Article

For Educational Inclusiveness: Design and Implementation of an Intelligent Tutoring System for Student-Athletes Based on Self-Determination Theory

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Abstract: Student-athletes frequently struggle to strike a balance between their academic and athletic responsibilities. Various factors, such as age and competitive level, contribute to differences in their academic motivation and identity, showcasing the multifaceted needs they possess. While self-determination theory (SDT) has been proven effective for explaining student-athletes academic needs, its integration into learning design for this group remains limited. The developing AI technology, especially the Intelligent Tutoring System (ITS), offers the potential for creating personalized learning environments that can cater to the varying levels of motivation among student-athletes within the framework of SDT. Therefore, our paper explored how to build an SDT-based ITS for student-athletes to enhance their academic engagement and motivation. A two-stage experiment was conducted for: (a) identifying academic challenges faced by student-athletes in an online ITS; (b) evaluating the effectiveness of an SDT-based ITS design; and (c) exploring how autonomy, competence, and relatedness design affect their motivation. Results revealed that student-athletes face three challenges in learning in ITS: inflexible technology, identity missing, and mismatched learning difficulty. However, a significant improvement in academic engagement and motivation was shown when student-athletes faced an SDT-based ITS. In the meantime, the athletic motivation, which leads them to higher athletic performance, remains preserved and unaffected, showing a favorable outcome for student-athletes. This paper can provide practical implications for building a more inclusive and diverse learning environment for student-athletes.

Keywords: student-athletes; intelligent tutoring system; self-determination theory; academic learning; educational inclusiveness

1. Introduction

Student-athletes constitute a unique subgroup of the student population, juggling the demands of academic pursuits with rigorous athletic training and competition. They face distinct challenges, as balancing academic responsibilities, rigorous training, and competition schedules is no easy feat. Numerous studies have highlighted the importance of studying education for student-athletes as a separate and distinct topic [1,2].

In current studies, there is a growing focus on academic achievement among student-athletes [3–5], as it may directly impact their athletic performance and future career prospects. Research has shown that student-athletes who excel academically are more likely to perform well on the field, court, or track [6]. Moreover, academic success can help student-athletes gain admission to prestigious colleges or universities, opening up more opportunities for future success in their athletic careers [7]. Additionally, academic achievement can improve the overall well-being of student-athletes, as it is linked to higher levels of athletic self-esteem, confidence, and mental health [8]. In summary, academic
success is crucial for the overall success and well-being of student-athletes and should be prioritized alongside athletic achievement.

However, it is crucial to acknowledge that academic motivation and identity among student-athletes vary, notably influenced by their competitive level and age. For instance, an insightful study by Lupo et al. [9] sheds light on the intricate relationship between student-athletes’ identities and these variables. The study reveals that younger and elite student-athletes tend to exhibit stronger academic identities compared to their older peers, while those competing at elite levels display more robust identity values than their sub-elite counterparts. Furthermore, differences in motivation for sports and career goals also surface within the domain of student-athletes, with elite athletes demonstrating higher motivation levels than their sub-elite counterparts [10]. This underscores the multifaceted nature of student-athletes’ learning requirements.

With the development of educational technology, AI systems, particularly Intelligent Tutoring Systems (ITS), show promise in providing flexibility and personalized tutoring to cater to their varying learning needs. Thus, the present study delves into the academic challenges encountered by student-athletes during their engagement with ITS and introduces an ITS design grounded in the self-determination theory (SDT) to address the inherent psychological needs identified within SDT. Furthermore, this study investigates shifts in academic engagement among student-athletes and examines the impact of the SDT-based ITS on their academic and athletic motivation.

2. Literature Review

2.1. Academic Performance among Student-Athletes

Previous studies suggest that student-athletes may encounter challenges in their academic performance and motivation. For instance, Van Rens et al. [11] investigated student-athletes in the Netherlands and found that those attending Topsport Talent Schools were less motivated in their regular academic studies, resulting in lower academic achievements in both secondary and further education. Similarly, Strum et al. [12] conducted a study to see the differences between being a student-athlete in Division I and Division III. The results showed that if someone strongly sees themselves as an athlete, they might not see themselves as much as a student, and vice versa. Pot et al. [13] also observed that participation in a sports program led to an increase in athletic identity and a decrease in academic identity in 10 to 12 year olds, with boys experiencing a decline in student identity. Earlier studies have also suggested a negative impact of being an athlete on academics [14,15].

These findings contribute to the prevalent belief that athletes are academically inferior to their non-athlete counterparts, which is often portrayed in a negative light [16–20]. Such stereotypes and biases held by peers, coaches, and faculty members perpetuate this viewpoint, leading to anxiety and self-fulfilling prophecies among student-athletes [21,22]. However, it is crucial to recognize that this stereotype is inaccurate and unfair to student-athletes. Some research has shown that student-athletes can perform as well or even better academically than their non-athlete peers. For instance, Routon and Walker [23] found only a small, negative, and insignificant effect on GPA between student-athletes and non-athletes in America. Grimit [6] found that athletic participation can lead to better academic performance, improved time management skills, increased motivation to complete degree requirements, enhanced class attendance and engagement, and a smoother college lifestyle transition for student-athletes. Moreover, participation in sports programs has demonstrated positive impacts on academic performance [24].

These studies underscore the potential of student-athletes to excel academically and emphasize the importance of supporting them to further enhance their academic success. It is essential to challenge negative stereotypes and biases against student-athletes and recognize their academic potential and achievements.

Motivation plays a significant role in student-athletes’ engagement with academic activities [25]. Since they fulfill dual roles as student-athletes, it is important to consider
their motivation for school and sports. Research indicates that strong academic motivation is linked to higher academic achievement among student-athletes [18,25]. Conversely, when student-athletes are more motivated by athletics, their academic grades may suffer compared to those motivated by academics [26]. The athletic identity of student-athletes can sometimes overshadow their academic identity, leading to reduced interest in their academic work. To improve their academic performance, it is vital to identify strategies that make learning more engaging and motivating for student-athletes.

2.2. Intelligent Tutoring Systems

Intelligent Tutoring Systems (ITS) are computer tools that use detailed methods to understand how learners think and feel. They provide personalized tutoring steps for students. These systems have been made for many subjects like mathematics, medicine, law, and reading to help learners gain specific skills and learn how to think about their own learning [27]. ITS has gained widespread recognition in education because it offers personalized learning experiences that accommodate individual needs and learning steps. Compared to other online learning methods like video courses, one of the main benefits of ITS is its ability to cater to the diverse needs of students with varying levels of knowledge, abilities, and learning preferences. For example, ITS can provide remedial support to struggling students and challenge more advanced learners with more complex material [28]. Additionally, ITS can accommodate different learning styles, such as visual, auditory, and kinaesthetic, by adapting their instruction accordingly [29]. Furthermore, ITS can provide immediate feedback and adaptive scaffolding to assist students in mastering challenging concepts and skills and promote deeper learning [30]. These features make ITS beneficial for different students, including those with disabilities, non-native language speakers, and gifted learners, among others [31]. ITS has been shown to improve student learning outcomes, motivation, and engagement across various educational contexts and disciplines [31,32].

Integrating ITS into education can be a promising strategy to enhance the quality and equity of learning for different students. However, there is still a significant gap in the use of ITS among student-athletes. Because student-athletes have unique academic demands, they require personalized support and equal opportunities to succeed academically. Therefore, this study used ITS as a personalized online learning tool and explored potential academic difficulties student-athletes may face while using it. Furthermore, the study aims to propose redesign strategies to make the ITS more suitable for student-athletes.

2.3. SDT in Student-Athletes and SDT-Based Design in Education

Self-determination theory (SDT) provides a scholarly foundation for examining motivation. This theory has considerable implications for classroom methodologies and broader educational policy changes [33,34]. The theory proposes that there are three essential psychological needs inherent in every individual: autonomy, relatedness, and competence. These needs underpin self-directed actions and involvement. SDT has been widely used to explore the factors influencing academic motivation in the studies of student-athletes. For instance, researchers assessed the academic motivation of 1042 Canadian college students using SDT to determine the extent to which different types of motivation influenced students’ persistence or withdrawal from school [35]. The findings showed that students who dropped out had notably reduced levels of identified, integrated, and intrinsic regulation in comparison to students who continued their education. Yukhymenko-Lescroart [36] linked the two-fold model of passion with the self-determination theory to study the motivational factors influencing how student-athletes see their efforts in both athletic and academic areas. The results showed that effort in sports was driven by interest in the sport, whereas effort in academics was influenced by how students identified with their academic role and how much they valued their courses.

These studies have shown that the SDT can serve as a useful framework for investigating academic motivation in student-athletes. They have also highlighted a significant
connection between autonomy, competence, relatedness, and the academic engagement of student-athletes. However, with many studies demonstrating that SDT could explain the academic change in student-athletes, there have been few studies focused on how to support their autonomy, competence, and relatedness in their learning environment.

Current SDT-based learning support for common students can be primarily categorized into two aspects: teacher support and digital support [37]. Autonomy-supportive teachers nurture students’ needs, interests, and preferences, allowing them to make choices in their learning and avoiding strict deadlines or constraints [38–40]. Relatedness-supportive teachers focus on emotional and motivational support, creating warm and caring learning environments where students feel connected and comfortable expressing their learning needs [41,42]. Competence-supportive teachers communicate clear expectations, provide guidance and feedback, and offer well-designed learning materials [43]. Ryan and Deci, who established the self-determination theory (SDT), recently indicated that further research using SDT is necessary to delve into how technology can directly enhance motivational needs. (i.e., digital support) [34]. Additionally, to the best of our knowledge, there has been no SDT-based design on ITS to improve students’ motivation and engagement. Therefore, our study aims at implementing SDT into ITS design and exploring the effectiveness of SDT-based ITS among student-athletes.

3. The Present Study
3.1. Research Questions

In this study, three research questions need to be addressed:
RQ1: How did inflexibility, identity missing, and mismatched learning difficulty influence student-athletes when they faced an ITS?
RQ2: To what extent did the student-athletes improve their engagement and motivation in academics within the SDT-based ITS?
RQ3: How did the autonomy, competence, and relatedness design in the ITS affect the change in motivation and participation of student athletes?

3.2. Participants

The research took place at a sports school in China. A group of 33 student-athletes specializing in wrestling and weightlifting were recruited to participate in this research study. The participants had an average age of 16.2 years and were primarily enrolled in junior or senior high schools. Among the participants, 16 were boys and 17 were girls. The sports school’s ethics committee approved this study. Before the research began, all student-athletes were informed and recognized as participants.

3.3. Instrument

The ITS we used in this study is named the ‘Lexue 100 Intelligent Tutoring System’, developed by ‘Lexue 100’ Co., Ltd., in Beijing, China. It has been proven to be effective in helping school students learn math and other subjects [44]. This system offers students step-by-step assistance in solving math and English questions online, guiding them from intermediate steps to final answers. It is specifically designed with algorithms for intelligent tutoring based on individuals’ learning levels and supports a wide range of math and English topics, with more than 10,000 questions available.

We conducted a two-stage experiment from September 2022 to December 2022 to answer the research questions, as shown in Figure 1. In Stage 1, a one week experiment was conducted among student-athletes. Initially, test questions were selected from the Lexue 100 database for the subjects of Math and English by their teachers to create a set of digitized test questions. These questions were then integrated into the Lexue 100 ITS platform for step-by-step tutoring.
Second, the task was assigned as homework that could be completed in the evening, allowing them to attend daytime classes and training. All students received the same test questions. We offered customized tablets that can only open the Lexue 100 application, and all answers should be provided through these tablets. The Stage 1 experiment is a pilot study in order to explore problems students might face in a traditional ITS environment.

3.4. Data Collection and Analysis Method in Stage 1

In Stage 1, this study conducted interviews with 9 randomly selected student-athletes (labeled S1 to S9) and collected the log data of all students in the ITS backstage database. The interviews mainly focused on the academic problems in their daily lives and the usage problems student-athletes face when interacting with ITS. The researchers used a qualitative method with a flexible interview guide. This allowed them to gather detailed information and delve into the participants’ thoughts, emotions, and opinions on the subject.

The interview data were examined using thematic analysis, employing both deductive and inductive methods [45,46]. For a thorough and unbiased understanding of the data [47], established codes like “technology” and “identity” were applied to categorize various segments of the information. After this deductive coding, inductive coding was undertaken to spot other important themes in the participants’ answers that had not been previously labeled.

Finally, emerging themes were pinpointed as consistent patterns evident throughout the data that encapsulated vital information relevant to the research questions. These themes were categorized under three primary headings: autonomy, relatedness, and competence. To validate the accuracy of the results, around 33% of the data (specifically, interviews with three out of nine participants chosen at random) was re-analyzed for consistency by two coders. This approach is consistent with best practices suggested in the qualitative research literature [48]. The consistency between the two coding sessions was evaluated using Cohen’s Kappa, which showed a significant level of agreement (Cohen’s Kappa = 0.79).

When disagreements occurred, they were addressed through dialogue, re-coding specific sections of the data, and adjusting the names of some themes. The NVivo 12 software was used to help with transcribing, coding, and structuring the thematic analysis.

3.5. Results in Stage 1

Not all student-athletes were willing to use ITS, even if the questions in ITS were their homework, as shown in Table 1. The absences happened heavily in the Math subject, where only 21.2% of student-athletes finished the given questions, and the mean accuracy was just around 60%. The same situation occurred in the English subject, with 55.7% of student-athletes completing the given questions. Furthermore, their performance in English was superior to that in Math, which had a mean accuracy of 72.05%.
Table 1. Descriptive statistics of test results in Stage 1.

<table>
<thead>
<tr>
<th>Subject</th>
<th>Completed Person Number</th>
<th>Completed Rate</th>
<th>Mean Accuracy</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Math</td>
<td>7</td>
<td>21.2%</td>
<td>59.28%</td>
<td>12.89%</td>
</tr>
<tr>
<td>English</td>
<td>25</td>
<td>55.7%</td>
<td>72.05%</td>
<td>21.35%</td>
</tr>
</tbody>
</table>

Note: Completed Person Number means how many students completed the given test questions; Completed rate means the percentage of Completed Person Number in the total student count.

To answer RQ1, qualitative data from nine student-athletes’ interviews (labelled S1 to S9) were analyzed. Student-athletes faced three main challenges in their online learning experience: inflexible technology, missing identity, and mismatched learning difficulty. The following sections explain these three challenges in detail.

3.5.1. Inflexible Technology

While ITS heavily relies on technology, student-athletes may encounter additional problems due to the limitations of certain devices. As highlighted by student S4, “I prefer to study on computers because I’m always studying on there during COVID-19. However, here (at Stage 1), I can only use tablets. I know they’re convenient, but they make it more difficult for me to operate them”. On the other hand, many student-athletes are accustomed to using smartphones for various aspects of their lives, ranging from communication to entertainment. This familiarity and comfort with smartphones make them an intuitive choice for accessing learning materials. As S1 expressed, “Compared to using tablets for studying, I’m more familiar with smartphones”. Additionally, portability becomes a focal point for student-athletes, especially during athletic training. “The mobility of a large screen can be great for sharing ideas and discussing answers with my peers, but it’s heavy and hard to hold, especially when I’m outside (without the tablets)”, said S4. In summary, for student-athletes in different learning environments, educators should support their diverse learning needs by providing them with various learning devices and allowing them the autonomy to choose the learning management system that best suits them.

3.5.2. Identity Missing

Student-athletes are likely to consider themselves athletes rather than students. S7 said, “It is difficult for me to answer whether I am a student or an athlete. I prefer to be considered as an athlete as most of the time I stay with my coach”. As athletes, they lack a sense of belonging to their student identity, which makes them negative about their student responsibilities. Identity construction is influenced by the sociocultural environment, which provides individuals with social roles and expectations that guide their behavior and influence how they perceive themselves [49]. As S5 expressed, “I feel like an athlete because I have a coach in real life, and I don’t feel like a student because I don’t have a teacher in real life (when using ITS)”. The growth and preservation of identity are greatly influenced by social interactions and relationships. From this perspective, providing more interaction with teachers and classmates and raising awareness of student identity are important for student-athletes’ academic learning.

3.5.3. Mismatched Learning Difficulty

In Stage 1, students were given the same test questions regardless of their learning backgrounds. Some student-athletes found the questions too easy, while others found them quite tricky. The mismatched test questions primarily affected the motivation of student-athletes, particularly when they started doing their homework online after training. According to S3, a student-athlete in wrestling, “After training, I feel exhausted and find it hard to do anything else. Wrestling also requires mental effort to come up with strategies. Moreover, I realized I was unable to solve any of the test questions, which completely demotivated me from continuing my studies”. Stereotypes such as “being inferior in academics” have been proven to decrease motivation among student-athletes. As S6 said, “I don’t think academic studying is my strength, and those questions (in Stage 1) were too...
hard for me. So, I just give up my homework to rest”. The lack of a sense of mastery in their learning can worsen when assigned difficult tasks. However, on the contrary, they will not improve their knowledge level by always providing simple questions. Therefore, ensuring a balanced and suitable learning task for student-athletes should be given consideration.

3.6. Procedure in Stage 2

In Stage 2, we designed a newer ITS based on SDT, aiming to address the learning problems we investigated in Stage 1. The following ITS designs were suggested to fulfill the three intrinsic needs identified by SDT:

- Autonomy: We offered a system that can be accessed on different learning devices, such as PC-based, tablet-based, and smartphone-based systems. This allowed students to plan their learning time and choose the device that best suited their environment for completing their learning tasks. To ensure all device types were available, we continued to offer the tablets used in Stage 1. Students reported having their own smartphones and personal computers or laptops, providing them with the freedom to select their preferred device;

- Relatedness: In the user interface, we included a “question answering” button that allowed students to chat with real teachers on the backstage through a dialog box. We invited teachers from their daily teaching sessions to answer students’ questions in the evening. Additionally, to promote a positive and familiar atmosphere, we introduced an animation teacher character. This character interacted with students by offering encouraging words and displaying happy or sad expressions based on the correctness of their answers;

- Competence: To address competence-related challenges, we offered different learning tasks based on the Item Response Theory (IRT). The difficulty level of each question was calculated using data from former users who answered the Lexue 100 ITS. Additionally, we assessed different student-athletes’ latent traits (capacity) values based on their answers from Stage 1. Using the IRT-based algorithm, we could calculate the correct probability of various learning tasks for each student and dynamically assign slightly easier tasks based on their individual capacity levels. The effectiveness of the algorithm used in the system was validated by previous studies [44,50].

The procedure of Stage 2 was based on the procedure of Stage 1, with the main difference being the experiment duration. In Stage 2, the experiment lasted for 11 weeks, whereas in Stage 1, it only lasted for 1 week. By incorporating these ITS designs and extending the experiment duration, we aimed to create a more supportive and engaging learning environment for student-athletes, addressing the challenges identified in Stage 1 and promoting better academic outcomes.

3.7. Data Collection and Analysis Method in Stage 2

In Stage 2, we collected log data from the ITS and conducted interviews with 9 student-athletes (labelled S1 to S9), 2 teachers (labelled T1 and T2), and 1 coach (labelled C1) to gain comprehensive insights. To examine the changes in student-athletes’ academic and athletic motivation in Stage 2, we utilized the Student-Athletes’ Motivation toward Sports and Academics Questionnaire (SAMSAQ) developed by Gaston-Gayles [51]. SAMSAQ consists of 30 items that measure Academic Motivation (AM), Student Athletic Motivation (SAM), and Career Athletic Motivation (CAM). Participants had to express their level of agreement with each statement using a six-point Likert scale, where “strongly agree” was marked as 6 and “strongly disagree” as 1.

As the participants in this study are middle school students and the original SAMSAQ was designed for college students, we modified the questionnaire to make it more suitable for middle school students. The modified questionnaire was tested and showed sufficient reliability (Cronbach’s alpha = 0.79).

The students completed the modified SAMSAQ questionnaire at the beginning and at the end of Stage 2. To analyze the data, t-tests were conducted to compare the differences in
students’ AM, SAM, and CAM before and after Stage 2. This analysis allowed us to assess any changes in motivation levels throughout the experimental period (Table 2).

Table 2. Descriptive statistics of test results in Stage 2.

<table>
<thead>
<tr>
<th>Subject</th>
<th>Completed Person Number</th>
<th>Completed Rate</th>
<th>Mean Accuracy</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Math</td>
<td>24</td>
<td>72.7%</td>
<td>70.45%</td>
<td>7.86%</td>
</tr>
<tr>
<td>English</td>
<td>30</td>
<td>90.9%</td>
<td>85.58%</td>
<td>12.31%</td>
</tr>
</tbody>
</table>

Note: Completed Person Number means how many students completed the given test questions; Completed rate means the percentage of Completed Person Number in the total student count.

3.8. Results in Stage 2

3.8.1. Engagement

To answer RQ2, we conducted a comparison of the test results between Stage 1 and Stage 2. The results indicated improvements in the accuracy of test questions in both Math and English in Stage 2 (from 59.28% to 70.45% in Math and from 72.05% to 90.9% in English). However, it is important to consider that the test questions in Stage 2 were different, and students received varied questions due to the recommendation algorithm used in the ITS. Therefore, the improvement in accuracy needs to be interpreted cautiously.

Additionally, the standard deviation of accuracy in Stage 2 was lower than that in Stage 1 (from 12.89% to 7.86% in Math and from 21.35% to 12.31% in English). This suggests that the precise algorithm used in the ITS effectively assigned learning tasks with suitable difficulty levels for student-athletes, contributing to the reduction in variability in their performance.

Another crucial factor to consider is the completion rate, which was higher in Stage 2 than in Stage 1 (from 21.2% to 72.7% in Math and from 55.7% to 90.9% in English). This indicates that student-athletes were more engaged and committed to their learning in Stage 2 when they used the SDT-based ITS. The improved completion rates demonstrate a positive impact on motivation and interest in academic learning among student-athletes.

3.8.2. Motivation

To answer RQ2, motivation differences across three aspects were calculated using t-tests, and the results are shown in Table 3. After implementing the designed intervention based on ITS, there was a significant increase ($t = -2.56, p < 0.05$) in the Academic Motivation of the student-athletes. However, their Student Athletic Motivation and Career Athletic Motivation only showed a slight decrease, and the results were not significant ($t = 0.58, p > 0.1$) or ($t = 0.96, p > 0.1$). This indicates that the intervention design can effectively enhance student-athletes’ academic motivation without negatively affecting their athletic motivation.

Table 3. A t-test of different motivations before and after Stage 2.

<table>
<thead>
<tr>
<th>Motivations</th>
<th>State</th>
<th>Mean</th>
<th>SD</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>AM</td>
<td>Before Stage 2</td>
<td>3.40</td>
<td>0.42</td>
<td>-2.56</td>
<td>0.018*</td>
</tr>
<tr>
<td></td>
<td>After Stage 2</td>
<td>3.68</td>
<td>0.43</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAM</td>
<td>Before Stage 2</td>
<td>4.24</td>
<td>0.34</td>
<td>0.58</td>
<td>0.565</td>
</tr>
<tr>
<td></td>
<td>After Stage 2</td>
<td>4.17</td>
<td>0.60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAM</td>
<td>Before Stage 2</td>
<td>4.03</td>
<td>0.52</td>
<td>-2.56</td>
<td>0.018*</td>
</tr>
<tr>
<td></td>
<td>After Stage 2</td>
<td>3.95</td>
<td>0.64</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: * $p < 0.05$. AM = Academic Motivation; SAM = Student Athletic Motivation; CAM = Career Athletic Motivation.

4. Discussion

Using mixed research methods, this two-stage experiment aimed to investigate the academic problems faced by student-athletes in an ITS and the impacts of an SDT-based environmental design on student-athletes’ learning engagement and motivation. The
experiment was conducted in two stages, with the same participants, to create a comparable experimental environment.

4.1. Theoretical Contributions

To answer RQ1, a thematic analysis was conducted on the interviews from Stage 1, and the log data revealed that student-athletes were not fully engaged in academic tasks. The thematic analysis identified three main problems faced by student-athletes: inflexible technology, identity missing, and mismatched learning difficulty. The log data further supported these findings, showing lower engagement and accuracy in the Math subject among student-athletes. This study expands the exploration of learning problems faced by student-athletes in ITS, providing evidence for the importance of designing environments that facilitate their motivation and engagement.

To answer RQ2, the log data from both stages and the SAMSAQ questionnaire were utilized. The results from Stage 2 demonstrated that the SDT-based ITS significantly enhanced student-athletes’ academic motivation (AM) while not negatively affecting their athletic motivation (SAM and CAM). SAM measures the degree to which student-athletes are motivated to achieve athletic tasks, and CAM measures their specific intention or desire to play at an elite or professional level. These two sub-dimensions together represent the athletic motivation of student-athletes.

Previous studies have shown a negative correlation between athletic motivation and academic engagement, suggesting that student-athletes who are reminded of their athletic identity may perform worse academically. However, our results contradict this notion, as student-athletes who were motivated by the three needs of SDT in their academic pursuits did not lose their motivation for athletics. This indicates that academic motivation and athletic motivation are not mutually exclusive. Educators can design a balanced approach to foster both academic and athletic motivation, contributing to the holistic development of student-athletes and creating an environment where they can thrive academically and athletically.

4.2. Empirical Implications

Regarding RQ3, the perceptions and attitudes of student-athletes toward the SDT-based ITS were generally positive. For autonomy design, student-athletes expressed that they appreciated the flexibility in handling their learning tasks and making their own learning decisions based on their learning environment and schedule. Autonomy, understood as the sense of freedom and perceived capability to make one’s own choices, is associated with increased enthusiasm, concentration, and intent in learning. This illustrates the process of self-directed learning [33,52]. Our findings suggest that when students have the freedom to select their learning tools and decide when to learn based on various practical learning settings, they feel more in control of their education. This can lead to increased involvement in the learning process.

Student-athletes also responded favorably to the relatedness design, mentioning the helpfulness of teachers in answering their questions and the positive impact of the virtual character, which made them feel supported as students. Supportive interactions between students and teachers have been proven effective in relatedness design [41,42,52,53]. Feeling safe, welcome, and connected to their school and subjects leads students to greater learning engagement [33]. While most relevant research has focused on designs based on real teachers, our findings suggest that combining virtual teachers with real teachers in the design of relatedness can have positive and promising outcomes, offering a novel approach to designing relatedness in various learning environments.

Student-athletes also appreciated the competence design, stating that as their learning deepened, they became more confident in completing their homework and appreciated the personalized difficulty level. The relationship between personalization and competence has been explored in previous studies [54–56]. Students’ feelings of competence can be enhanced when they find that the content offered by a personalized learning pathway
matches their learning needs and interests [53]. The precise AI algorithms used in our study required a substantial amount of data as a foundation and initial input. The answering data from previous users on Lexue 100 ITS trained the algorithms, and the answering data from Stage 1 provided an initial configuration for the questions assigned to student-athletes in Stage 2. These factors ensured that the questions were tailored and accurate in addressing their learning needs. Our design demonstrated a practical approach to meeting students’ competence needs through the use of algorithms.

The results of our study demonstrated that the SDT-based ITS positively influenced the completion rate and academic motivation (AM) among student-athletes. These findings align with similar outcomes shown in previous studies [41,52]. When the three intrinsic needs of SDT are fulfilled, students are more likely to shift their motivational orientation from extrinsic to intrinsic [33,34]. Student engagement is commonly viewed as a result of motivational mechanisms. Boosting motivation serves as a driving force that encourages students to take part in educational tasks [57]. While pedagogical designs with teachers have been the main focus of SDT designs, few studies have explored the design of technological learning environments to support students’ innate needs. Our results extend the positive impact of SDT on ITS.

5. Conclusions and Limitations

This paper delves into the development of an SDT-based ITS for student-athletes to enhance their academic engagement and motivation. The results revealed three challenges that student-athletes face when learning through ITS: inflexible technology, missing identity, and mismatched learning difficulty. However, the implementation of an SDT-based ITS led to a significant improvement in academic engagement and academic motivation among student-athletes. Importantly, their athletic motivation, valued by both the student-athletes themselves and their coach, remained preserved and unaffected, showing a favorable outcome for student-athletes. The autonomy, competence, and relatedness design of ITS in our experiment showed a promising way to support student-athletes’ academic success.

However, it is important to acknowledge several limitations of this study. Our study focused on student-athletes from one sports school in China, and only two sports (wrestling and weightlifting) were involved. That may lead to bias when implementing our findings in other countries and programs. Additionally, pre-investigation about their online learning experience or academic levels was inadequate, which may weaken the effectiveness of our findings. Overall, despite these limitations, this exploratory study offers valuable insights and provides a foundation for future research in this area. By implementing these practical suggestions, educators and technology developers could enhance the learning experiences and overall well-being of student-athletes.

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