knowledge.

Methodology

The process used to research and create the *2018 Technology Outlook for Chinese Vocational Education: A Horizon Project Report* is a carefully constructed process that is informed by both primary and secondary research. Dozens of technologies, meaningful trends, and critical challenges are examined for possible inclusion in the report. The report draws on the considerable expertise of an internationally renowned panel of experts that first considers a broad set of important technology trends, challenges, and developments, and then examines each of them in progressively more detail, reducing the set until the final listing of trends, challenges, and important developments in educational technology is selected.

Much of the process takes place online, where it is captured and placed in the Horizon Project wiki. This wiki, which has grown into a resource of hundreds of pages, is intended to be a completely transparent window onto the work of the project, and contains the entire record of the research for each of the various editions. The section of the wiki used for the *2018 Technology Outlook for Chinese Vocational Education* can be found at china.nmc.org.

The procedures for selecting the topics that are in this report include a modified Delphi process now refined over years of producing the NMC Horizon Report series, and it began with the assembly of the expert panel. The panel as a whole was intended to represent a wide range of backgrounds and interests, yet with each member bringing a particularly relevant expertise. To date, more than 2,000 internationally recognised practitioners and thought leaders have participated in the NMC Horizon Project Expert Panels.

Once the expert panel for a particular edition is constituted, their work begins with a systematic review of the literature — press clippings, reports, essays, and other materials — that pertains to emerging technology. Panel members are provided with an extensive set of background materials when the project begins, and are then asked to comment on them, identify those that seem especially worthwhile, and add to the set. The group discusses existing applications of emerging technology and brainstorms new ones. A key criterion for the inclusion of a topic is the potential relevance of the topic to teaching, learning, or creative inquiry. A selection of dozens of relevant publications ensures that background resources stay current as the project progresses. They are used to inform the thinking of the participants throughout the process.

Following the review of the literature, the expert panel engages in the central focus of the research — the research questions that are at the core of the Horizon Project. These questions are designed to elicit a comprehensive listing of technology trends, challenges, and developments from the panel:

1. Which of these important developments in technology will be most important to Chinese vocational education within the next five years?
2. What important developments in technology are missing from our list? Consider these related questions:
    a. What would you list among the established technologies that some Chinese vocational colleges and educational programmes are using today that arguably ALL Chinese vocational colleges and educational programmes should be using broadly to support or enhance teaching, learning, or creative inquiry?
    b. What developments in technology that have a solid user base in consumer, entertainment, or other industries should Chinese vocational colleges and educational programmes be actively looking for ways to apply?

   c. What are the emerging technologies you see developing to the point that Chinese vocational colleges and educational programmes should begin to take notice during the next four to five years?
3. What key trends do you expect to accelerate the uptake of emerging technology across Chinese vocational education?
4. What do you see as the significant challenges impeding emerging technology uptake across Chinese vocational education?

One of the expert panel's most important tasks is to answer these questions as systematically and broadly as possible, so as to ensure that the range of relevant topics is considered. Once this work is done, moves quickly over just a few days, the expert panel moves to a unique consensus building process based on an iterative Delphi-based methodology.

The responses to the research questions are systematically ranked and placed into adoption horizons by each panel member using a multi-vote system that allows members to weight their selections. Each member is asked to also identify the timeframe during which they feel the technology would enter mainstream use — defined for the purpose of the project as about 20% of institutions adopting it within the period discussed. (This figure is based on the research of Geoffrey A. Moore and refers to the critical mass of adoptions needed for a technology to have a chance of entering broad use.) These rankings are compiled into a collective set of responses, and inevitably, the ones around which there is the most agreement are quickly apparent.

For additional detail on the project methodology or to review the instrumentation, the rankings, and the interim products behind the report, please visit the project wiki, which can be found at china.nmc.org.

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End Notes

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