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# Research on digital informal learning of sports knowledge of Chinese undergraduates

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## Abstract

With the development of digital technology, the proportion of time spent on digital informal learning in students' daily lives is increasing. However, digital informal learning behaviors in sports field have not been fully justified and studied. This article aims to investigate the current situation and influencing factors of digital informal learning of sports knowledge (DIL-S) of Chinese undergraduates. As a cross-sectional study, 401 non-sports undergraduate students from six Chinese universities completed the DIL-S measurement questionnaire. The partial least squares structural equation modeling (PLS-SEM) was constructed to explore association among DIL-S, technology expectancy (TE) and digital competence (DC). Results show that (1) Male students' cognitive learning (CL) was significantly better than that of females; Senior students' metacognitive learning (MCL) was significantly better than that of junior students; Sports university students' cognitive learning, metacognitive learning, and social and motivation learning (SML) were significantly better than that of non-sports university students. (2) Digital competence has a significant positive impact on technology expectancy and digital informal learning of sport knowledge, while technology expectancy has a significant negative impact on digital informal learning of sport knowledge. Based on the results, following conclusions can be made (1) Undergraduates have a strong competence to use digital technology and have a high interest in using digital technology to participate in learning. However, they have a low investment in digital informal learning of sports knowledge fields. (2) Males' sports knowledge learning consciousness and actual performance are better than girls; Compared with freshmen, senior students have stronger monitoring and planning ability for personal sports knowledge learning; The behavior of digital informal learning of sports knowledge in sports university students is better than that of non-sports university students. (3) Digital competence and technological expectancy are key factors influencing digital informal learning of sport knowledge, with digital competence having the most significant impact. These findings underscore the need to enhance the promotion of digital informal learning among undergraduates and to develop assessments that improve their understanding and knowledge of sports.

**Keywords:** Sports knowledge, Digital informal learning, Influencing factors, PLS-SEM model

## Introduction

In the past few years, many policy documents issued by the Chinese government have confirmed that efficient and accurate sports-related knowledge dissemination is important for the country's sports development, especially for promoting public health and physical activity (Healthy China Action Plan Commission 2019; Office of China State Council 2019; General Administration of Sport of China 2021).As the future and hope of national development, students' sports knowledge learning should be given more attention (Côté et al. 2007). While in traditional learning process, students' access to knowledge in the informal learning environment is limited, they rely deeply on the formal learning environments like schools or training institutions (Sawyer 2006). But now, everything has changed greatly because of the rapid development of digital technology (Heidari et al. 2020; Murphy 2020). Digital technology makes the learning process more autonomous and flexible and won't be limited by time and place. This change increases the proportion of digital informal learning (DIL) in students' daily life (He and Li 2019). Studies have shown that DIL can directly affect the quality and effectiveness of college students' formal learning behavior, which is of great significance to the study of higher education (Gikas and Grant 2013; Ungerer 2016; Heidari et al. 2020; Heidari et al. 2021).

Under the background of "Internet+" and "post-epidemic" era, the use of personal computers, mobile devices, and social networks among undergraduate students has become more popular, and the use of digital technology to acquire sports knowledge has become an important way of students' lives (Toquero 2020; Villela et al. 2020). Digital informal learning behavior and its influencing factors have become the focus of the government. The "14th Five Year Plan for Sports Development", as China's programmatic document firstly proposed: (1) Digital technology should be widely used in the field of sports; (2) To promote the development of national physical fitness, promote "Internet + fitness", "Internet of things + fitness", and vigorously promote home fitness and national fitness network events; (3) To build a scientific and authoritative fitness method library, publicity platform and online training platform to provide scientific fitness and sports knowledge and methods for the masses (General Administration of Sport of China 2021). Thus, the use of digital technology will gradually become the mainstream of sports knowledge learning in China.

Nowadays, most researchers focus on DIL of general knowledge learning, curriculum knowledge learning and language learning (Yuan 2009; Evans et al. 2014; Lee 2017; Yang 2020; Lee and Sylven 2021). A meta-analysis focusing on the use of digital media for informal learning in informal learning settings reported 26 relevant investigations and found no findings related to physical education or sports knowledge (Degner et al. 2021). In addition, due to the special nature of sports knowledge, as it includes both descriptive and procedural knowledge, people tend to focus only on procedural knowledge (e.g., acquisition of movement skills) and neglect to understand the acquisition of descriptive knowledge (e.g., knowledge of sports culture and physiological health) in daily physical activities and physical education field (Zhou 2017). Therefore, it is of great significance to analyze the mechanism and current situation of digital informal learning of sports knowledge in China.

The theoretical implications are, by constructing a structural equation model to determine the important influencing factors and influencing modes of digital informal

learning of sports knowledge, the theory of digital informal learning is extended, its applicability in the context of physical education discipline is verified, and a theoretical basis is provided to guide the revolution of the learning mode of sports knowledge. In addition, this study focused on the differences of grades, genders, and university categories, which is conducive to further deepening the theoretical explanation of the concept of digital informal learning.

The practical implications are, an in-depth understanding of the current situation of digital informal learning of undergraduate students' sports knowledge can help understand how undergraduate students achieve the behavioral process of sports knowledge learning (Ungerer 2016), which can guide educators to use digital technology to facilitate students' formal learning in physical education or various other fields (Chan et al. 2015) as well as to achieve quality learning on the move (Gikas and Grant 2013). In addition, it also helps to fully utilize the advantages of digital informal learning and provides evidence to support the government, society, and universities to further develop appropriate policies and programs to build efficient digital informal learning platforms to improve the quality and efficiency of students' sports knowledge acquisition.

This study focuses on the digital informal learning of sports knowledge (DIL-S) of undergraduates in universities in China, including the following two research questions:(1) To investigate the current situation of DIL-S of Chinese undergraduates. (2) To explore the influencing factors and mechanism of DIL-S of Chinese undergraduates.

## Literature review

### Sports knowledge

In the 1950s, with the rapid progress of society and the deeper understanding of sports, a group of Western sports philosophers began to focus on the concept of sports knowledge (Zhang 2012). In the book "An Introduction to Sports Philosophy," Osterhoudt (1991) believes that sports knowledge is a field of knowledge involving self-knowledge, which originates from the basic characteristics of sports and the knowledge about self, sports, and the wider world in its forms of achievement. The above defines the intrinsic value of sports knowledge from its nature but ignored the role of sports knowledge on the body and the objective world to some extent (Zhang 2012). Hyland (1990), in his book "The Philosophy of Sport," argues that sport tends to explicitly show who we are, to be brave, generous, loyal, and so on. In general, sport is a place of self-knowledge because of its nature and structure, which can reveal some unnoticed qualities. This view further expands Osterhoudt's view, emphasizes the specific content of self-knowledge represented by sports knowledge, and believes that it has explicit characteristics. Besides, some scholars did not give a clear definition of "what is sports knowledge" but explained "what sports knowledge have" (Osterhoudt 1991; Luo 2001; Gao 2012). This study defines sports knowledge as the procedural knowledge with physical activity as the core, declarative knowledge based on physiology and pedagogy knowledge, and interdisciplinary knowledge closely related to people's lifelong development and career planning (Zhou 2017).

### Digital informal learning

On the contrary to most people's thought that formal environments like schools are the most important place for human beings to learn knowledge, even school-age children spend about 79% of their time doing informal learning outside school. In one's career development, 70–80% of vocational skills come from informal learning. In the longer term, people spend nearly 90% of their lives doing informal learning (Ji et al. 2017).

At present, digital technology has been widely used in students' lives, whether in formal environment or in private life. Digital technology makes knowledge easier to find, access, operate and disseminate, which together constitute the dynamic process of digital learning (McGeveran and Fisher 2006). Huang et al. (2016) define DIL as learning opportunities and environments mediated by digital technology in informal learning environments. He et al. (2017) believe that the actual behavior of digital informal learning refers to the process of actually adopting digital technology in informal learning, which can be regarded as a dynamic informal learning process using digital technology, including what individuals can choose to learn, how to learn, and how to evaluate learning process in daily life.

Mayer (1998) and Vermunt's (1996) research pointed out that DIL includes the following different aspects: (1) Cognitive Learning (CL) refers to the actual behavior of learners to control learning through physical or psychological control in the process of interaction with digital media; (2) Metacognitive Learning (MCL) is a process of planning learning behavior and monitoring the understanding and creation of knowledge. (3) Social and Motivation Learning (SML) refers to learners interacting with others to help their own learning or gain learning motivation. In this study, sports knowledge is a part of general knowledge, which can be seen as a part of DIL. Thus following the concept above, considering that DIL-S includes (1) cognitive learning (CL), that is, learners control their actual behavior of sports knowledge learning through physical or psychological control; (2) metacognitive learning (MCL), that is, planning sports knowledge learning behavior, monitoring the process of understanding and creating sports knowledge; (3) social and motivational learning (SML), that is, the learner interacts with others to help themselves in sports knowledge learning or sports knowledge learning motivation.

### Digital competence

The concept of Digital Competence (DC) was first proposed by the European Commission (2006) and was regarded as one of the eight key competencies for lifelong learning (He and Zhu 2017). DC refers to the individual's confident and critical use of Information Society Technology (IST) for work, leisure, and communication. It is based on the basic skills of Information and Communication Technologies (ICT), such as the use of computers to retrieve, evaluate, store, produce, display, and exchange information, and to communicate and collaborate over the Internet (European Commission 2006). This view emphasizes that not any direct use of digital technology belongs to the category of digital ability, and individuals must also have a positive and clear subjective attitude (He et al. 2018). At the same time, the European Commission believes that DC includes the following three components: (1) Instrumental skills and knowledge (ISK) for digital tools and media; (2) Advanced skills and knowledge (ASK) for communication and

cooperation, resource management, problem solving and active and meaningful participation; (3)Attitudes to social-ethical (ASE), digital social-ethical knowledge and skills for cross-cultural, critical, creative, responsible and autonomous use of technology (Janssen et al. 2013; He and Li 2019).

Calvani et al. (2012) constructed a highly recognized digital capability evaluation model (He and Zhu 2017). The main idea is that digital competence is a multidimensional ability, which includes (1) Technological Skills (TS), which refers to the ability of users to flexibly discover and deal with new problems and technical backgrounds, including visual literacy, solving obstacles and understanding technical concepts; (2) Cognitive Skills (CS), which refer to the ability of users to read, select, interpret and evaluate data and information and to consider the accuracy and reliability of information, including the ability to combine text and visual data, organize structured data and conduct information research; (3) Ethical Knowledge (EK), refers to the ability of individuals to interact constructively and the sense of responsibility with others in using technology, including ensuring the safety of online information acquisition and respecting the knowledge of others (Calvani et al. 2012). Scholars agree with this view and attach significant importance to the positive impact of students' digital competence in this framework on their learning and performance in a formal digital learning environment (Van et al. 2017; Elstad and Christophersen 2017). It is also believed that digital abilities can affect students' digital informal learning behavior (He et al. 2018; Nyikes 2018). This research follows Calvani's concept, believes that DC refers to the individual's confident and critical use of information society technology for work, leisure, and communication, which includes three dimensions: technological skills (TS), cognitive skills (CS) and ethical knowledge (EK).

#### Technological expectancy

As society evolves, the information technology industry needs to understand more deeply the extent of users' behavioral intention to use and adopt information systems, and this has led to the birth of the Technology Acceptance Model (TAM). This model was first constructed based on the Theory of Reasoned Action (TRA) in the field of social psychology (Fishbein and Ajzen 1975), whose main idea is that an individual's use of a system depends on his or her behavioral intention, which is influenced by perceived usefulness (PU) and perceived ease of use (PEU) (Davis et al. 1989; Chen 2011; Li 2016). Since then, many technology acceptance models with different perspectives have been generated in the academic community. In recent years, many studies have applied the Unified Theory of Acceptance and Use of Technology (UTAUT), which was developed based on the TAM model, to specifically examine students' technology-assisted learning behaviors (Arenas-Gaitán et al. 2011; Abbad 2021). Technological Expectancy (TE), which refers to individuals' intentions and attitudes toward the use of technology (Lai et al. 2012), has its theoretical basis in the UTAUT (He and Li 2019). The model believes that Performance Expectancy (PE), Effort Expectancy (EE), Social Influence (SI) and Facilitating Conditions (FC) are the four key variables that affect users' behavioral intention, attitude, and actual use behavior. Gender, Age, Experience, and Voluntariness of Use are the four moderating variables (Li 2016). Results show that the UTAUT model can explain about 70% of the users' behavior, and its explanatory power exceeds

any other information system acceptance model (Marchewka and Kostiwa 2007; Abbad 2021).

The research literature on the UTAUT model in technology-assisted learning environments such as digital learning and mobile learning has proved that the key factor affecting students' learning behavior is TE (Chen 2011). TE can have a significant positive impact on the actual behavior of respondents, and the four key factors affecting TE are EE, PE, SI, FC. From the perspective of educational research (Arenas-Gaitán et al. 2011; Chang et al. 2012), EE is defined as the degree to which an individual believes that no effort is required to use a specific system; PE is defined as the degree to which individuals believe that using a particular system will improve their academic performance; FC is defined as the degree to which individuals perceive that technical resources and solutions can be used to support learning; SI is defined as the degree to which a person perceives that other important people think he should or should not perform learning behaviors (Venkatesh et al. 2012). To sum up, this research believes that TE refers to the individual's intention and attitude towards the use of technology, which includes EE, PE, FC, SI.

The effect of digital competence on digital informal learning has been confirmed in several studies (He and Zhu 2017; He et al. 2018; Mehrvarz et al. 2021), and technology expectancy has been identified as a crucial factor influencing the adoption of individual learning behaviors (Chen 2011; Meyers et al. 2013). Besides, He and Li (2019) constructed a theoretical model based on digital competence, technology expectancy, and digital informal learning in a study based on cultural differences and found that digital competence and technology expectancy can significantly and positively influence digital informal learning. Meanwhile, digital competence can significantly influence technology expectancy. The findings provide a description of the relationship between the three from a general learning perspective, while they are unable to explain the acquisition of knowledge with different disciplinary backgrounds. Therefore, this study will explore whether this model can effectively explain digital informal learning in the field of sport knowledge. This study proposes the following hypothesis:

*H1* Digital Competence (DC) has a significant positive impact on digital informal learning of sports knowledge (DIL-S).

*H2* Technology Expectancy (TE) has a significant positive impact on digital informal learning of sports knowledge (DIL-S).

*H3* Digital Competence (DC) has a significant positive impact on Technology Expectancy (TE).

## Method

### Design

This research is a cross-sectional study. DIL-S is taken as the dependent variable, and DC and TE are taken as the independent variables (He and Li 2019). From the perspective of gender, university category and grade, the research model of DIL-S of Chinese undergraduates is constructed, as shown in Fig. 1.

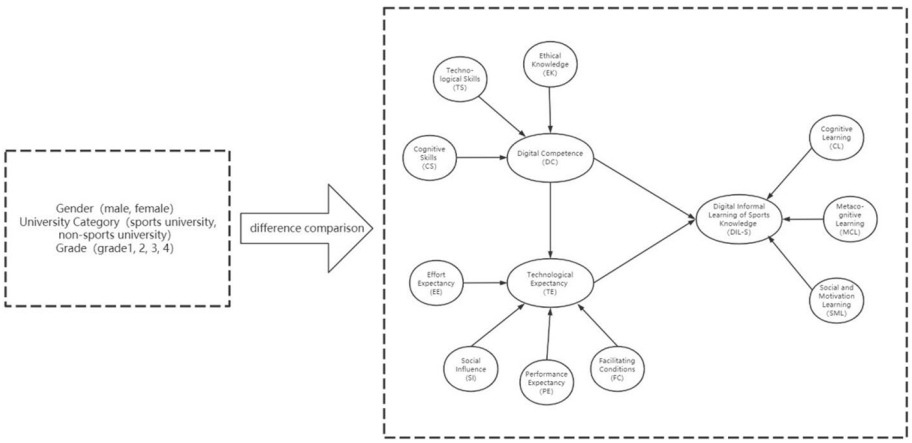


**Fig. 1** Research model of DIL-S of Chinese undergraduates

The research tool DIL-S measurement questionnaire adapted from the DIL measurement questionnaire compiled by He et al. (2019). The questionnaire consists of three parts. The first part is the cover letter of the questionnaire, which is mainly used to let the respondents understand the main contents of the questionnaire, emphasize the confidentiality of the questionnaire results, and help the respondents grasp the meaning of the proper nouns in the questionnaire, so that they can answer more accurately. The second part is the information collection of demographic statistical variables. The third part is the main measurement items, including 3 senior dimensions (e.g. DC, TE, DIL-S), and 10 junior dimensions (e.g. CL, MCL, SML, PE, EE, SI, FC, TS, CS, EK), for a total of 40 questions.

All the measurement items included in the third part of the questionnaire design were measured using the five-point Likert scale method. Each measurement item was given a quantitative score of 1 to 5, of which 5 was the highest score (indicating "very agree") and 1 was the lowest score (indicating "very disagree").

### Participants

This study adopts the method of stratified sampling. In order to ensure the universality and accuracy of the research, according to the geographical region and school type, one sports university and one non-sports university are selected in the northern, eastern, and southwestern regions of China, respectively. The subjects are non-sports (not sports-related majors) undergraduates from 6 universities, namely Beijing Sport University (BSU, in northern China), Shanghai university of sport (SUS, in eastern China), Chengdu Sport University (CSU, in southwestern China), Beijing Language and Culture University (BLCU, in northern China), Nanjing University (NU, in eastern China) and Chongqing Technology and Business University (CTBU, in southwestern China).

The survey was conducted from January 25 to March 5, 2022, and questionnaires were distributed both online and offline. Online collection used the *Wenjuanxing* applet ($n = 336$), and participants can access the online questionnaire homepage by scanning the QR code or clicking the link, without any password protection. Through the program setting, the same participant can only fill out the questionnaire once,

avoiding the situation of multiple responses. Offline questionnaires were distributed in the campuses of universities ($n=65$). All questionnaires were completed and collected without incentive initiative. 423 questionnaires were distributed for the first time, and 421 questionnaires were recovered. Screening criteria: (1) choosing the same answer for all questions in the questionnaire will be eliminated. (2) If the filling time of online questionnaire is less than 2 min, it will be eliminated. Through classification and screening, 65 questionnaires that did not meet the requirements were eliminated and 45 questionnaires were re-collected. Finally, 401 valid questionnaires were obtained, with an effective rate of 95.25%, adolescents' demographic characteristics can be seen in Table 1.

Regarding the gender composition, the sample size of males was 210 (52.4%) and the sample size of females was 191 (47.6%). As for the composition of grades, the sample size of freshmen was 98 (24.4%), sophomores were 88 (21.9%), juniors were 119 (29.7%), and seniors were 96 (23.9%), which shows that the sample size of juniors was the largest, and the sample size of the rest of grades was relatively similar. Regarding the composition of schools, the sample sizes of Beijing Sport University, Shanghai university of sport, Chengdu Sport University, Beijing Language and Culture University, Nanjing University, and Chongqing Technology and Business University were 70, 58, 71, 63, 67, and 72, accounting for 17.5%, 14.5%, 17.7%, 15.7%, 16.7%, and 17.9%, respectively. Among them, the sample sizes of sports and non-sports universities were 199 (49.6%) and 202 (50.4%), respectively.

### Data analysis

Considering that partial least squares (PLS) can maximize the predictive ability and can deal with formative and reflective indicators, this study used partial least squares structural equation modeling (PLS-SEM). For the comparison of different data parameters, t-test and one-way ANOVA are used according to the situation. SmartPLS 3.0 version and SPSS22.0 version were used for data analysis.

**Table 1** Participants' demographic characteristics

| Name of University | Gender | Grade 1 | Grade 2 | Grade 3 | Grade 4 | Total |
|---|---|---|---|---|---|---|
| Beijing Sport University | Male | 5 | 3 | 8 | 16 | 32 |
| | Female | 9 | 6 | 7 | 16 | 38 |
| Shanghai university of sport | Male | 3 | 2 | 15 | 14 | 34 |
| | Female | 8 | 3 | 7 | 6 | 24 |
| Chengdu Sport University | Male | 24 | 11 | 13 | 0 | 48 |
| | Female | 12 | 6 | 5 | 0 | 23 |
| Beijing Language and Culture University | Male | 15 | 10 | 0 | 8 | 33 |
| | Female | 11 | 13 | 0 | 6 | 30 |
| Nanjing University | Male | 5 | 6 | 7 | 15 | 33 |
| | Female | 6 | 16 | 3 | 9 | 34 |
| Chongqing Technology and Business University | Male | 0 | 0 | 24 | 6 | 30 |
| | Female | 0 | 12 | 30 | 0 | 42 |
| Total | | 98 | 88 | 119 | 96 | 401 |

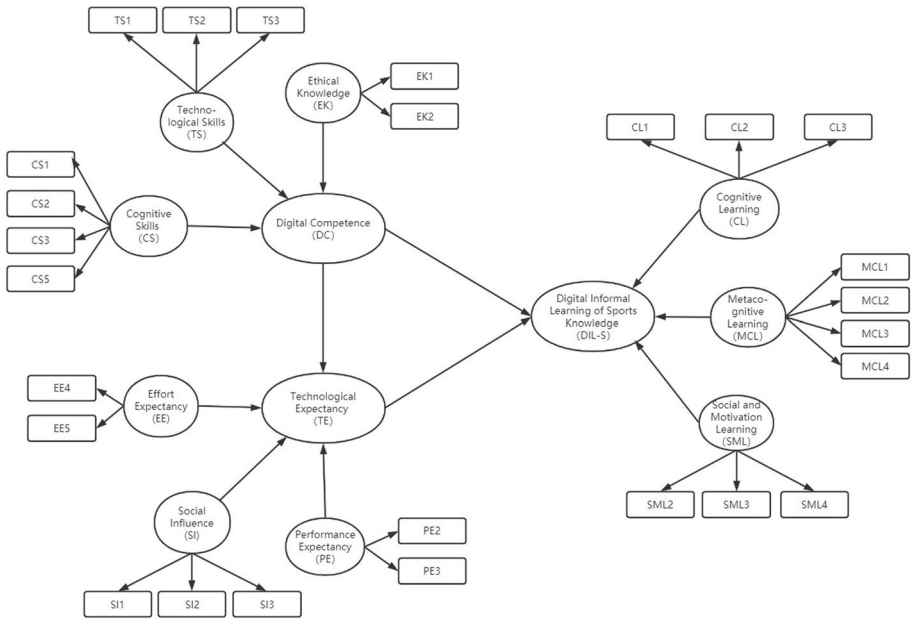


**Fig. 2** PLS-SEM model of DIL-S of Chinese undergraduates

**Table 2** Convergent validity analysis results

| Dimension | Average variance extracted (AVE) |
|---|---|
| CL | 0.634 |
| MCL | 0.582 |
| SML | 0.672 |
| PE | 0.840 |
| EE | 0.775 |
| SI | 0.828 |
| TS | 0.680 |
| CS | 0.640 |
| EK | 0.783 |

## Results

### Convergent validity analysis

PLS Algorithm was used to calculate the model, and the results showed that the factor loadings of TS4, TS5 and CS4 was less than 0.7. Although the factor loading of SML1, PE1, EE1, EE2, EE3, EK3, FC1, FC2, FC3, FC4, FC5 was greater than 0.7, it was lower than its cross-loading or the value is close, indicating that its subordinate relationship was not clear, and some of the questions had similar meanings, so the above questions were deleted. The factor loadings of each item after correction were greater than 0.7, and the modified PLS-SEM model is shown in Fig. 2.

The convergent validity results can be seen in Table 2. The AVE values of the nine dimensions were between 0.582 and 0.840, all of which were greater than 0.5, with high convergence validity.

**Table 3** Results of discriminant validity analysis

| | CL | CS | EE | EK | MCL | PE | SI | SML | TS |
|---|---|---|---|---|---|---|---|---|---|
| CL | **0.796** | | | | | | | | |
| CS | 0.563 | **0.800** | | | | | | | |
| EE | 0.348 | 0.429 | **0.881** | | | | | | |
| EK | 0.424 | 0.482 | 0.726 | **0.885** | | | | | |
| MCL | 0.647 | 0.601 | 0.375 | 0.400 | **0.763** | | | | |
| PE | 0.337 | 0.396 | 0.870 | 0.665 | 0.390 | **0.917** | | | |
| SI | 0.383 | 0.430 | 0.788 | 0.872 | 0.382 | 0.802 | **0.910** | | |
| SML | 0.659 | 0.452 | 0.345 | 0.336 | 0.739 | 0.362 | 0.385 | **0.820** | |
| TS | 0.539 | 0.633 | 0.511 | 0.489 | 0.591 | 0.454 | 0.454 | 0.599 | **0.825** |

Diagonal bold font is the square root of AVE, the rest is the correlation coefficient

**Table 4** Reliability analysis results of each dimension

| Dimension | Cronbach's alpha | Composite reliability (CR) |
|---|---|---|
| CL | 0.711 | 0.838 |
| MCL | 0.759 | 0.847 |
| SML | 0.756 | 0.860 |
| PE | 0.810 | 0.913 |
| EE | 0.712 | 0.873 |
| SI | 0.893 | 0.935 |
| TS | 0.765 | 0.865 |
| CS | 0.812 | 0.876 |
| EK | 0.723 | 0.878 |

### Discriminant validity analysis

The discriminant validity was based on the Fornell–Larcker Criterion. The analysis results can be seen in Table 3. The square root of the AVE value of each dimension was greater than the correlation coefficient of any other variable. Therefore, the model had high discriminant validity. The results of convergent validity and discriminant validity analysis showed that the constructed model had good validity.

### Reliability analysis

In this study, Cronbach's alpha, and Composite Reliability (CR) were used as indicators for reliability analysis. The results showed that the Cronbach's alphas of the 9 dimensions were between 0.711 and 0.893, all greater than 0.7. The Composite Reliabilities (CR) were between 0.838 and 0.935, which were greater than 0.7, as shown in Table 4. Therefore, each dimension has high reliability.

### The current situation of DIL-S of Chinese undergraduates

In the DIL-S of Chinese Undergraduates model, SI got the highest score of 3.76, SML got the lowest score of 3.42, and the SD ranged from 0.57431 to 0.76323, as shown in

**Table 5** Overall level of DIL-S of Chinese undergraduates

| Dimension | N | Min | Max | Mean | SD |
|---|---|---|---|---|---|
| CL | 401 | 1.00 | 5.00 | 3.43 | 0.71742 |
| MCL | 401 | 1.00 | 5.00 | 3.49 | 0.66681 |
| SML | 401 | 1.00 | 5.00 | 3.42 | 0.76323 |
| PE | 401 | 1.00 | 5.00 | 3.66 | 0.71263 |
| EE | 401 | 1.00 | 5.00 | 3.70 | 0.68554 |
| SI | 401 | 1.00 | 5.00 | 3.76 | 0.66842 |
| TS | 401 | 1.00 | 5.00 | 3.53 | 0.64768 |
| CS | 401 | 1.50 | 5.00 | 3.65 | 0.57431 |
| EK | 401 | 1.00 | 5.00 | 3.69 | 0.67050 |

**Table 6** Gender differences in DIL-S of Chinese undergraduates

| Dimension | Male ($n=210$) (Mean, SD) | Female ($n=191$) (Mean, SD) | *t* | *p* |
|---|---|---|---|---|
| CL | (3.52, 0.70) | (3.34, 0.72) | 2.483 | 0.013* |
| MCL | (3.50, 0.61) | (3.48, 0.73) | 0.233 | 0.816 |
| SML | (3.43, 0.71) | (3.40, 0.82) | 0.461 | 0.645 |
| PE | (3.71, 0.73) | (3.62, 0.69) | 1.255 | 0.210 |
| EE | (3.76, 0.68) | (3.63, 0.68) | 1.956 | 0.051 |
| SI | (3.85, 0.68) | (3.67, 0.64) | 2.727 | 0.007** |
| TS | (3.58, 0.65) | (3.48, 0.64) | 1.536 | 0.125 |
| CS | (3.73, 0.54) | (3.56, 0.60) | 2.894 | 0.004** |
| EK | (3.79, 0.67) | (3.59, 0.66) | 2.882 | 0.004** |

*$p<0.05$, **$p<0.01$

Table 5. Scores of the dimensions related to DC and TE were higher, and scores of the three dimensions related to the DIL-S (CL, MCL, SML) were relatively low.

Two sample t test was used to compare the difference between male and female in different dimensions. The results showed that there was significant difference in the dimensions of SI, CS and EK ($p<0.01$), and the scores of males were significantly higher than those of girls. There was significant difference in CL ($p<0.05$), males scored significantly higher than females. There was no significant difference in the dimensions of MCL, SML, PE, EE, and TS, as shown in Table 6. Among the three dimensions related to DIL-S, only CL had significant difference.

Through two sample t tests, this study compared the difference between sports university students and non-sports university students in different dimensions. The results showed that there was extremely significant difference in CL, MCL, SML, TS and CS ($p<0.001$), and the scores of sports university students were significantly higher than those of non-sports university students. There was very significant difference in the dimension of EK ($p<0.01$), and the scores of sports university students were significantly higher than those of non-sports university students; there was significant difference in the dimension of SI ($p<0.05$), and the scores of sports university students were significantly higher than those of non-sports university students; there

**Table 7** University type differences in DIL-S of Chinese undergraduates

| Dimension | Sports universities ($n=199$) (Mean, SD) | Non-sports universities ($n=202$) (Mean, SD) | *t* | *p* |
|---|---|---|---|---|
| CL | (3.74, 0.56) | (3.13, 0.73) | 9.416 | 0.000*** |
| MCL | (3.74, 0.63) | (3.25, 0.61) | 7.971 | 0.000*** |
| SML | (3.67, 0.70) | (3.17, 0.74) | 6.832 | 0.000*** |
| PE | (3.72, 0.68) | (3.61, 0.74) | 1.509 | 0.132 |
| EE | (3.73, 0.65) | (3.67, 0.72) | 0.954 | 0.341 |
| SI | (3.84, 0.64) | (3.68, 0.69) | 2.376 | 0.018* |
| TS | (3.79, 0.56) | (3.29, 0.63) | 8.372 | 0.000*** |
| CS | (3.89, 0.49) | (3.41, 0.55) | 9.204 | 0.000*** |
| EK | (3.81, 0.57) | (3.58, 0.74) | 3.447 | 0.001** |

*$p<0.05$, **$p<0.01$, ***$p<0.001$

was no significant difference in PE and EE, as shown in Table 7. There all has significant difference in the three dimensions related to DIL-S.

Through one-way ANOVA, the difference in DIL-S among undergraduates of different grades was compared. The results showed that there was extremely significant difference in CS ($p<0.001$). There was significant difference in MCL and EE among different grades ($p<0.05$). There was no difference in the dimensions of CL, SML, PE, SI, TS and EK, as shown in Table 8. Only MCL was significantly different among the three dimensions related to DIL-S.

In order to determine the specifics of the three dimensions with significant difference, homogeneity of variance test was performed on the three, as shown in Table 9. Among

**Table 8** Grade differences in digital informal learning of undergraduate sports knowledge

| Dimension | Grade 1 ($n=98$) (Mean, SD) | Grade 2 ($n=88$) (Mean, SD) | Grade 3 ($n=119$) (Mean, SD) | Grade 4 ($n=96$) (Mean, SD) | *F* | *p* |
|---|---|---|---|---|---|---|
| CL | (3.36, 0.54) | (3.36, 0.78) | (3.47, 0.65) | (3.54, 0.87) | 1.502 | 0.213 |
| MCL | (3.38, 0.63) | (3.38, 0.69) | (3.55, 0.63) | (3.65, 0.70) | 3.827 | 0.010* |
| SML | (3.46, 0.80) | (3.35, 0.83) | (3.47, 0.63) | (3.36, 0.81) | 0.698 | 0.554 |
| PE | (3.66, 0.71) | (3.61, 0.70) | (3.67, 0.74) | (3.71, 0.70) | 0.276 | 0.843 |
| EE | (3.64, 0.65) | (3.57, 0.72) | (3.71, 0.67) | (3.86, 0.68) | 3.046 | 0.029* |
| SI | (3.83, 0.69) | (3.67, 0.65) | (3.70, 0.65) | (3.85, 0.68) | 1.804 | 0.146 |
| TS | (3.48, 0.66) | (3.48, 0.55) | (3.53, 0.58) | (3.64, 0.78) | 1.270 | 0.284 |
| CS | (3.56, 0.55) | (3.54, 0.42) | (3.58, 0.64) | (3.91, 0.56) | 9.748 | 0.000*** |
| EK | (3.65, 0.73) | (3.67, 0.66) | (3.62, 0.63) | (3.85, 0.66) | 2.350 | 0.072 |

*$p<0.05$, **$p<0.01$, ***$p<0.001$

**Table 9** Homogeneity of variance test results

| | Levene's test | *df*1 | *df*2 | *p* |
|---|---|---|---|---|
| MCL | 0.138 | 3 | 397 | 0.937 |
| EE | 0.608 | 3 | 397 | 0.610 |
| CS | 3.503 | 3 | 397 | 0.016* |

*$p<0.05$

**Table 10** Post hoc test results

| Dimension | (I) Grade | (J) Grade | SD (I–J) | SE | *p* | Test method |
|---|---|---|---|---|---|---|
| MCL | Grade 4 | Grade 1 | 0.27083* | 0.09475 | 0.044 | Scheffe |
| | | Grade 2 | 0.26231 | 0.09738 | 0.066 | |
| | | Grade 3 | 0.09961 | 0.09052 | 0.750 | |
| EE | Grade 4 | Grade 1 | 0.22162 | 0.09770 | 0.163 | Scheffe |
| | | Grade 2 | 0.28551* | 0.10041 | 0.046 | |
| | | Grade 3 | 0.14929 | 0.09333 | 0.466 | |
| CS | Grade 4 | Grade 1 | 0.35284* | 0.08012 | 0.000 | Games-Howell |
| | | Grade 2 | 0.37429* | 0.07272 | 0.000 | |
| | | Grade 3 | 0.33003* | 0.08207 | 0.000 | |

*$p < 0.05$

**Table 11** $R^2$ and modified $R^2$

| Dimension | $R^2$ | Modified $R^2$ |
|---|---|---|
| DIL-S | 0.403 | 0.400 |
| TE | 0.708 | 0.708 |

them, MCL and EE were equal in variance and should accept the null hypothesis, so the Scheffe method was used for post hoc test. The variance of CS was different, and the null hypothesis should be rejected. Therefore, the Games-howell method was used for post hoc test, as shown in Table 10.

In the MCL dimension, senior students' score was significantly higher than freshmen. In the EE dimension, senior students' score was significantly higher than sophomores ($p < 0.05$). In the dimension of CS, senior students' score was significantly higher than freshmen, sophomores, and juniors ($p < 0.05$).

### Influencing factors of DIL-S of Chinese undergraduates

In order to test the explanatory power of the structural equation model, the coefficient of determination $R^2$ was used as a standard. The latent variables in the first-order model as an indicator, the second-order model using Bootstrapping operation, and the second-order model fitting results were shown in Table 11. From the table, the $R^2$ value of DIL-S was 0.400, indicating that TE and DC can explain 40% of its variance; the $R^2$ value of TE was 0.708, indicating that DIL-S and DC can explain 70.8% of its variance. To sum up, TE and DC are the key factors affecting DIL-S (Hair et al. 2014).

Bootstrapping operation was used for the first-order model and the second-order model. The number of sub-sample sampling was set to 5000 times, and the significance level was set to 0.05. The path coefficient results were as follows in Table 12, with the final model results shown in Fig. 3. It can be seen:

1. The direct path coefficient of DC on DIL-S was 0.846, and significantly positive, H1 holds.
2. The direct path coefficient of TE on DIL-S was − 0.275, and significantly negative, H2 false.

**Table 12** Path validity test results

| Influencing path | Path coefficient | *p* |
|---|---|---|
| DC -> DIL-S | 0.846*** | 0.000 |
| TE -> DIL-S | − 0.275** | 0.002 |
| DC -> TE | 0.840*** | 0.000 |
| CL -> DIL-S | 0.325*** | 0.000 |
| MCL -> DIL-S | 0.431*** | 0.000 |
| SML -> DIL-S | 0.368*** | 0.000 |
| PE -> TE | 0.316*** | 0.000 |
| EE -> TE | 0.283*** | 0.000 |
| SI -> TE | 0.468*** | 0.000 |
| TS -> DC | 0.402*** | 0.000 |
| CS -> DC | 0.491*** | 0.000 |
| EK -> DC | 0.299*** | 0.000 |

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

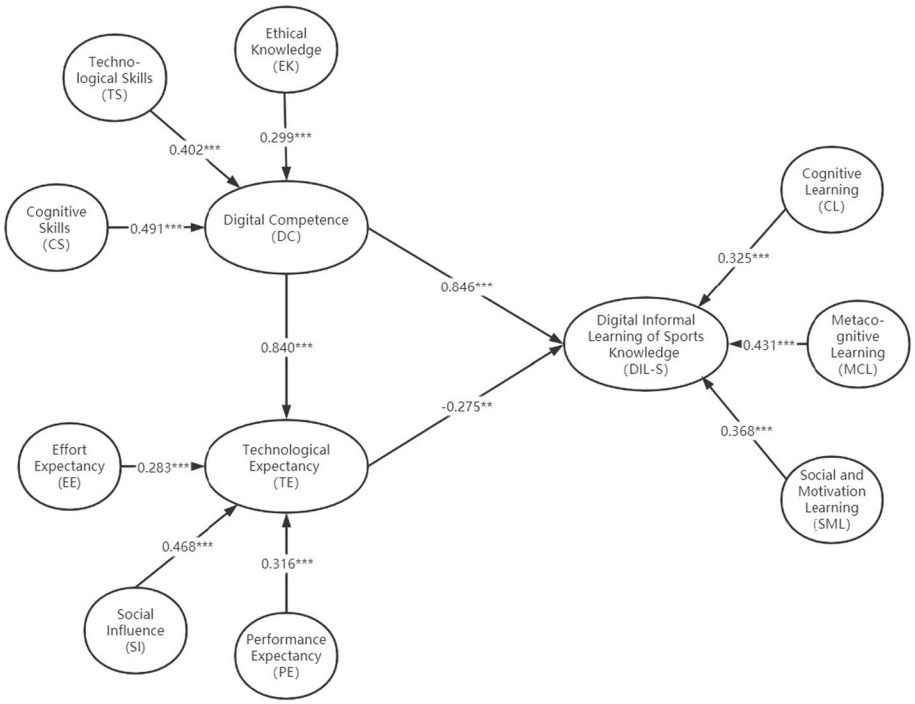


**Fig. 3** Path coefficient of PLS-SEM model of DIL-S. *Note*: *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

3. The direct path coefficient of DC on TE was 0.840, and significantly positive, H3 holds.

Bootstrapping results also supported a negative indirect effect of TE on DC and DIL-S ($\beta = -0.258$, $p = 0.000$), confirming the mediating effect of TE. In addition, the direct path coefficients of CL, MCL, SML on DIL-S were 0.325, 0.431 and 0.368 respectively, all showed a significant positive impact. The direct path coefficients of PE, EE and SI on TE were 0.316, 0.283 and 0.468 respectively, all showed a significant

positive impact. The direct path coefficients of TS, CS and EK on DC were 0.402, 0.491 and 0.299 respectively, all showed a significant positive impact.

## Discussion and conclusion

### The current situation of DIL-S of Chinese undergraduates

In general, the mean values of the dimensions related to DC and TE were higher, but the dimension related to DIL-S scored lower than the former two. This shows that the current undergraduates have a strong ability to use digital technology as a whole and have a high interest in using digital technology to participate in learning, but their investment in digital informal learning of sports knowledge is relatively low. This can also be further verified by the path coefficient results. The higher TE, the lower DIL-S, showing a significant negative impact. Nowadays, with the increasing popularity of digital technology, although the time and frequency of undergraduates using digital technology for informal learning is increasing, they are reluctant to use digital technology to spend more time on the acquisition of sports knowledge. This aspect reflects the lack of understanding of the importance and significance of sports for undergraduates, and they cannot consciously learn sports knowledge through subjective initiative (Ma et al. 2020a, b). On the other hand, it reflects the sports knowledge acquisition in the minds of students' priority is not high, which may be due to the university not having mandatory sports knowledge learning tests and assessment (Zhang et al. 2010; Li 2017).

In the comparison of gender difference, only the CL dimension had significant difference, and boys were higher than girls. There was no significant difference in MCL and SML dimensions, which is inconsistent with past research conclusions and people's traditional cognition. In the past, investigations on the sports learning of undergraduates majoring in non-sports in Chinese universities, the researchers found that boys were significantly better than girls in terms of learning attitude, consciousness, and actual behavior of sports knowledge (Han 2006; Gao and Gu 2017). Therefore, the status quo of digital informal learning of boys' sports knowledge should also be significantly better than that of girls. A probable reason for this result is that with the progress of society and the public's deeper understanding of sports, women's awareness of sports knowledge learning has gradually increased. Especially in the just-concluded 2020 Tokyo Olympic Games and 2022 Beijing Winter Olympic Games, the excellent play and example setting of female athletes could further promote gender equality in sports and improve women's sports learning and participation in daily life (Huang 2022). Thus, the female undergraduates' MCL of sports knowledge was improved internally, and the social and motivational learning was improved externally, which ultimately led to the insignificant difference between boys and girls in the above two dimensions.

In the comparison of grade difference, only the MCL dimension had significant difference, and the senior students were significantly better than the freshmen. There was no significant difference in CL and SML, which is inconsistent with previous studies. Previous studies have shown that with the increasing time on university campus, undergraduates are receiving higher education for longer and their social needs are becoming more abundant. Therefore, they will have a deeper understanding of the role, significance, and value of sports activities, and thus increase their time and energy in sports knowledge learning (Yang and Zhou 2005; Han 2006). At the same time, most universities will

arrange the main courses in the lower grades. As the grade increases, the academic burden will gradually decrease, which further increases the possibility of senior students participating in sports knowledge learning and sports activities. Therefore, it is generally believed that the DIL-S of senior students should be significantly better than that of junior students. The possible reasons for the results of this study are as follows: freshmen have just entered the university through the Chinese Gaokao, and their understanding and participation in sports are relatively low. In addition, the extracurricular time that can be freely allocated is increased, and the extracurricular life is richer. Therefore, the self-monitoring and planning ability of sports knowledge learning will be relatively poor. On the contrary, senior students, after four years of university study, especially some of them through the initial internship into the community, will have relatively strong monitoring and planning capabilities. However, in addition, due to the personality characteristics of undergraduates have been basically determined, and there is no rigid assessment of sports knowledge in the university campus environment, the learning situation of students' sports knowledge will not change greatly with the change of grade.

In the comparison of school category difference, undergraduates in sports universities were significantly better than those in non-sports universities in the dimensions of CL, MCL and SML. This not only verifies the previous views, but also conforms to the traditional cognition, and proves that the current situation of DIL-S of sports university undergraduates in China is significantly better than that of non-sports ones. Among all kinds of universities, the campus sports culture of sports universities has a unique advantage (Gu et al. 2010). It is directly influenced by sports culture and is deeply imprinted with sports culture everywhere (Ye 2005; Gu 2022). Therefore, the sports universities' non-sports undergraduates' sports knowledge, understanding and participation should be better than non-sports ones.

#### Influencing factors of DIL-S of Chinese undergraduates

This study proposes and demonstrates the PLS-SEM model of DIL-S, which proves that digital competence and technical expectancy are the key factors affecting digital informal learning of sports knowledge. Among them, the influence of DC was the most significant, and it also positively affected the DIL-S and TE. This shows that improving students' competence to use digital technology can help improve the learning effect. In addition, the study also demonstrates that CL, MCL and SML are the three key dimensions that positively affect DIL-S; EE, PE and SI are the three key dimensions that positively affect TE. CS, TS and EK are three key dimensions that positively influence DC.

The exception is that TE had a significant negative impact on DIL-S, which is inconsistent with H2. This also led to a negative indirect effect of TE as a mediating variable for DC and DIL-S. In general, the higher degree that individuals may use technology to learn, that is, the higher TE is, the higher DIL is. The probable reason is that the digital informal learning of sports knowledge is only a small part of the digital informal learning field. The undergraduates are more willing to spend their informal time in other learning fields when the technical expectancy is improved, thus reducing their time in sports knowledge learning (Li 2017). Since there is no mandatory assessment test for sports knowledge in universities (the undergraduate physical fitness test is a physical

competence test, which does not fall under the category of sports knowledge), students may spend less time on DIL-S within a certain amount of digital informal learning time.

## Implications for practice/policy

### Attention should be paid to the popularization of digital informal learning among undergraduate students

Digital technologies make knowledge easier to find, manipulate, integrate, and disseminate, all steps that are central to teaching and learning in higher education (McGeveran 2006). In informal learning environments, students can access these digital resources at their own discretion, without regard to any learning objectives, thus ensuring both student interest and aiding formal learning in class, meanwhile reducing the burden on the instructor (Laurillard 2009). Thus, the acquisition of sports knowledge through digital informal learning offers a new way of thinking about improving students' understanding of physical education, in that student rather than teacher, "customize" the content and resources for sports or physical education learning. At the government level, policies should be formulated to integrate and create standardized, scientific, interesting, and high-quality online sports knowledge learning resources based on policy guidance, and to provide digital informal learning channels for college students. At the school level, attention should be paid to guiding students to change their learning style, reduce their reliance on classroom learning, and actively and consciously carry out knowledge learning outside of class. At the teacher level, physical education teachers can also try to adopt new teaching modes such as flipped classroom and micro-classroom, encourage students to use the digital resources around them, and increase their awareness of and participation in digital informal learning of sports knowledge (Huang and Oh 2016; Mehrvarz et al. 2021).

### Assessments should be constructed to enhance undergraduate students' knowledge and understanding of sports

This study found that undergraduate students were reluctant to use digital technology to spend more time on sports knowledge acquisition despite the increasing time and frequency of using digital technology for informal learning. This suggests that students' knowledge and understanding of sports needs to be enhanced. In fact, there is currently a disconnect between what Chinese undergraduate students know about sports and what they actually do (Liu et al. 2022). On the one hand, sports, physical education and exercise are directly related to physical health, and everyone knows that regular participation in physical activities can keep their bodies healthy and understands the harm of lacking physical activities; on the other hand, due to the long-standing influence of "exam-oriented education", "emphasis on literature over sports" and "sports is only about physical fitness", they are unable to form a correct view of sports after entering college, and fail to form reasonable exercise habits and the concept of lifelong sports (Gao and Gu 2017). The result is that students are often well aware and lacking in action. China State Council (2020) has states that "the assessment of physical education for college students need to be strengthened." In the future, education departments can set scientific and reasonable sports knowledge level tests from the guiding role of educational evaluation, so that students can realize

the importance through certain compulsory force and ensure that the proportion of students' digital informal learning of sports knowledge increases (Heidari et al. 2021).

## Limitations and future research

The quantitative analysis method used in this study will inevitably produce some errors due to the limitation of the total sample size, affecting the results. At the same time, this limits the researchers' predictive analysis of the results and cannot accurately verify the causes of a series of results. In future research, the combination of qualitative and quantitative methods can be further used to improve the accuracy of the results analysis.

In addition, this study is a cross-sectional study, and the survey results only represent a preliminary trend. Individuals often have contingency and uncertainty when using digital technology, and are greatly affected by emotions, environments, and important others, which will affect the accuracy of conclusions. In the future, research can try to combine cross-sectional research with longitudinal research, and further narrow the scope of use of digital technology to study the characteristics of digital informal learning.

Finally, with the continuous popularization of online education, the use of digital media and virtual networks to complete university courses has become the norm, which has led to the definition of digital informal learning becoming increasingly blurred. Adolescents may not be able to accurately distinguish between digital formal learning and digital informal learning, and ultimately affect their judgment of personal digital informal learning. Therefore, in the future, it is possible to consider conducting research on specific stages or models of digital informal learning, such as investigating students' digital informal learning of sports knowledge at a certain time period or using a specific type of software.

**Abbreviations**

| | |
|---|---|
| DIL-S | Digital informal learning of sports knowledge |
| DC | Digital competence |
| TE | Technology expectancy |
| CL | Cognitive learning |
| MCL | Metacognitive learning |
| SML | Social and motivation learning |
| PE | Performance expectancy |
| EE | Effort expectancy |
| FC | Facilitating conditions |
| SI | Social influence |
| TS | Technological skills |
| CS | Cognitive skills |
| EK | Ethical knowledge |

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YZ designed the study, conducted the survey, analyzed data and completed the article. ZH contributed in method design and analyzing data. All authors have read and reviewed the manuscript in detail.

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**Availability of data and materials**

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**Competing interests**
The authors declare they have no competing interests.

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