Article

The Three-Dimensional Transformation of Education in the Context of the Intelligent Era: An Assessment Based on Self-Directed Learning of Students Majoring in Infant and Toddler Care Service and Management

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Abstract: Building a learning society and a learning nation centered on lifelong learning for all embodies the vision that "everyone can learn, learning can happen everywhere, and learning can occur at any time." In the era of intelligence, various AI-based learning platforms provide multiple pathways for students in higher vocational colleges to pursue autonomous learning, injecting new vitality into the development of a learning society. This study applies Professor Williamson's Self-Directed Learning Scale to evaluate students across three academic years majoring in Infant Care Service and Management at higher vocational institutions. The findings indicate that students possess a certain degree of self-directed learning ability. The total score of self-directed learning decreases from the freshman to the sophomore year, then rises again in the junior year. Students perform well in learning strategies and interpersonal communication, but show room for improvement in learning evaluation, learning awareness, and learning behavior. Based on these results, this paper explores the three-dimensional transformation of education in the context of the intelligent era-specifically, the temporal transformation of education, the spatial transformation of education, and the subject transformation of education.

Keywords: intelligent age; self-directed learning; temporal turn; spatial turn; subjective turn

Published: 31 October 2025

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1. Introduction

Artificial intelligence (AI) has become a key driving force behind the new wave of technological revolution and industrial transformation. It profoundly reshapes how people produce, live, and learn, highlighting the importance of promoting the deep integration of AI and education. This integration facilitates educational reform and innovation while maximizing the advantages of intelligent technology. The goal is to accelerate the development of lifelong education for all-education that is equitable, personalized, open, and flexible [1].

By reconstructing the educational ecosystem driven by intelligent technology, it is possible to achieve a fundamental transformation of the educational model through the full and deep integration of AI with teachers, students, environments, and cultural elements. Learners can now utilize AI technology to support their learning, thereby breaking the traditional barriers of time, space, and subject. In this sense, the intelligent era provides powerful technological empowerment for realizing "learning for all, learning everywhere, and learning at all times."

However, when learning resources have become so easily accessible in the intelligent era, the question arises as to whether learners can cultivate their own learning abilities in line with the evolving times and the transformation of educational paradigms. This

largely depends on the awakening of self-directed learning awareness-the ability that influences one's lifelong development. The educational revolution in the intelligent age is thus driving the emergence of new learning paradigms.

Self-directed learning (SDL) refers to a learning process initiated and sustained by learners themselves without reliance on external forces. Self-directed learners are able to clearly define their learning needs, formulate learning plans, develop or select learning resources, adopt suitable strategies, and evaluate their outcomes based on their developmental goals [2]. Such learners are proactive, motivated, and purposeful in their learning, making their learning more meaningful and sustainable. Because SDL aligns well with the essential features of lifelong learning-such as self-planning, goal orientation, and self-actualization-it is considered a core competency for future professional development [3].

Students majoring in Infant and Toddler Care Service and Management should therefore possess a strong sense of lifelong learning and self-directed learning ability to meet the growing societal demand for skilled childcare professionals. To cultivate high-quality technical and skilled childcare talent and provide the human capital needed for the development of the childcare industry, educational reform must be deepened, teaching methods must be innovated, and educational paradigms must be restructured to align with the requirements of a learning society.

Based on this background, the present study investigates three cohorts of students majoring in Infant and Toddler Care Service and Management at a higher vocational college. Using the Self-Directed Learning Scale as an assessment tool, this study aims to provide meaningful insights for classroom reform in the intelligent era and to support the creation of "golden courses" in vocational education that enhance students' self-directed learning ability.

2. Data and methods

2.1. General Information

At the initial stage of this study, after gaining an understanding of the Infant and Toddler Care Service and Management major, 248 full-time students from the first, second, and third years of a higher vocational college were selected as research participants, and questionnaires were distributed accordingly. A total of 240 questionnaires were retrieved, and one invalid response was excluded, resulting in an effective rate of 96.37%. Among the valid responses, 228 were female (95.38%) and 11 were male (4.62%). By grade, 110 participants (46.22%) were from two first-year classes, 87 participants (36.55%) from two second-year classes, and 41 participants (17.23%) from one third-year class.

Before the survey, the purpose of the study was clearly explained to all participants. Informed consent was obtained, and participation was entirely voluntary. All data were collected anonymously, with full consideration given to the participants' privacy and willingness to participate.

2.2. Survey Methods

2.2.1. Survey Tools

The study employed an electronic questionnaire distributed via the Wenjuanxing platform. The questionnaire was based on the Self-Directed Learning Assessment Scale developed by Professor Williamson. It consists of five dimensions: learning awareness, learning behavior, learning strategy, learning evaluation, and interpersonal communication. Each dimension contains 12 items, totaling 60 questions, in addition to 3 items on basic demographic information, bringing the total to 63 questions.

The total score of the scale is the sum of all items across the five dimensions, with a minimum of 60 and a maximum of 300 points. A higher score indicates a stronger self-directed learning ability. The Cronbach's α coefficient for the scale is 0.966, demonstrating high reliability. The questionnaire adopts a five-point Likert scale (ranging from "never"

to "always," or from "completely inconsistent" to "completely consistent"), with scores from 1 to 5. Respondents selected the option that best reflected their own learning experience, and all items were positively scored.

2.2.2. Statistical Methods

The research was conducted over two weeks among students from the three grades of the Infant and Toddler Care Service and Management major. The first step involved randomly selecting students from each grade for a pilot test to ensure that the questions were clearly understood. In the second step, a researcher conducted a one-week field survey by class, introducing the purpose of the study and explaining the questionnaire items to ensure that respondents understood all questions and that unrelated factors were minimized. During the process, clear instructions and guidance were provided to ensure accurate completion of the questionnaire.

Participants completed the online survey voluntarily and with informed consent. The online system was set to automatically detect missing or inconsistent responses to ensure data accuracy. In the third step, another researcher used Microsoft Excel to input the collected data and remove invalid questionnaires. In the fourth step, two researchers jointly reviewed the data to correct logical inconsistencies and verify completeness.

In the fifth step, the cleaned data were processed and analyzed. Descriptive statistics were expressed as mean ± standard deviation to represent self-directed learning scores. Data analysis was conducted using IBM SPSS 25.0 and GraphPad Prism software. Frequency and percentage were used to describe categorical variables, while measurement data were expressed as mean ± standard deviation. One-way analysis of variance (ANOVA) was applied for comparisons of mean values across multiple groups. For data not following a normal distribution, non-parametric tests were employed.

3. Results

3.1. Overall Situation of Self-Directed Learning Ability Assessment

The total score of self-directed learning ability among students majoring in Infant and Toddler Care Services and Management was 204.49 ± 23.59 points. As shown in Table 1, the scores for each grade and each dimension are presented in detail. The assessment results indicate that the students' overall self-directed learning ability was at a moderate level, suggesting that while they possessed a certain degree of autonomy in learning, they still relied to some extent on teacher guidance.

Table 1. Score of Self-directed Learning Ability (n = 239).

Grade/Dimension	Learning awareness	Learning strategies	Learning behaviors	Learning evaluation	Interpersonal communication	Total SDL score
Freshman	40.81±3.99	42.39±5.10	39.13±4.60	40.92±5.64	42.27±5.24	205.52±20.06
Sophomore	40.77±5.80	40.97±5.60	37.78±5.60	38.41±6.7	40.1±5.90	198.02±25.65
Junior	41.9±5.03	45.10±5.29	41.71±5.04	42.54±6.14	44.34±5.55	215.59±23.49
P value	0.42	<0.001	<0.001	<0.001	<0.001	<0.001

The descending order of scores across the five dimensions of self-directed learning ability was as follows: learning strategy, interpersonal communication, learning evaluation, learning awareness, and learning behavior (see Table 1). Among these, the top 10 items representing stronger self-directed learning abilities and the bottom 10 items reflecting weaker abilities are listed in Table 2.

Table 2. Ranking of the top 10 items with better self-directed learning performance and the bottom 10 items with poorer performance.

The top 10 entries	Percentage (%)	The last 10 entries	Percentage (%)
I maintain good interpersonal relationships with others.	0.80	I was able to monitor my learning progress.	0.30
I am open to the opinions of others.	0.73	I use concept mapping (mind mapping) as a useful way to understand broad information.	0.29
I found it useful to learn from cases.	0.69	I will identify areas that need further development to learn from all the things I have done.	0.28
I think teachers are facilitators of learning and merely provide information.	0.68	I was able to choose the best way for my own learning	0.28
I found interactive teaching courses to be more effective than just attending lectures.	0.67	I arranged a self-study schedule to help me develop the idea of lifelong learning in my life	0.28
I have found that modern educational interactive technology has enhanced my learning process.	0.61	Even without the guidance of a teacher, I was able to keep learning	0.23
I participated in the group discussion.	0.60	I am able to analyze and critically reflect on new ideas, information, or any learning experience.	0.23
I found that mock teaching is helpful for learning.	0.60	I enjoy exploring information beyond the prescribed course objectives.	0.19
I have breaks in the middle of long working hours.	0.59	I review and relive the new lessons I've learned.	0.17
I found that both success and failure motivated me to study further.	0.57	I raised relevant questions in my teaching.	0.12

3.2. Comparison of Self-Directed Learning Abilities among Students of Different Grades

As shown in Figure 1, the analysis of variance and rank-sum tests on self-directed learning ability among freshmen, sophomores, and juniors revealed the following results. First, compared with freshmen, sophomores showed a decrease in overall self-directed learning ability and in scores for each dimension, with significant differences in learning evaluation and interpersonal communication ($P < 0.05$). Second, compared with sophomores, juniors had significantly higher scores in overall self-directed learning ability and in most dimensions, except for learning awareness, which did not show a significant difference ($P < 0.05$). Third, compared with freshmen, juniors demonstrated higher self-directed learning ability and higher scores in all dimensions, with significant differences observed in learning strategy, learning behavior, and the total score ($P < 0.05$).

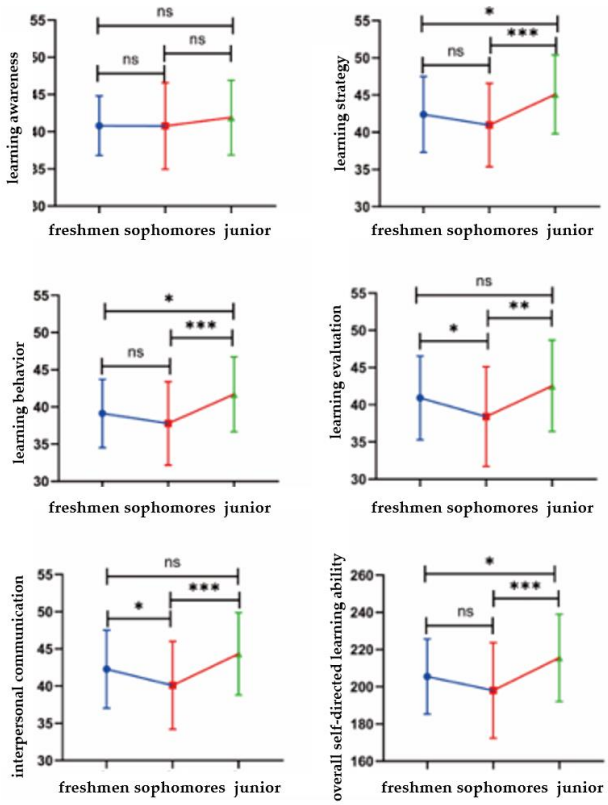

Figure 1. One-way analysis of variance or rank sum test of self-directed ability and dimension scores in different grades.1

4. Analysis and Discussion

4.1. Analysis of the Overall Situation of Student Self-Directed Learning

Self-directed learning ability refers to the capacity of learners to independently manage their own learning process and is a key competence for achieving lifelong learning [4]. This study found that students demonstrated a certain level of self-directed learning ability, with total scores from freshmen to juniors showing a trend of first decreasing and then increasing. Based on the Groo stage self-directed learning model and the results of this assessment, freshmen are at a moderate stage of self-directed learning. Students at this stage are moderately autonomous, show interest in learning, and are often willing to engage in tasks that they find meaningful. They demonstrate confidence and active participation in various activities, though they may have limited awareness of the learning subject itself [5].

Sophomores scored the lowest across overall self-directed learning and the five dimensions. They tend to be more dependent and influenced by educational authority, which affects their self-directed learning. Junior students, however, are in an intermediate stage of self-directed learning with a higher degree of self-orientation. They are engaged learners who have mastered basic knowledge and skills, view themselves as active participants in education, and independently acquire qualifications. They also begin to participate in employment-related activities such as resume preparation and interviews, either under teacher guidance or independently, showing a better overall pattern of self-directed learning compared to other grades.

4.2. Analysis of the Dimensions of Self-Directed Learning by Students

Among the five dimensions evaluated in this study, learning strategy received the highest scores, followed by interpersonal communication. The learning strategy scores of junior students improved significantly, which aligns with previous studies on self-

directed learning among vocational college students [6,7]. In contrast, undergraduate and graduate students in prior studies tended to score lower in these two dimensions [8,9]. This suggests that higher vocational students emphasize practical operation, interaction, and application during learning, and they are able to address learning problems through communication and cooperation. Teaching models that incorporate digital and intelligent interactive technologies, such as cooperative teaching, case-based teaching, and situational simulation, are particularly effective in enhancing their learning.

Undergraduate and graduate students, however, often face greater academic pressure and more demanding professional requirements, with a stronger focus on independent research and innovation, which may explain their lower scores in learning strategies and interpersonal communication. The advantage of higher vocational education lies in its emphasis on situational teaching to develop practical and applied abilities, and this teaching model is an important approach for enhancing self-directed learning. The intelligent era allows for the exploration of more effective context-based teaching models. The human-machine collaborative teaching model proposed in recent research represents a trend in educational reform and practice. This model stimulates students' motivation and interest, improving communication, collaboration, and classroom engagement [10,11]. Therefore, higher vocational colleges should leverage AI-based learning software to reform existing learning strategies and support autonomous learning.

The scores for learning strategies and interpersonal communication show a pattern of first increasing and then decreasing across grades. There is no significant difference in learning strategy scores between freshmen and sophomores, while juniors score significantly higher than both. This may be due to juniors' greater maturity and efficiency in applying learning strategies, and their improved ability to use AI technology to address learning tasks as they accumulate academic and professional knowledge.

Regarding interpersonal skills, freshmen and juniors scored higher than sophomores. Freshmen, adapting to a new environment and social circle, are proactive in communication, resulting in higher scores. Sophomores, having entered a relatively stable comfort zone, may experience some relational burnout and invest less in interpersonal communication, leading to lower scores. Juniors face various pressures and prepare to enter new environments, prompting them to improve their communication skills, consistent with social adaptation theory, which posits that individuals adjust their behavior and thinking to fit new circumstances. Teachers and learners interact to establish mutual care, support, respect, and cooperation, fostering a humanistic atmosphere conducive to self-directed learning [12].

Intelligent teaching systems integrate a variety of functional, user-friendly, and reliable tools that provide immediate feedback, appropriate resources, personalized guidance, and evaluation, facilitating engaged and effective learning [11]. During self-directed learning, learners and educators can establish multiple human-machine collaboration models-teacher-teacher, teacher-machine, teacher-student, student-student, and student-machine-to seek or provide help through discussions, peer assistance, or teacher guidance, thereby enhancing interaction and self-directed learning ability in higher vocational students.

Learning evaluation**,** as considered in this study, refers to self-evaluation where students act as evaluators. Scores for this dimension were moderate overall but relatively low, especially among sophomores, whose scores were significantly lower than those of freshmen and juniors. This may be due to increased academic workload and external evaluations for sophomores, which can reduce engagement in self-evaluation. Research shows that using digital learning systems to track and evaluate learning behavior enables students to understand their progress clearly and improve self-directed learning outcomes [13]. Vocational education emphasizes multi-subject participation in evaluation, equal dialogue feedback mechanisms, and collaborative evaluation processes. The integration of AI technology allows the reconstruction of learning evaluation systems,

effectively promoting lifelong learning and social development [14]. Multi-subject collaborative evaluation supported by AI can enhance the effect of external evaluation on self-evaluation, addressing imbalances in evaluation participation.

In the learning awareness dimension, higher vocational students scored relatively low, whereas undergraduates and graduates in prior studies scored higher [8,9]. This suggests that junior college students lack active learning awareness and need improvement in learning initiative and task completion. Learners' willingness to assume responsibility for their learning is a crucial internal driver for self-directed learning [15,16]. Encouraging engagement in digital learning activities such as online learning can strengthen students' sense of responsibility for planning learning pace and strategies, improving self-directed learning levels [17]. Educators can provide abundant learning materials, flexible methods, and real-job experiences to stimulate interest and motivation, while guiding students to set clear goals, make learning plans, adhere to them, and assume responsibility for their learning.

Learning behavior scores were the lowest among all dimensions, though juniors showed significant improvement. Comparisons with graduate anesthesiologists and undergraduate nursing students indicate similarly low scores in this dimension [8]. This reflects limited autonomy in learning, with many students unable to engage in independent thinking, knowledge review, exploration, questioning, or reflection. The low scores may result from traditional education models that prioritize knowledge transmission over autonomous learning skill development, or from students' unfamiliarity with effective learning methods. Learning behavior is a key indicator of learning level and a predictor of performance [18-20]. High-level self-directed learners can monitor progress, evaluate outcomes, identify gaps, and adjust learning behaviors effectively. Teacher guidance is beneficial, but broader strategies are needed to improve generally low learning behavior scores.

Human-intelligence collaborative learning in blended learning follows a full-cycle logic: pre-class online guidance, in-class blended learning, and post-class online consolidation. This approach supports problem-solving-oriented cooperation, interactive inquiry, project-driven guidance, and scenario simulation for immersive learning experiences [21,22]. Educators should emphasize student leadership, integrate multidisciplinary knowledge, and use blended teaching to optimize classroom and extracurricular learning time [23,24]. Pre-class tasks, in-class exercises, and post-class online consolidation can stimulate learning initiative and improve effective learning behaviors [25].

5. Conclusions and Suggestions

Self-directed learning is a crucial ability for enhancing learning quality and achieving lifelong learning. It plays an important role in improving students' academic performance and supporting career development. Based on the assessment, the following conclusions can be drawn:

Current higher vocational students possess a certain level of self-directed learning ability. They perform relatively well in learning strategies and interpersonal communication but show room for improvement in learning evaluation, learning awareness, and learning behavior. This indicates that interactive technologies in the intelligent era have facilitated the learning process, allowing students to adopt more diverse strategies and enhancing interpersonal communication. These factors contribute to the development of students' self-directed learning skills.

Significant differences in self-directed learning exist across different grade levels. From the first to the third year, three distinct types of self-directed learning emerge: "interest-driven," "dependent," and "engaged." Therefore, cultivating talents in higher vocational education requires breaking through traditional educational models and integrating intelligent technologies to establish a new high-quality education pattern. This

pattern should focus on three main dimensions: building a learning society, integrating vocational talent cultivation models, and exploring educational transformation across time, space, and subject domains. Such an approach provides evidence for constructing a learning society and developing professional talents in Infant and Toddler Care Services and Management in the intelligent era.

5.1. Learning at All Times: The Shift in Educational Time

The theory of educational time suggests that as society progresses, the distribution of educational time becomes more equitable and humane, and its effectiveness improves with social development. In the knowledge acquisition and skill development of vocational college students, the application of artificial intelligence and digital technologies has greatly enhanced educational efficiency.

In the intelligent era, educational time should undergo the following shifts:

First, a functional shift. Self-directed learning emphasizes maximizing the benefits of educational time rather than merely accumulating hours. It focuses on aligning educational time with students' critical periods of development, optimizing teacher guidance, and effectively integrating various educational factors. Blended teaching models in the intelligent era combine online and offline learning, allowing students to flexibly manage their own time while teachers adjust instructional design in real time through intelligent feedback systems.

Second, a structural shift. Learners should gain autonomy at both macro and micro levels, from grade structures, school systems, and curriculum sequences to specific class schedules. For higher vocational colleges, the second year often has the heaviest course load. Future talent training programs should consider reducing and redistributing courses to optimize learning time. At the micro level, classroom time should prioritize student-led activities such as task-based, group, flipped, and smart platform learning, ensuring students control their learning time.

Third, improving time flexibility. Management of self-directed learning time should emphasize scheduling, timing, and rhythm rather than fixed allocations. Intelligent tools allow flexible use of time and enhance learning efficiency. For example, students can complete practical training projects efficiently through cross-course integration, digital tools, and regulated time allocation, achieving effective self-directed learning.

5.2. Everywhere to Learn: A Shift in Educational Space

Self-directed learning occurs continuously in both physical and digital educational spaces. Expanding learning spaces enables students to take initiative and construct knowledge actively.

First, a purposeful shift. Educational space should transition from teacher-centered to learner-centered, supporting lifelong self-directed learning. Smart classrooms, holographic classrooms, and virtual simulation training rooms can enhance students' independent learning. For example, in the Infant and Toddler Care Services and Management major, virtual simulation rooms allow students to practice infant care skills even in the absence of real children, integrating virtual and real environments to support multi-scenario learning.

Second, a synergistic shift. Higher vocational education is inherently cross-boundary, and learning spaces extend beyond classrooms to schools, industries, enterprises, and social institutions. Schools provide basic physical space, industries offer practical learning spaces, and digital technology creates virtual learning spaces. Intelligent technologies connect these spaces, forming a three-dimensional teaching environment that promotes autonomous learning and improves practical teaching outcomes.

Third, a dynamic shift. AI and digital education create a demand for flexible, evolving learning spaces. Learning is a continuous process of self-development, and educational spaces must accommodate this variability. Drawing on Bronfenbrenner's

ecosystem theory, self-directed learning is shaped by interactions across macro, meso, and micro systems. Dynamic, flexible learning spaces enable students to adapt and develop their self-directed learning abilities throughout society.

5.3. Accessible to All: A Shift Towards Intersubjectivity in Education

Intersubjectivity emphasizes both educators and learners as active participants, forming a "subject-subject" relationship while considering educational resources as shared objects. This approach enhances self-directed learning and collaborative interaction.

First, an equality shift. Self-directed learning theory highlights learners' autonomy. Every learner becomes the master of their learning, collecting information, constructing experiences, and using technology independently. Traditional teacher-centered classrooms often limit students' opportunities to ask questions, which can hinder the effectiveness of AI-assisted learning. A shift towards equality allows students to engage actively, driving self-directed learning.

Second, a personalization shift. Individualized learning approaches are essential in the intelligent era. Different learners have diverse cognitive abilities and learning preferences, requiring personalized strategies. Methods such as group learning, problem-based learning (PBL), and case teaching can meet these individual needs, maximizing the effectiveness of self-directed learning.

Third, a value shift. Assessment results show low scores in learning awareness, indicating limited positive learning attitudes. Lifelong learning should cultivate values beyond academic achievement, emphasizing societal contribution, personal development, cultural dissemination, and professional competence. Vocational students should recognize the broader significance of continuous learning, developing far-reaching goals that align with personal and societal progress.

In summary, higher vocational education in the intelligent era should promote flexible, dynamic, and learner-centered approaches, integrating advanced technologies to cultivate autonomous, capable, and value-driven learners.

Funding: This work was supported by the 2022 General Project of the Chongqing "14th Five-Year Plan" for Education Science: "Research on the Resource Allocation and Realization Mechanism of Universal Preschool Care Services in Chongqing" (Project No.: K22YG304281).

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