How teaching style influences learning effectiveness through learning motivation: An example of an advanced mathematics course for undergraduate students at university

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ABSTRACT

This study investigates the relationship between teaching style and learning effectiveness and further examines the mediating effect of learning motivation in the relationship between teaching style and learning effectiveness. This study adopted the undergraduate students of University A in China as the research sample and conducted a quantitative survey to test the hypothetical relationship between these variables. The results showed that (i) the teacher-centered teaching style significantly negatively affected professional knowledge. (ii) the student-centered and the eclectic-centered teaching styles significantly positively affected professional knowledge and comprehensive ability, respectively. In addition, the hierarchical regression technique was used to examine the mediating effect of learning motivation. The findings revealed that (iii) intrinsic learning motivation had a partial mediating effect on the relationship between teaching style (student-centered and eclectic-centered teaching style) and learning effectiveness (professional knowledge and comprehensive ability). (iv) extrinsic motivation partially mediates the relationship between student-centered teaching style and learning effectiveness (professional knowledge and comprehensive ability).

Introduction

Education is essential for a country to cultivate talents and accumulate competitiveness in development. School is an important place to achieve educational goals, in which teachers assume the vital task of imparting knowledge and training talents. In a review of previous studies, teachers’ teaching styles vary with the variability of their characteristics but profoundly impact students’ learning attitudes and behaviors. Su (2020) indicated that teaching style is a personal and unique teaching trait or a style developed by teachers in their long-term teaching practice. More specifically, teaching style is a preference for teaching behavior, a higher-level form of educational activity that does not vary with the teaching content (Heimlich & Norland, 2002).

In the teaching and learning environment, teachers and students are two crucial factors that are indispensable for creating the learning atmosphere and effectiveness. Since students are the carriers of knowledge, instructors’ teaching style, teaching mode, and teaching behavior will have an invisible influence on students’ learning motivation, learning process, and effectiveness. Take the advanced mathematics course as an example; the course aims at developing students to think creatively and to be able to apply various concepts and skills of mathematics to solve problems in daily life (Kızıltoprak & Köse, 2017). However, advanced mathematics is highly abstract and computational. In exploring the nature and laws of mathematics, students must have rigorous logical derivation, judgment ability, and induction and deduction processes. It may be difficult for students who are not good at analytical or divergent thinking and may make them avoid or decline this course. Studies have shown that many students fear learning advanced mathematics, and such thoughts make them afraid of mathematics, leading to anxiety and difficulty coping with the subject (Capinding, 2021).
Therefore, teachers must demonstrate an appropriate teaching style to reduce students' learning anxiety, motivate them, and enhance their learning effectiveness.

In addition, motivation has a significant impact on learning effectiveness. Many scholars believe motivation is a critical factor in students' learning effectiveness (e.g., Boaler, 1999; Zimmerman, Bandura, & Martinez-Pons, 1992). In other words, the intensity of individual motivation to learn is essential in motivating or inhibiting students' effort and persistence in learning. According to La Belle (2005), individuals have diverse perceptions of reward preferences for learning goals and benefits. Some individuals prefer intrinsic rewards (e.g., satisfying learning interests), while others prefer extrinsic rewards (e.g., receiving praise from others), resulting in intrinsic or extrinsic motivation needs. Wang (2021) argued that the crucial factors affecting learning effectiveness include learning motivation, teaching style, and psychological aspects. In other words, when students learn advanced mathematics, the stimulation of individual learning goals and perceived benefits through teachers' techniques will help them enhance their intrinsic and extrinsic motivation to take the initiative and learn consciously. Students will improve their learning effectiveness accordingly.

Based on the above discussion, this study attempts to determine which teaching styles can enhance or inhibit individuals' effectiveness in advanced mathematics courses and to explore whether they mediate between teaching styles and teaching effectiveness by using learning motivation as a mediating factor to grasp the influence path of the development process from teaching techniques to learning effectiveness more completely.

**Literature Review**

**Theoretical and Conceptual Background**

**Teaching Styles**

Teaching is an activity in which the instructor uses appropriate methods to induce the recipient to perceive that learning the subject is meaningful or valuable. Heimlich and Norland (2002) argued that teaching style results from a teacher's teaching behavior that integrates their beliefs and values in the teaching process and that such behavior is consistent with personal beliefs and values and does not change with changes in teaching content. In other words, teaching style consists of teachers' internal unique characteristics and external teaching behaviors that are stable and consistent (Grasha, 2003). These characteristics are displayed in teaching methods, teaching behaviors, teacher-student interactions, and teaching patterns. Cooper (2001) defined teaching style as the preferred behaviors and techniques teachers exhibit in the teaching process and the combination of teaching skills and behaviors they feel most comfortable in the classroom. Based on those characteristics of teaching styles, teachers' delivery of knowledge and ideas may influence the quality of students' experiences and feelings about learning specific subjects and content (Coldren & Hively, 2009), as well as the ultimate learning effectiveness.

With the increasing attention to research related to teaching styles, scholars have proposed many classifications of teaching styles. For example, Conti (1985) distinguished teaching techniques into learner-centered, teacher-centered, and teacher-centered. Based on Knowles' concept of adult teaching with an emphasis on problem-solving. Treffinger classified teachers' teaching styles into teacher-directed, group-directed, and self-directed based on their teaching objectives, discussion topics, learning activities, and teaching assessments (Johnsen & Goree, 2005). Efili and Coklar (2013) distinguished five teaching styles: expert, formal authority, personal model, facilitator, and delegator. Although scholars have different names for the various classifications of teaching styles, the implications are primarily the same. This study classifies teaching techniques into student-centered type, teacher-centered type, and eclectic-centered type based on the extent to which students are allowed to participate in teaching activities during the teacher's instruction. Student-centered style refers to teaching activities centered on students, with the teacher playing the role of facilitator and resource provider. Teacher-centered type refers to teaching activities centered on the teacher, focusing on the teacher's authority, which is more controlling and ignoring students' autonomy and needs. Eclectic-centered style refers to the teacher who will not only guide students to express their opinions and ideas to teachers and students but also can discuss the content and activities together. This kind of teaching technique attaches importance to the interaction between teachers and students, and the teacher will listen to students' opinions but will not accept them totally and uncritically.

**Learning Motivation**

Learning motivation, which refers to students' inherent or integrated ability to trigger and sustain learning activities in the learning process, is the external expression of an individual generated by the inherent mental activity. It is also the process that drives self-learning behavior to achieve predetermined goals to satisfy one's learning needs. For this study, learning motivation is defined as a psychological drive that triggers and sustains students in learning activities to achieve the learning goals of advanced mathematics courses.

LaBelle (2005) noted that based on individual differences in perceptions of reward preferences for learning goals and benefits, some individuals prefer intrinsic rewards, while others pay great attention to extrinsic rewards, resulting in intrinsic or extrinsic motivations. From the point of investigation in this study, the inherent compensation of learning refers to the self-directed motivational attributes of students who can gain pleasure and satisfaction inwardly while engaging in learning activities of advanced mathematics. The main focus is on their intrinsic desires or interests, and the goals are personal self-directed motivational attributes. The extrinsic reward of learning, on the other hand, mainly focuses on goal-driven inducements. Individual students pursue achievement in mathematics to
conform to and achieve the goals, expectations, and approval of significant others or for other-directed motivational attributes related to obtaining honorary titles, scholarships, and pursuing an enviable career or social relationships, etc.

Self-determination theory (SDT) states that intrinsic motivators (i.e., interests) or extrinsic motivators (i.e., goals) are a continuum (Deci & Ryan, 2002). Although differences in the interests and goals cause individuals to act, they may bring satisfaction or pleasure to individuals when they are intrinsically or extrinsically motivated to engage in a particular activity (Knuudsen-Martin, 2011). In terms of intrinsic motivation, students are motivated to study advanced mathematics mainly because of the inherent pleasure and sense of accomplishment they can derive from pursuing knowledge. From an extrinsic motivation point of view, although students are not interested in or afraid of advanced mathematics curriculum, they will still choose to participate in activities that meet the learning objectives of the advanced mathematics curriculum. The main reasons are that they can earn credits and receive praise from significant others or the pleasure of gaining honor by studying the subject.

As summarized from the above views of scholars, individual motivation can be influenced by stimulation from external sources and intrinsic needs to generate intrinsic or extrinsic motivation needs. Consequently, the present study distinguishes between intrinsic and extrinsic learning motivations for the study learning.

Learning Effectiveness

Learning effectiveness refers mainly to the indicators of students' educational gains, including the knowledge granted by profession, the ability to apply the knowledge in practice, and the ability to combine theory and practice. Furthermore, learning effectiveness is a measure of the learning outcomes of learners to understand the extent to which students understand, master, and change their subject knowledge or skills after engaging in learning activities for some time. Other- and self-assessment are the two main pathways for learning effectiveness evaluation. Other-assessment (e.g., school) adopts tests, scales, interviews, observations, and other methods and techniques to collect complete quantitative or qualitative data and adopt an integrated perspective to evaluate and judge whether students' learning effectiveness has achieved the course objectives. From a self-assessment perspective, Young et al. (2003) argued that learning effectiveness can be defined as students' self-evaluation of the overall knowledge, skills, and abilities they have acquired and the effort they have put into a particular course compared to others. Bai and Zhou (2018) stated that learning effectiveness is the development of knowledge, skills, and values that students can confirm in some specific way after completing a course or major.

In summary, this study considers learning effectiveness as an indicator of educational benefit in terms of professional knowledge and skills, flexibility in application, and integration of theory and practice those learners achieve with the help of others. With high-level educational benefit indicators, students will absorb the knowledge more efficiently and thus learn more effectively. This study focuses on students' subjective perceptions of whether their understanding of advanced mathematics and ability to apply it in practice has improved. Therefore, this study examines the effectiveness of individual learning of advanced mathematics from the perspective of students' self-assessment and focuses on professional knowledge and comprehensive ability. Professional knowledge refers to the extent to which students have mastered the professional understanding of advanced mathematics they have learned. Comprehensive ability refers to how students' various problem-solving and self-management skills, such as time management, written report writing, and oral communication, have been improved through the study of advanced mathematics.

Empirical Review and Hypothesis Development

The Relationship between Teaching Style and Learning Effectiveness

Since teachers' teaching styles are revealed in their teaching methods, teaching behaviors, teacher-student interactions, and teaching modes. Previous studies have represented that a unique teaching style contributes to teachers' prestige and educational influence (Kuo, 2017). In other words, students' learning attitudes are influenced by teachers' teaching styles. For example, when students meet a teacher with their preferred teaching style, they are more likely to be engaged in advanced mathematics and to be able to understand the content or integrate it into the learning pattern of the course, resulting in better learning effectiveness. Conversely, when students do not like or cannot adapt to the teacher's teaching methods or modes, they may not fully understand the teacher's lectures and tend to feel anxious about learning advanced mathematics or even avoid and reject it. Atma (2021) also revealed that there is a relationship between teaching style and learning effectiveness, but teachers must display an appropriate teaching style according to the diversity of learning objectives to improve students' academic performance.

Accordingly, this study argued that there might be a differentially meaningful relationship between teaching style and learning effectiveness. For example, when teachers excessively deliver mathematics course content in their way of thinking while ignoring students' learning needs and problems, they may prevent students with weaker mathematical abilities from fully understanding the content. With the accumulation of confusion that cannot solve, it is easy to develop anxiety and fear of learning the mathematics curriculum, and the learning effect may be poor. In addition, when teachers focus on students' learning needs, design more diverse learning styles, and increase teacher-student interaction and communication to stimulate learning, or when teachers combine both approaches, deliver mathematics-related knowledge partly through their expertise and guiding students to raise opinions and questions, students' learning effectiveness will be improved. Based on the above analysis, the following hypothesis for validation is proposed in this study.

H1: Teacher-centered teaching style has a significant negative effect on learning effectiveness.
H1-1: Teacher-centered teaching style has a significant negative effect on professional knowledge.
H1-2: Teacher-centered teaching style has a significant negative effect on comprehensive ability.
H2: Student-centered teaching style has a significant positive effect on learning effectiveness.
H2-1: Student-centered teaching style has a significant positive effect on professional knowledge.
H2-2: Student-centered teaching style has a positive effect on comprehensive ability.
H3: Eclectic-centered teaching style has a significant positive effect on learning effectiveness.
H3-1: Eclectic-centered teaching style has a significant positive effect on professional knowledge.
H3-2: Eclectic-centered teaching style has a significant positive effect on comprehensive ability.

The Mediating Role of Learning Motivation

Motivating students to learn is one of the important tasks of teachers engaged in teaching. Previous studies have explicated that teaching style is associated with the motivation of individuals to learn. For example, studies by Chiang (2020), Su (2021), and Zhu (2021) empirically demonstrated that teaching style and learning motivation have a positive relationship, respectively. These findings showed that students’ motivation to learn will be motivated when teachers can demonstrate teaching behaviors or patterns that are preferred by students during teaching. In addition, the results of Özlem’s (2017) study stated that the more motivated students are, the better their academic performance. Vollmeyer and Rheinberg (2000) also showed that motivation affects learning persistence and that students with greater motivation spend more time on learning activities and have greater perseverance in overcoming learning difficulties than those with lower motivation.

Based on the above, this study argued that when teachers exhibit students' preferred styles in their teaching behaviors or teaching styles, students' motivation to learn will be affected and their learning effectiveness will be differentially impacted. A study by Nir and Hameiri (2014) stated that teaching style and quality of instruction have a positive relationship with students' motivation and can even motivate students to learn and influence their attitudes, thus affecting learning effectiveness. As mentioned above, when students realize that teachers do not pay attention to their needs and questions about the course content during instruction, it may make them internally uninterested in pursuing mathematical knowledge, which, combined with learning anxiety caused by the accumulation of doubts, may, in turn, lead to poor learning effectiveness. On the other hand, if the teacher is willing to listen to the learning needs of the students, or if he/she can adjust his/her teaching style according to the feedback from the students, then the students will realize that the teaching style shown by the teacher can make them understand and master the course and solve their problems in learning mathematics, which will enhance their interest in learning. And even if students are not interested in the course, however, when students realize that the teacher's teaching behaviors and patterns can help them improve their learning dilemmas and achieve learning goals, such as getting good grades in math exams, it will virtually improve the students' learning effectiveness.

H4: Learning motivation mediates the relationship between teacher-centered teaching style and learning effectiveness.

H4-1: Intrinsic learning motivation mediates the relationship between teacher-centered type and professional knowledge.
H4-2: Intrinsic learning motivation mediates the relationship between teacher-centered teaching style and comprehensive ability.
H4-3: Extrinsic learning motivation mediates the relationship between teacher-centered teaching style and professional knowledge.
H4-4: Extrinsic learning motivation mediates the relationship between teacher-centered teaching style and comprehensive ability.
H5: Learning motivation mediates the relationship between student-centered teaching style and learning effectiveness.
H5-1: Intrinsic motivation mediates the relationship between student-centered teaching style and professional knowledge.
H5-2: Intrinsic motivation mediates the relationship between student-centered teaching style and comprehensive ability.
H5-3: Extrinsic motivation mediates the relationship between student-centered teaching style and professional knowledge.
H5-4: Extrinsic learning motivation mediates the relationship between student-centered teaching style and comprehensive ability.
H6: Learning motivation mediates the relationship between eclectic-centered teaching style and learning effectiveness.
H6-1: Intrinsic learning motivation mediates the relationship between eclectic-centered teaching style and professional knowledge.
H6-2: Intrinsic learning motivation mediates the relationship between eclectic-centered teaching style and comprehensive ability.
H6-3: Extrinsic learning motivation mediates the relationship between the eclectic-centered teaching style and professional knowledge.
H6-4: Extrinsic learning motivation mediates the relationship between the eclectic-centered teaching style and comprehensive ability.

Figure 1 illustrates the relationships among the variables in our research model.
Research and Methodology

Sample and Procedures

This study adopted a convenience sampling method to investigate the undergraduates learning advanced mathematics courses in public university A in China. A total of 287 questionnaires were sent out; the valid questionnaires were 219, representing a 76.3% response rate. Among all the respondents, female students accounted for 73.5%; students from rural areas accounted for 60.3%; first-year students and juniors accounted for 30.6% and 40.6%, respectively. 76.7% majoring in science and engineering, followed by 12.8% of students majoring in liberal arts.

Common Method Variance Analysis

Considering that the respondents of all the questionnaires in this study were all students, it is prone to common method variance (CMV) due to the single source of respondents. Therefore, this study further conducted Haman’s single-factor post hoc analysis (Podsakoff et al., 2003) to detect whether CMV is likely to happen. All the items from every construct were entered into principal component factor analysis, checked the unrotated factor solution, and examined to assess the number of factors that could cause the variance in the variables (Tehseen et al., 2017). The analysis result shows that 7 factors were extracted through unrotated principal component factor analysis and the explained variance of the first factor accounts for 36.46% (< 50%); this means that CMV is not a severe problem in the study (Mattila & Enz, 2002).

Measurement

The teaching style was measured using the scale developed by Chiang (2020) with three sub-dimensions of teaching style and a total of 10 items, including (1) teacher-centered type: (e.g., the teacher values his or her dominance in the classroom) with 3 items (α=0.74); (2) student-centered type (e.g., the teacher adjusts the focus of teaching according to the needs of students) with 4 items (α =0.84); (3) eclectic-centered type (e.g., the teacher takes into account the learning status of students when implementing teaching tasks), with 4 items (α =0.88).

The learning motivation scale was adopted from Cheng (2017) and has two sub-facets with a total of 10 items: (1) intrinsic motivation (e.g., I need to learn in a way that makes me happy) with 5 items (α=0.87); and (2) extrinsic motivation (e.g., success for me means that I do better than others) with 5 items (α=0.85).

The learning effectiveness scale was developed with two dimensions based on the revision of many scholars’ scales by Lin (2014) with a total of 8 items, including (1) professional knowledge (e.g., the classroom enables me to understand most of the learning content) with 4 items (α=0.878) and (2) comprehensive ability (e.g., I learned reading skills after taking an advanced mathematics course), with 4 items (α =0.910).

Results

Reliability, and Validity Analysis

As shown in Table 1. (1) Cronbach’s α values exceed 0.7, indicating a good internal consistency among the items of each dimension (Nunnally & Bernstein, 1994). (2) the composite reliability (CR) values are between 0.75 and 0.91 (> 0.6). (3) the measurement of convergent validity: the average variance extracted (AVE) of each latent construct is greater than 0.5 (Fornell & Larcker, 1981). (4) the measurement of discriminant validity: the AVE for each latent construct exceeds the respective squared correlation (Fornell &
Larcker, 1981). The above data exceed the recommended value, indicating that the measurement model in this study has good reliability, convergent validity, and discriminant validity.

Table 1: Correlations, Composite Reliability, Convergent Validity, and Discriminant Validity

|   | C.R. | AVE | 1. | 2. | 3. | 4. | 5. | 6. | 7. |
|---|------|-----|----|----|----|----|----|----|----|
| **α** | 0.74 | 0.75 | 0.50 | **0.71** | | | | | |
| **1.TC** | 0.84 | 0.85 | 0.53 | -0.20*** | **0.73** | | | | |
| **2. SC** | 0.88 | 0.89 | 0.66 | -0.17** | **0.68** | **0.81** | | | |
| **3. EC** | 0.87 | 0.88 | 0.59 | -0.30*** | 0.50** | 0.51** | **0.66** | | |
| **4. LLM** | 0.85 | 0.84 | 0.51 | -0.26** | **0.43** | **0.38** | **0.53** | **0.75** | |
| **5. PK** | 0.88 | 0.88 | 0.65 | -0.26** | **0.70** | **0.69** | **0.54** | **0.43** | **0.81** |
| **6. CA** | 0.91 | 0.91 | 0.72 | -0.21** | **0.68** | **0.68** | **0.56** | **0.42** | **0.79** | **0.85** |

Note: α = Cronbach’s α; TC: teacher-centered; SC: student-centered; EC: eclectic-centered; LLM: intrinsic learning motivation; PK: professional knowledge; CA: comprehensive ability; AVE = average variance extracted. The square root of AVE is displayed in bold on the diagonal of the matrix; ‘* p<0.05’ ‘** p<0.01’ ‘*** p<0.001’

Testing of Hypotheses

The Relationship between Teaching Style and Learning Effectiveness

In this study, regression analysis was used to verify the hypothesis of the influencing relationship between variables, and gender and birthplace were included as control variables to enhance the stability of the study results. Firstly, the multiple regression method was used to evaluate the hypothesis of teaching style on learning effectiveness. As shown in Table 2, the teacher-centered teaching style significantly negatively affected professional knowledge (β = -0.08, p<0.05). Hence, H1-1 was supported. However, the empirical data did not support H1-2 since teacher-centered teaching style was not significantly associated with comprehensive ability (β = 0.03, p>0.05). Secondly, the finding illustrated that student-centered and eclectic-centered teaching styles significantly positively affected professional knowledge (β = 0.43, p<0.001, β = 0.42, p<0.001) and comprehensive ability (β = 0.38, p<0.001, β = 0.44, p<0.001), respectively. Hence, the data supported H2-1, H2-2, H3-1, and H3-2.

Regarding the relationship between teacher style and motivation to learn, as seen in Table 2, both student-centered and eclectic-centered teaching styles depicted positive associations with intrinsic motivation to learn (β = 0.34, p<0.01, β = 0.37, p<0.01), respectively. Meanwhile, the student-centered teaching style is positively associated with extrinsic motivation to learn (β = 0.45, p<0.001).

Table 2: Multiple Regression Results for Teaching Styles predicting LM and LE

| IV↓ | LM | | LE | |
|---|----|---|---|---|
| Gender | -0.07 | -0.06 | -0.02 | -0.03 |
| Birth place | 0.14 | 0.10 | 0.00 | -0.04 |
| TC | -0.07 | -0.01 | -0.08* | -0.03 |
| SC | 0.34*** | 0.45*** | 0.43*** | 0.38*** |
| EC | 0.37*** | 0.13 | 0.42*** | 0.44*** |
| F | 47.53*** | 26.59*** | 94.09*** | 86.17*** |
| R² | 0.45 | 0.31 | 0.62 | 0.60 |

Note: LM = learning motivation; LE = learning effectiveness; TC = teacher-centered; SC = student-centered; EC = eclectic-centered; LLM = intrinsic learning motivation; ELLE = extrinsic learning motivation; PK = professional knowledge; CA = comprehensive ability; ‘* p<0.05’ ‘** p<0.01’ ‘*** p<0.001’

The mediating effect of learning motivation

This study investigates the mediating effects of learning motivation by following Baron & Kenny’s (1986) prerequisites for mediating effects. As shown in Table 3, the regression coefficients of student-centered and eclectic-centered teaching styles on professional knowledge decreased when intrinsic learning motivation was introduced into the study model. However, the regression coefficients were still significant (β = 0.41, p<0.001 → β = 0.35, p<0.001; β = 0.41, p<0.001 → β = 0.34, p<0.001), indicating that intrinsic learning motivation partially mediated the relationship between student-centered and eclectic-centered teaching styles and professional knowledge, respectively. Therefore, H5-1 and H6-1 were supported.

In addition, Table 3 shows that intrinsic and extrinsic motivation to learn had a positive relationship with professional knowledge (β = 0.52, p<0.001, β = 0.17, p<0.05) and comprehensive ability (β = 0.53, p<0.001, β = 0.14, p<0.05), respectively. Moreover, Table 3 also shows that intrinsic motivation partly mediated the impact of student-centered and eclectic-centered teaching styles on professional knowledge. Therefore, H5-1 and H5-6 were supported.
comprehensive ability, respectively (β=0.38, p<0.001 → β=0.30, p<0.001; β=0.44, p<0.001 → β=0.36, p<0.001). Hence, H5-2 and H6-2 were supported.

Table 3: The Mediating Effect of ILM in the relationship between TS and LE

| DV → LE | PK | CA |
|---------|----|----|
| IV↓ | M | M | M |
| Gender | 1-1 | 1-2 | 1-3 |
| Birth Place | 2-1 | 2-2 | 2-3 |
| TC | -- | -- | -- |
| SC | 0.41*** | 0.35*** | 0.38*** |
| EC | 0.41*** | 0.34*** | 0.44*** |
| ILM | 0.19*** | 0.22*** | 0.52*** |
| ELM | 0.17 | 0.14 |

Note: TS= teaching style; LE= learning effectiveness; TC= teacher-centered; SC= student-centered; EC= eclectic-centered; ILM=intrinsic learning motivation; ELM=extrinsic learning motivation; PK= professional knowledge; CA.= comprehensive ability; β=p<0.05 ***p<0.001

In addition, as shown in Table 4, after the introduction of extrinsic motivation in the research model, extrinsic motivation had partial mediating effects on the relationship between student-centered teaching style and professional knowledge and comprehensive ability, respectively (β=0.76, p<0.001 → β=0.69, p<0.001; β=0.74, p<0.001 → β=0.67, p<0.001). Hence, H5-3 and H5-4 were supported.

Table 4: The Mediating Effect of ELM in the Relationship between TS and LE

| DV → LE | PK | CA |
|---------|----|----|
| IV↓ | M | M | M |
| Gender | 4-1 | 4-2 | 4-3 |
| Birth Place | 5-1 | 5-2 | 5-3 |
| TC | -- | -- | -- |
| SC | 0.76*** | 0.69*** | 0.74*** |
| EC | -- | -- | -- |
| ELM | -- | 0.13*** | 0.67*** |
| F | 0.23 | 123.57*** | 96.51*** |
| R² | 0.00 | 0.57 | 0.58 |

Note: the abbreviation for each variable is the same as Table 3; β=p<0.05 ***p<0.001

Sobel Test

This study used the Sobel test method to test further whether the indirect effect of the independent variable on the dependent variable through the mediator variable is significant. When the z-value exceeds the absolute value of 1.96, the indirect impact reaches a significance level of α=0.05 (Sobel, 1982). Firstly, the indirect effect of intrinsic learning motivation was significant in the relationship between student-centered teaching style and professional knowledge (z=9.53) and comprehensive ability (z=9.49), respectively. Moreover, the indirect effect of intrinsic learning motivation was significant in the relationship between eclectic-centered teaching style and professional knowledge (z=9.67) and comprehensive ability (z=9.63), respectively. Thirdly, the indirect effect of extrinsic learning motivation was significant in the relationship between student-centered teaching style and professional knowledge (z=6.84) and comprehensive ability (z=6.74), respectively.

Findings and Discussions

This study examines the effect of the teaching style of advanced mathematics courses on the learning effectiveness of undergraduate students. Further, it looks at the mediating impact of learning motivation between the two. The findings of this study show that when teachers focus excessively on their thinking and teaching patterns and ignore students' learning problems, students' understanding and mastery of mathematical knowledge will be poor. Furthermore, their ability to apply mathematical knowledge to solve problems in life will not be better demonstrated. Since motivation significantly impacts learners' attitudes and learning behaviors (Hakan & Munire, 2014), this study found that teachers' self-centered teaching patterns or behaviors undermine students' intrinsic motivation to learn advanced mathematics and, in turn, affect learning effectiveness. As teachers focus on their authority and control the classroom but ignore students' needs, students will gradually become anxious, fearful, and even refuse the learn advanced...
mathematics when their doubts cannot be solved for a long time. They only have a limited understanding of the more complex calculations and derivations, and the learning will be less effective with a lack of intrinsic motivation to learn. Therefore, keeping an eye on students’ learning needs and eliminating barriers and anxieties become essential for teachers to maintain students’ motivation to learn.

Furthermore, the results of this study showed that the student-centered teaching style improved the students' professional knowledge and comprehensive ability in mathematics. That is because teachers act as facilitators with an open mind, pay attention to students' learning difficulties and comprehension, reflect on students' learning problems and feedback, and provide relevant resources. Meanwhile, the student-centered teaching style has a positive motivational effect on learning, making students more resilient to overcome learning difficulties and willing to spend more time on mathematical learning activities. As a result, even if they are not interested in the course, they are eager to spend time studying math to pass the tests for credit, which will improve students' learning effectiveness.

Conclusions

Practical Implications

Adult learning is experience and problem-centered. Teachers are expected to enhance students' learning effectiveness and problem-solving skills by acting as facilitators and resource providers and demonstrating their professional authority at the right time. From the viewpoint of teaching practice, besides systematically instilling students with mathematical knowledge, the teacher can help students understand and integrate the course content by providing more classroom exercises and two-way discussion sessions or by offering diversified resources such as extracurricular reading materials, videos, rewards, mutual-help support groups, and after-school tutorials in the teaching and learning process of mathematics. In that way, the positive experience of learning mathematics is strengthened, the barriers and anxieties to learning are reduced, the motivation and willingness to learn are increased, and the mastery of mathematical knowledge and the ability to apply it in practice is improved.

Research Limitations and Future Research

The results of this study are affected by at least the following limitations. Firstly, the analysis is restricted to students at University A, and the results may only apply to that university. Therefore, the external validity of the survey is constrained. Future studies can compare the validity of this study with that of other universities and students of the same major to establish the validity of this study on the one hand and to understand better the problems and the differences on the other hand.

Secondly, this study is a cross-sectional survey, which cannot precisely capture the developmental continuity of teaching style on motivation and learning effectiveness. Subsequent researchers can adopt longitudinal research to accurately catch the continuity of the relationship development process of variables. In addition, the sample of this study was from a single source (all students), and although this study did not produce CMV problems, it may affect the inference and analysis of the findings. Future studies can utilize the teacher-student matching method for questionnaire sampling to respond to scholars’ calls in research design.

Finally, future research can consider other potential contextual variables, such as classroom learning climate, collective psychological capital, and possible variables at the individual level, such as learning emotions, learning strategies, and self-efficacy. The cross-level research design allows the inference and analysis of the influence relationships between variables at different levels and can be further examined with greater precision simultaneously.

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