The Real and the Virtual are Merging: Metaverse Reshapes the New Ecology of "Learning Factory"

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Abstract

This article explores how the metaverse is reshaping the traditional "learning factory" in education, creating a new ecosystem. It highlights how the impact of metaverse technologies, including virtual reality and augmented reality, is making learning more immersive and personalised. The new Learning Factory ecosystem provides a richer learning experience through virtual labs, virtual mentors, and global collaborations, producing students with real-world skills and a global perspective. This article highlights the potential of learning factories in the meta-universe perspective to meet the needs of modern education and shape the future of learning.

Keywords

Learning factory; Meta-universe; Higher education; Design.

1. Introduction

The Higher Education Symposium of the Global Conference on Digital Education (GCDE) was held in Beijing in February 2023 with the support of UNESCO, the Ministry of Education of the People's Republic of China and Tsinghua University. The symposium will focus on the digital transformation of higher education, explore its realisation path and development countermeasures, and provide services for the high-quality and innovative development of higher education in the world. This topic will systematically sort out Germany's production and education ideas on the digital transformation of higher education 4.0 in recent years, and improve the system of learning factory by combining with the development of the current meta-universe education industry, and refine and summarise the education planning and implementation mechanism, in order to provide reference for promoting the digital transformation and upgrading of China's higher education.

2. Analysis of the Connotation of Learning Factory and the Concept of Industry-Education Integration

Only through practice can we better cultivate a sense of participation, develop participatory skills, form participatory aspirations and reach a broad consensus[1].

2.1. Inside the Learning Factory

The term "learning factory" does not refer to a "production line" in the narrow sense of the word, but rather to a real-world approach to education that integrates experiential learning, game-based learning, problem-based learning, project-based learning, and research-based learning to promote active participation in learning by students. Students are motivated to actively participate in learning. This approach enhances students' real-world project experience and fosters a group of outstanding practitioners who can solve real-world problems to shape and build the future. The Learning Factory's mode of operation provides students with

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real-world experience and training, and is divided into a series of processes such as co-operation agreements, identification of projects or problems, replication of production environments, instructors and business technicians, student participation, problem solving, implementation of improvements, academic assessment, and sharing of results (Figure1). Overall, the Learning Factory operates by bringing real-world problems and production environments into the school so that students can learn and apply their knowledge in practice, as well as provide new ideas and solutions to the enterprise. This model helps to improve students' competitiveness in employment and supports industrial development and technological innovation. The Learning Factory model realises the deep integration of "production, teaching and research", improves the quality and suitability of skilled personnel training, and better serves the design of high-quality outputs.

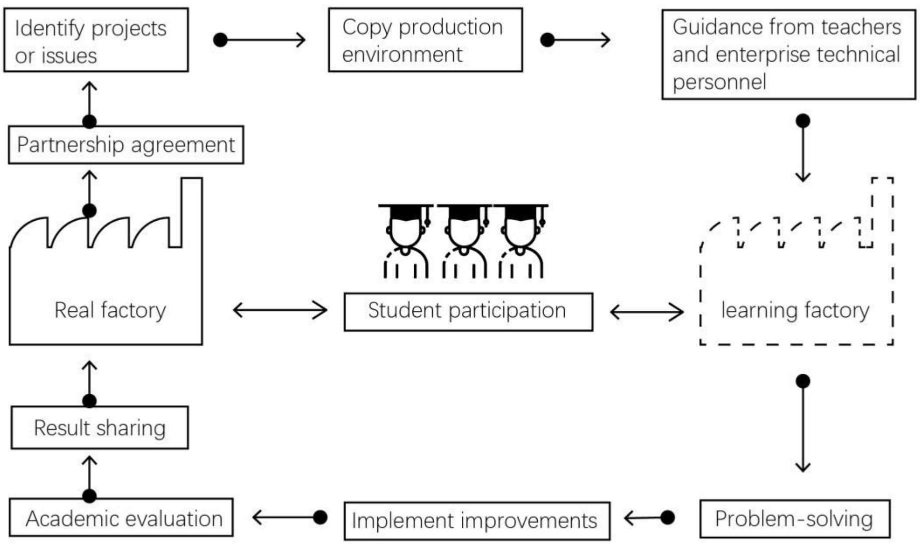

Figure 1. Learning Factory Flowchart

2.2. Literature Review of Learning Factories

The Learning Factory is an innovative educational model that introduces the real work environment into education and provides students with real-world related learning experiences. The author has conducted a systematic literature review of the Learning Factory, outlining the development, characteristics and impact of this educational model.

The Learning Factory is an educational model based on practice-orientated learning, whose features include placing students in real industrial environments and engaging them in practical projects and problem-solving processes [2]. This model focuses on interdisciplinary education and encourages students to integrate knowledge and skills from different fields [3]. The origin of learning factories can be traced back to the dual-track education system in Germany, which combines academic and vocational training and provides the conceptual basis for the development of learning factories [4]. With the rapid development of technology and industry, companies began to increase their demand for high skills and practical experience, which led to the rise of the learning factory model [5]. The operation of learning factories usually involves the cooperation between enterprises and schools, bringing actual industrial production problems or projects into schools, where students participate in actual work in a simulated factory environment and receive guidance from professional tutors [6]. This model

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emphasises problem-oriented learning, in which students acquire knowledge and skills by solving real problems, reinforcing the importance of practical education [7]. The Learning Factory model helps to improve students' competitiveness in employment, as they already have practical work experience after graduation and can adapt to the work environment more quickly [8]. This model also helps to promote industrial innovation and development, and students provide new ideas and solutions when solving practical problems [9]. With the development of digital technology and virtual reality, learning factories have begun to integrate advanced technologies to better simulate real factory environments and provide highly interactive learning experiences [10]. The learning factory model has been promoted and adopted globally, and countries have introduced this model to improve the quality and international competitiveness of technical education [11]. In recent years, the learning factory model has begun to pay attention to sustainable development and social responsibility, emphasising the integration of skills training with social and environmental issues, and fostering future leaders with a sense of social responsibility [12].

2.3. The Case for Learning Factories

The United States was the first country in the world to introduce the "learning factory" model in engineering teaching, which realises the organic integration of industrial production and engineering teaching. The U.S. Natural Science Foundation (NSF) in 1994 approved the Pennsylvania State University (British University) led a closely related to the industry's advanced engineering design programme, the programme was named Learning Factory (Learning United). Since then, Penn State has made improvements to the facilities and continued to strengthen the talent development function of the Learning Factory. In 2006, the National Academy of Engineering honoured Penn State with an Innovation in Engineering Education Award for excellence in engineering. In Europe, the first R&D Factory conference was held in 2011 at the Technical University of Darmstadt, Germany, and led to the creation of the European R&D Factory Alliance. Since then, the learning factory has become a new type of talent cultivation method, which has attracted more and more attention. 2013, Germany formally put forward the concept of "Industry 4.0", under the guidance of the concept, the "Learning Factory" model appeared in Germany, which builds up a "Learning Factory" model by strengthening the in-depth collaboration between schools and enterprises, and building up a "Learning Factory" model. Under the guidance of this concept, the "learning factory" model has emerged in Germany, which builds a "school-enterprise-student" system by strengthening the in-depth collaboration between schools and enterprises, and promotes the integration of work and study, and the combination of theory and practice [13]. According to a survey on the employment situation of university graduates published by Singapore in 2020, the employment rate of university graduates under the "learning factory" model reached 90.7 per cent within half a year, which is much higher than that of the traditional "training" method.

2.4. Learning Factory's Concept of Industry-Education Integration

In recent years, in the integration of industry and education in higher vocational colleges and universities, "knowledge factories", "teaching factories", "model factories" and other forms have emerged, which are similar to "learning factories", but also have their fundamental differences. Although these forms are similar to the "learning factory", they have their fundamental differences. The "learning factory" refers to the direct face of the creation and manufacture of products, focusing on practical and practical problem solving, the actual work situation introduced into the classroom, to provide students with a higher quality learning process. The German concept of "Industry 4.0" is considered a revolutionary change in industry and education, emphasising digitalisation, automation and interconnectivity in the manufacturing process. The authors summarise the concept of integration of industry and

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education in their "Learning Factory" as: production-orientated, discipline-orientated and action-orientated (Figure 2).

First, production orientation

The original purpose of the "Learning Factory" at German universities was to combine business-related activities such as product design and production with engineering and to pass on advanced technologies and methods to students. After a long period of development, the German "Learning Factory" has been extended to more fields, including management knowledge, participation in production, work organisation and so on. The German "Learning Factory" is a practice-oriented teaching model, which provides students with a variety of different areas of teaching and learning situations, and on this basis improves the students' ability to analyse and solve practical problems from multiple perspectives. "Learning Factory" is a new mode of combining education, teaching and industry, combining theory and practice, and combining production and education, which better realises the multiple functions of combining production and education. It can use high technology to link scientific research and production and provide services for industrial production; it can also provide teaching units with corresponding teaching venues and facilities for the purposes of teaching and training.

Secondly, law-orientation

The "learning factory" has expanded the connotation and concept of learning, broken through the rigid concept of "field" in the past, and integrated more scenario-based learning modes with work situations as the main means of learning, thus improving the effectiveness of classroom teaching. Scholars have proposed that the process of competence development is an iteration of the learning space, and the development of composite knowledge and competence based on vocational work must be established in an interdisciplinary composite context. From the perspective of informal learning, learning is a contingent phenomenon that includes soft skills such as interpersonal relationships, creativity and work motivation. Based on informal learning, the "learning factory" proposes a model of learning in the work environment that is behaviour-centred, people-oriented and closer to the reality of production.

Thirdly, action-oriented

The "Learning Factory" teaching model is an integrated action-oriented teaching process, which consists of the following steps: preparation of the teaching place and equipment; implementation of the curriculum based on practicality, using the curriculum design and process, business collaboration and other methods to organically integrate theory and practice; the desire to collaborate with industry, enterprises and relevant research units; and the application of existing learning outcomes. The desire to co-operate with industry and relevant research units; the application of existing learning outcomes, and so on. The German "learning factory" organically combines education, teaching activities and production environment, which makes the tripartite relationship between enterprises, higher vocational education and students closer: it reconstructs the talent cultivation objectives according to the needs of enterprises, effectively solves the problem of imbalance between production and education, and promotes the close combination of higher vocational education and enterprises; based on this, it puts forward the idea of strengthening the social thinking ability of college students and improving the employment ability of college students. social thinking ability of college students and improve the countermeasures of college students' employability. In practice, teachers should give full play to the role of teachers, enrich the form of teachers' classroom teaching, combine students' theoretical knowledge with practice, and promote a closer relationship between higher vocational education and students. For learners, the "learning factory" is a kind of behavioural learning model that enables learners to give full play to their abilities in all aspects.

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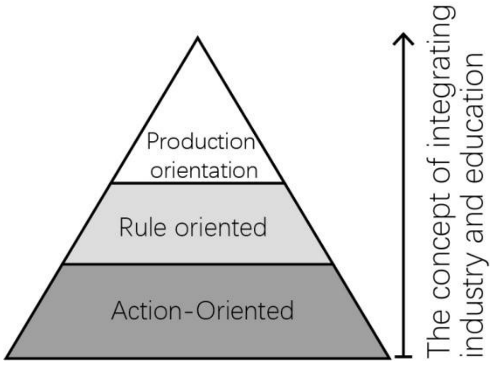

Figure 2. Production-orientated production and education concept

In addition, the concept of "Industry 4.0" was first formally proposed in Germany in 2011, and a report was published by the High-Tech Strategy Working Group of the German Government. This report clearly sets out the vision of combining information and communication technologies with industrial manufacturing to achieve the digital and intelligent transformation of manufacturing. This concept is seen as a technological revolution in the industrial world, aimed at improving the competitiveness and productivity of the manufacturing sector. The core concepts of "Industry 4.0" include the Internet of Things (IoT), digital production, smart manufacturing, personalised manufacturing, and collaborative robotics, and this set of core concepts lays the foundation for a new ecology of learning factories in the meta-universe perspective and an industry-teaching approach that integrates the real and the virtual.

3. Meta-universe Concept to Reinvent the "Learning Factory"

The concept of the Metaverse represents a virtual world in which people can interact with digital environments, objects and other users. While the metaverse is often associated with entertainment and social experiences, it also has the potential to reshape the field of education, including the "learning factory" model of education. The metaverse model of education is characterised by the four dimensions of technology, ethics and field (Figure 3).

3.1. Characteristics of the Meta-cosmic Educational Model

First, technological symbiosis reconfigures the education system.

The use of meta-universe technology in online teaching and learning enables existing online teaching and learning to reconstruct the systematic form of online teaching and learning in a technological symbiosis. In the context of meta-universe, the most intuitive manifestation of educational resources is diversified. These resources include not only existing and complete fixed courses, but also the ability to instantly and automatically retrieve text, image, audio and video materials related to the subject matter and present them in a contextualised way so that students can experience continuously updated knowledge. Firstly, autonomous material content is expressed in a meta-universe environment. Learners are not only able to learn preset course content, but are also free to rearrange or create entirely new educational resources, integrating fragmented information into an organic whole. Secondly, the middle level system plays a key role in the operation of online education. Meta-universe online education breaks through the time and space limitations of current online education and abandons the single programme interface interaction. Meta-universe pushes learning into the digital world beyond real life, expanding the depth and breadth of learning, while stimulating the adaptive potential of learners and facilitating the exchange between explicit and tacit knowledge. In educational operations, students can be immersed in the process of knowledge generation, thus enhancing the effectiveness of education and teaching. Finally, a high-level public service system is constructed. Since its birth, online education has provided a way to narrow the education gap

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and promote education equity in the public service system, while meta-universe technology makes up for its shortcomings in the public service system. The characteristics of digital drive, continuous innovation and immersive experience can eliminate the gap in public service in education caused by the "digital divide", and also make education data become a sustainable development and sustainable development of production factors, which is of strong practical significance.

Secondly, the virtual immersion standardises the scale of education.

Online education, which integrates "virtual" and "real" education, is of great significance in enhancing the equity of education. Online education represents the fruit of mankind's entry into the post-industrial information age, and it is the product of "information technology + education". On the one hand, it represents the influence and control of artificial intelligence technology on human consciousness and behaviour, and on the other hand, it is also developed to satisfy human demand for knowledge. Metaverse online education uses 3D holographic virtual and real fusion equipment to create an engaging learning experience, which can change the form of education, significantly improve the efficiency of education, accelerate the circulation of educational resources, enable more people to obtain high-quality education, and thus promote the fairness of education. Secondly, the combination of "virtual" and "real" network education pays more attention to the comprehensive development of students. With the support of meta-universe digital technology, online education enables learners to be immersed in a physically and mentally pleasurable experience, thus effectively filtering out or discarding the interference of the external environment. The fusion of virtual and real includes many aspects such as learning situation, teacher-student interaction and learning mode. "Meta-universe" online education conforms to the basic laws of educational development, fully stimulates the enthusiasm of the main body of education, takes meeting the educational needs of teachers and the learning needs of students as its main goal, promotes the harmonious and coordinated development of human-computer interaction, and pays better attention to the comprehensive growth of the stable long term.

Thirdly, spatial and temporal interactions broaden the panoramic field.

The temporal and spatial interactions characterising the metaverse have led to new expansions in the areas of learning, psychology and ethics. First, a new field of learning, characterised by technological applications. Meta-universe online learning is centred on digital technologies such as somatosensory, extended reality, artificial intelligence, and learning analytics, which first have an impact on the external forms of education (e.g., infrastructure), and then on online learning, and gradually lead to the formation of an innovative and engaging learning space. Secondly, it is a new kind of mental field which is vicarious. Virtual immersion is an important psychological experience in meta-universe online learning, which can help learners better understand the content and structural elements of teaching and learning through the strong correlation between physical and mental flows. In this new mental domain of "meta-universe", the interaction between perceptual cognition and rational cognition reconfigures the learning space, interaction mode, emotional communication and other elements of online education, which in turn promotes the healthy ecology of online education. Third, the new ethical field, centred on "virtual" and "real". The virtual world is an imitation of the "essence", so the "bilocation" can find its own "itself" in the virtual world. The coexistence of the "real" and the "virtual" in the meta-universe, fuelled by technology, poses a new challenge to the concept of education.

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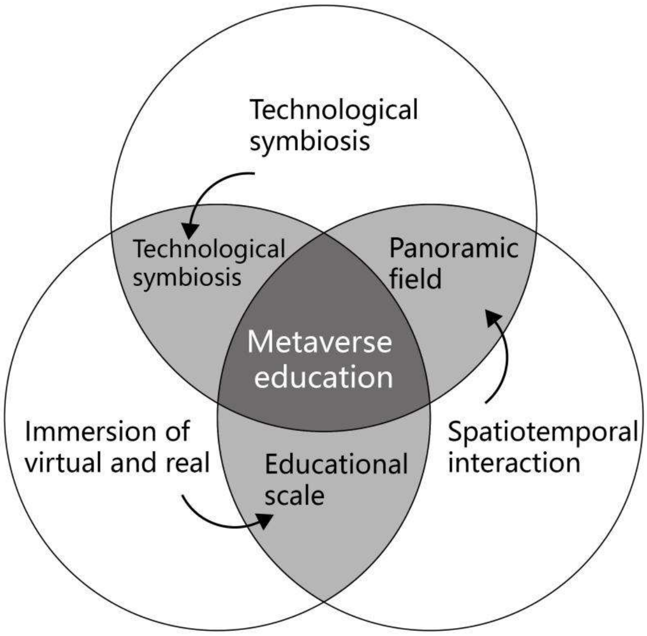

Figure 3. Characteristics of the meta-universe education model

3.2. Meta-Universe Reinventing the Learning Factory

Under the Metaverse perspective, learning factories can undergo a series of significant changes to better adapt to the digital and virtualised educational environment. The following are some of the possible evolutions and features of the learning factory under the Metaverse perspective, which will constitute a new ecology of the learning factory (e.g., Fig. 4): (1) Virtual factory environment: The learning factory can establish a virtual factory environment in the Metaverse through technologies such as digital twins, in which students can simulate real factory operations and experience various industrial processes first-hand, so as to learn practical skills. (2) Global Learning Community: Metaverse will bring about a global learning community. Students and teachers can cross geographical and cultural boundaries and participate in virtual learning factory projects together, promoting cross-cultural collaboration and knowledge sharing. (3) Virtual internships and practicums: Students can participate in virtual internships that simulate working in a factory environment. These virtual internships can provide an experience similar to an actual internship, but in a virtual environment, reducing physical distance and cost. (4) Highly immersive education: Metaverse's virtual reality technology can provide a highly immersive learning experience. Students can wear virtual reality headsets as if they were in an actual factory scene to gain a deeper understanding of industrial processes and operations. (5) Personalised Learning Paths: Metaverse can provide personalised learning paths and content according to students' learning progress and needs. Students can freely choose courses and projects according to their interests and goals. (6) Real-time data and analysis: The virtual factory in the meta-universe environment can generate a large amount of real-time data. Students can use this data for analysis and decision-making to improve problem-solving and decision-making abilities. (7) Interdisciplinary education: learning factories are more likely to integrate educational elements from different disciplines in the meta-universe. Students can learn about a wide range of fields such as engineering, design, management and science in a virtual environment. (8) Visualisation education: Through the meta-universe, students can learn using virtual tools and models. This visualisation education helps in better understanding of abstract concepts and complex systems.

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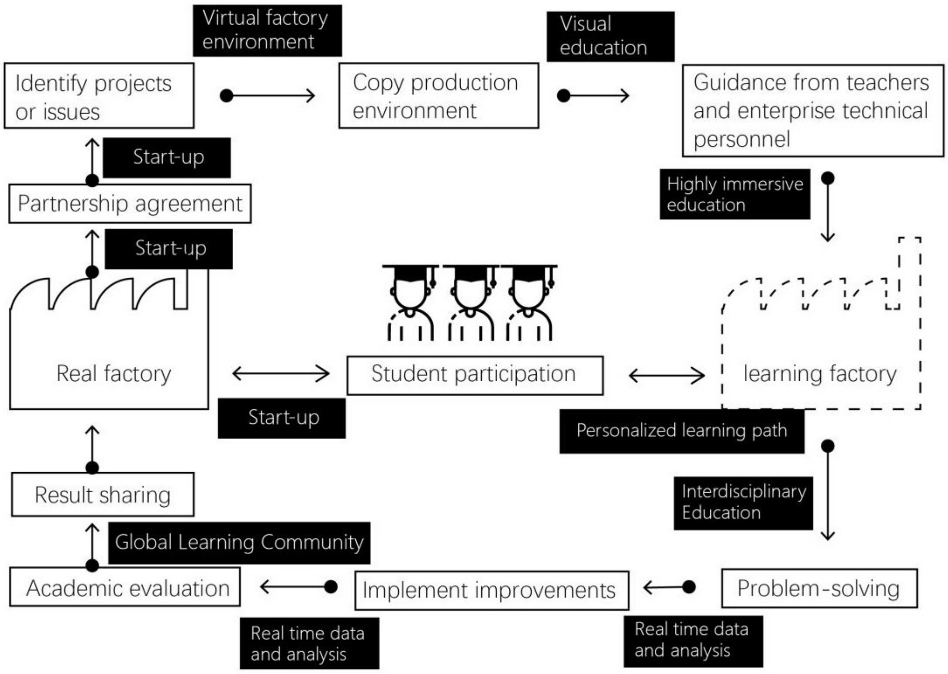

Figure 4. Learning factory in meta-universe perspective

It is important to note that the development of meta-universes in education is still in its early stages, and there are still challenges to overcome in terms of technology, security and privacy. However, the potential of meta-universes is huge to bring more innovation and possibilities to learning factories and other educational models to provide richer, interactive and personalised learning experiences.

4. The Integration of the Real and the Imaginary: The Pedagogical Implementation of the "Learning Factory".

Educational technology in teaching practice can really do to benefit teaching, help teachers and students [14].

4.1. School-Enterprise Expansion in Emerging Industries

The formulation of incentives at the government level is an effective way to stimulate the endogenous motivation of enterprises to participate in the integration of industry and education, which can guide and motivate enterprises to change from "wanting me to do it" to "wanting me to do it" in the process of participating in the integration of industry and education and to promote enterprises to become "learning factories" to support the development of high-quality vocational education [15]. It can guide and motivate enterprises to change from "I want to do" to "I want to do" in the process of industry-teaching integration, and promote the construction of enterprises to become "learning factories" supporting the high-quality development of vocational education. School-enterprise outreach can be regarded as the basis or support for the implementation of learning factories, which can help learning factories better achieve their educational goals. The following is the relationship between SITs and learning factories: SITs provide students with the opportunity to gain practical work experience in a real work environment. This provides an important practical foundation for the Learning Factory to enable students to integrate classroom learning with real-world applications. The most important goal of the Learning Factory is to develop the practical skills needed by students in a particular industry or field. School-enterprise top-ups can provide students with the

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opportunity to practise and develop these skills in real work situations. Learning factories often require close partnerships with industry to ensure that educational content is aligned with real-world needs. SBE Top-ups provide a way for schools to build partnerships with companies to develop curricula and projects.

However, the design field is undergoing rapid changes, and traditional design enterprises may need to adapt to this change, and the design programme needs to incorporate emerging enterprises and trends urgently in order to ensure the social competitiveness and sustainable development of teachers and students. In the summer of 2023, through investigation, visit and study, the advertising major signed a school-enterprise cooperation agreement with "Nanjing Vision Information Technology Co. Ltd., which developed a full-platform product based on augmented reality technology, including the website, mobile apps (Android & iOS) and smart glasses. By uploading your goals and videos on the Sigma website, you can use the Sigma App to show your friends the effects of augmented reality. Sigma App enables users to scan a pattern to get relevant information directly (AR effect), supporting text, audio, video, 3D animation and other forms of presentation, suitable for application in newspapers, magazines, books, exhibitions, museums, bars, cafes, supermarkets and other scenes, in order to a wide range of multi-language, low-cost, vivid image to support the physical access to information. Based on such characteristics, Vision Network is a suitable software for higher education students to learn and express the diversity of design forms, so it is highly conducive to the co-operation with the company (as shown in Figure 5).

Figure 5. Enterprise learning

4.2. Cat Litter Design Teaching Case Implementation

After identifying the collaboration of Baofei's cat litter packaging design, students were organised to sort out the project problems (Figure 6), including the following aspects: (1) Colour coding: each scent of cat litter can be packaged in different colours so that consumers can easily differentiate them when shopping. For example, green packaging could be used for peppermint scent, purple packaging for lavender scent, yellow packaging for lemon scent, and so on. (2) Fragrance Icons: Add fragrance-related icons or graphics to the packaging to help consumers quickly identify the product's fragrance. This could be an icon of a related fruit, plant or other relevant element. (3) Fragrance description: Provide a clear and concise description of the fragrance on the package, such as "Fresh Mint" or "Lemon Fragrance". This helps to communicate the product's scent profile. (4) Scent mapping: Include visual elements on the package, such as a scent mapping or scent ripple pattern, to help consumers associate the scent. (5) Brand consistency: Ensure that packaging for different scents is consistent in terms of brand identity, fonts and overall design style to reinforce the brand image. (6) Transparent window: Consider adding a transparent window to the package when designing the package so that consumers can see the colour and particles of the litter and also smell the scent. (7) Re-sealable sealed bags: Consider designing bags with re-sealable features to maintain the freshness and

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fragrance of the cat litter. Clear product information: Packaging should include clear product information such as directions for use, capacity and ingredients to meet consumer needs. (8) Clear product information: Packaging should include clear product information such as instructions for use, capacity and ingredients to meet consumer needs. After analysing the above issues, further simulation in the replicated packaging design learning factory scenarios, in which the idea of "transparent window" time cost cost exceeds the budget, and is not conducive to the preservation of cat litter moisture, after removing this point in the design, the final packaging design should be able to arouse the interest of consumers, to convey the characteristics of the product, and so that consumers to have a clear understanding of the different scents of cat litter. At the same time, the packaging should be consistent with the brand image to build brand loyalty and provide a consistent shopping experience, as shown in Figure 7.

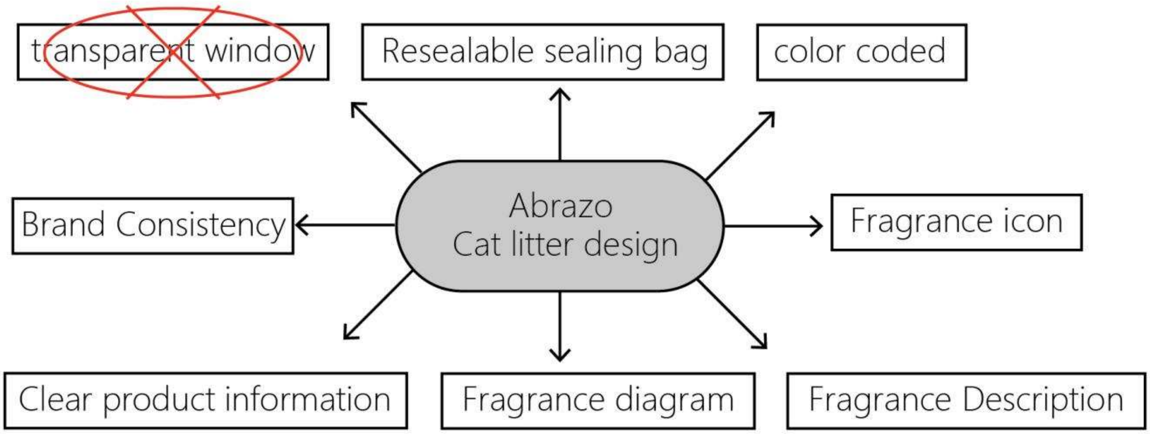

Figure 6. Balfour's Cat Litter Packaging Design Project Combing

Figure 7. Cat litter packaging design

Once the floor plan has been designed, and the learning factory has been utilised to make adjustments to the design fit, the packaging design needs to be adapted to suit the materials and packaging type chosen. The designer needs to ensure that the design elements can be successfully applied in actual production, taking into account printing and manufacturing requirements. This includes the following considerations: (1) Material selection: Firstly, the selection of suitable packaging materials depends on the nature of the product and the purpose of the packaging. Materials can include paper, cardboard, plastic, metal, glass, etc. The material chosen should have sufficient strength and durability to protect the product. (2) Printing: The packaging design needs to be printed on the chosen material. This can involve different printing techniques such as offset printing, flexo printing, digital printing, etc. The printing process needs to consider various details such as colours, patterns, text, etc. (3) Cutting and moulding:

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After printing, the printed material needs to be cut and moulded to the designed size and shape to create the shell or bag of the package. This can be done by automated machines or by hand. (4) Folding and gluing: Some packaging needs to be folded and glued to form the final packaging container. This includes boxes, paper bags, sealing bags, etc. The gluing is usually done using adhesives or heat sealing techniques. (5) Quality control: Quality control is carried out during the production process to ensure print quality, dimensional accuracy and package integrity. Any defects or problems need to be resolved before the product reaches the market. (6) Packaging and Crating: The finished packaged product is packaged and crated for shipment to distribution points or retailers. Packing and crating usually follows specific packaging and stacking standards to ensure that the product is not damaged during transport. (7) Recycling and sustainability: The sustainability and environmental friendliness of packaging materials should be considered during the packaging design and production process. Encourage the use of recyclable materials and promote packaging recycling and reuse. Based on the above production considerations, adjustments are made to the design drawings and the finished product is shown in Figure 8.

Figure 8. Finished cat litter packaging design

Figure 9. Before and after scanning the cat

On the basis of the packaging, we added the design concept of "meta-universe"-adoption instead of purchase. Firstly, we collect the identification map, which is the picture that needs to be scanned in the AR, the identification map of this project is exported using the design, which can ensure that the identification map is exactly the same as the real thing, and the stability of it will be better. Secondly, upload the recognition map to the meta-space, use the CMS content management system on the PC side of the "Vision", and create five kinds of AR material files, namely, picture material, audio material, video material, 3D material, and subtext links, and create a meta-space with the name of "Baofei Cat Litter". metaspace. After uploading the materials, we switched to the AR editor on mobile to create the visual design. After completing the above design, scan the cat in the package to see the "Adoption Notice" (Figure 9). By integrating the "Adoption Notice" into the packaging design, it can inject fun, interactivity and emotional connection into the brand, thus enhancing the brand's tone and attracting more consumers, and at the same time, providing an opportunity for customers to interact with the brand.

5. Conclusion and Outlook

This paper delves into how the meta-universe has revolutionised the learning factory in the field of education. Powered by virtual reality, augmented reality and global connectivity, the Learning Factory is no longer limited to traditional classroom education, but incorporates a richer, more immersive and personalised approach to learning. This new ecosystem provides more opportunities for students to develop more innovative and real-world skills, promising to drive innovation and progress in education. However, there are still a number of challenges facing meta-universe education. Among them is the issue of accessibility of technology and infrastructure, which needs to be improved, and not all students have easy access to metaverse learning tools. Addressing these inequalities is key to ensure that all students can enjoy the benefits of this emerging ecosystem. In addition, while the metaverse offers students more opportunities for self-directed learning, there is a need for effective guidance and monitoring mechanisms to ensure that students are able to make full use of these resources, while also maintaining the quality and security of their learning.

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