On the Application of PLS-SEM Structural Model in Online Construction Engineering Courses

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Abstract: PLS-SEM is suitable for complex model structures, capable of effectively handling multiple mediator and moderator variables, with less stringent assumptions about data distribution. This makes it an ideal tool for analyzing the impact of teaching methods, course content, and teacher performance. This study analyzes the basic principles and characteristics of the PLS-SEM model, including measurement and structural models, and its applications in the field of education, such as the analysis of teaching quality and student satisfaction, optimization of course design and development, assessment of learning outcomes and skills enhancement, as well as education resource allocation and management decisions. The research findings indicate that the PLS-SEM model can help educators better understand and improve online construction engineering courses, enhancing teaching effectiveness and student satisfaction.

Keywords: PLS-SEM model; Construction engineering; Online education; Course design

DOI: 10.62639/sspjinss09.20240101

1. Introduction

In the modern educational environment, the effective design and implementation of online construction engineering courses have become increasingly important in higher education. With the rapid development of teaching methods and learning tools, the evaluation of educational quality and student satisfaction has become more complex and multidimensional. In this context, the application of Partial Least Squares Structural Equation Modeling (PLS-SEM) provides an effective method for a deeper understanding and improvement of online construction engineering courses. As Ping Wang stated, "In order to cultivate talents more effectively in construction engineering and cultivate students' critical thinking, creative thinking, high-level thinking, as well as students' perseverance, learning ability, global competence, and responsibility, combined with the integrated stem education concept, this paper makes an in-depth study on the online teaching model of construction engineering course in PLS-SEM mode." Like its widespread application in various disciplinary fields, PLS-SEM has demonstrated outstanding performance in educational research. The core advantage of this model lies in its ability to handle complex model structures, including multiple mediator and moderator variables, with less stringent assumptions about data distribution, providing great flexibility for addressing real-world issues. Therefore, this study will explore the specific application of the PLS-SEM structural model in online construction engineering courses, aiming to promote the scientificity of course design and effectively enhance teaching effectiveness.

2. Introduction to PLS-SEM Model

Partial Least Squares Structural Equation Modeling (PLS-SEM) is an advanced statistical analysis tool widely

(Manuscript NO.: JINSS-24-1-12001)

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applied in various disciplines, especially in marketing, management, social sciences, and educational research. The core advantage of PLS-SEM lies in its ability to handle complex model structures, including multiple mediator and moderator variables, while not strictly requiring assumptions about the distribution of data. This flexibility makes it highly versatile in addressing practical issues. In PLS-SEM, the primary analytical objective is to explore causal relationships among different variables, which can be either explicit (directly observable) or latent (not directly observable but reflected through a series of indicators).

PLS-SEM achieves this objective through model construction, consisting of two main parts: the measurement model and the structural model. The measurement model involves the relationship between latent variables and their indicators, which are specific representations of latent variables. For instance, in educational research, a latent variable such as "academic self-efficacy" may be measured through a series of questionnaire items. The structural model investigates the relationships between different latent variables, such as how academic self-efficacy influences students' academic performance.

Another notable feature of PLS-SEM is its use of the partial least squares estimation method. Compared to traditional least squares methods, partial least squares is more efficient in estimating parameters of complex models, particularly when data volume is not very large, or the data structure is intricate. It optimizes model parameters iteratively, seeking values that minimize the sum of squared residuals for each equation in the model. This iterative approach enables PLS-SEM to provide reliable results, especially when facing practical application issues, particularly in cases where data does not strictly follow a normal distribution or when sample sizes are limited.

Additionally, PLS-SEM excels in handling relationships between latent variables, effectively managing complex mediating and moderating effects. Mediation analysis reveals how a variable influences another variable through one or more intermediary variables, while moderation analysis studies how a variable's impact on causal relationships varies under different conditions. For example, in consumer behavior research, it may be necessary to investigate how brand image influences loyalty through consumer satisfaction (mediation effect) and whether this influence varies based on different consumer characteristics (moderation effect).

3. Application of PLS-SEM Model in the Education Sector

(1) Analysis of teaching quality and student satisfaction

In the field of education, especially in the teaching of online courses in architectural engineering, the analysis of teaching quality and student satisfaction is a crucial indicator for evaluating course effectiveness. Utilizing PLS-SEM to assess these indicators provides in-depth insights into teaching methods, course content, and teacher performance. Through statistical analysis, the model quantifies the complex relationships between teaching elements and student satisfaction, revealing how different teaching strategies and content impact students' learning experiences and satisfaction. For instance, using the PLS-SEM model, one can analyze the specific effects of factors such as classroom interaction, real case studies, and course diversity on student satisfaction. Moreover, the model can delve into the relationship between teaching quality and student learning outcomes, including factors like student participation in the course, the quality of assignments, and final exam scores. Through such analyses, educators can understand which teaching methods are most effective, which course content is most popular among students, and which aspects of a teacher's performance most effectively stimulate student interest and engagement.

(2) Optimization of course design and development

During the design phase of architectural engineering online courses, this model can be employed to provide

data-driven decision-making, thereby enhancing course effectiveness and attractiveness. PLS-SEM can help educators understand how different course design elements influence learning outcomes by analyzing historical data and student feedback. For example, the model can reveal how specific teaching methods or course content align with students' learning objectives and expectations or which course design elements are correlated with students' academic achievements and participation. This in-depth analysis assists course designers in making more effective decisions when developing new courses or adjusting existing ones, ensuring consistency between course content and educational goals. Furthermore, the application of the PLS-SEM model facilitates continuous improvement in course content. By regularly analyzing student feedback and learning outcomes, course designers can continuously optimize course structures, adjust teaching methods, and better meet students' learning needs.

(3) Evaluation of learning outcomes and skills enhancement

Through the application of the PLS-SEM model, educators can thoroughly analyze the impact of different teaching strategies on students' skill enhancement, particularly in critical areas such as critical thinking and problem-solving. This model can reveal which teaching methods or activities more effectively promote the development of these skills, helping educators understand and improve teaching practices. For instance, the PLS-SEM model can assist in analyzing how activities like group discussions, case studies, or project-based learning affect students' critical thinking. Moreover, this model can be used to compare the effectiveness of online education environments with traditional teaching methods in promoting student learning outcomes. Based on the comparison of data from different educational environments, educators can effectively assess whether online education meets requirements and understand in which contexts online education may enhance student learning performance or skill mastery.

(4) Education resource allocation and management decision-making

The application of the PLS-SEM model in this context can provide insights into education resource allocation, such as teacher assignments, selection of teaching materials, and utilization of online learning platforms. For instance, the model can be used to evaluate how specific types of teacher training or professional development activities affect teachers' teaching performance, subsequently influencing student learning outcomes. Similarly, by analyzing the usage of different types of teaching materials or online learning platforms, educators can understand which resources are more effective in enhancing students' learning motivation and performance. This data-driven management decision-making process optimizes the allocation of educational resources and enhances the overall quality of the education system. Through continuous data collection and analysis, educational decision-makers can make more precise and effective resource allocation decisions, ensuring that all students have access to a high-quality educational experience. In summary, the application of the PLS-SEM model in the evaluation of learning outcomes and skills enhancement, as well as in education resource allocation and management decision-making, holds significant importance for optimizing teaching strategies, improving education quality, and promoting educational equity.

4. Conclusion

This article delves into the application potential of PLS-SEM in the design and teaching practices of online courses in architectural engineering. The research reveals that the model not only possesses robust explanatory power in theory but also demonstrates significant practical value in real-world applications. By precisely analyzing the relationship between teaching elements and student satisfaction, PLS-SEM provides educators with a crucial tool to optimize teaching strategies and course content.

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