Quantitative Analysis of Behavioral Engagement Based on Machine Learning Algorithm

Liangliang Wang, Kai Ma, Yumeng Lu
School of Marxism, Xi'an Petroleum University, Xi'an, China
Corresponding author: Liangliang Wang (e-mail: wangliangliang@xsyu.edu.cn).

ABSTRACT To quantitatively characterize learners' behavioral engagement in specialized electromagnetic-related coursework and extract its core predictive determinants, this paper presents a machine-learning-enabled quantitative analytical framework centered on Random Forest Regression (RFR). Targeting one designated course as the empirical research setting, we adopted the IPTCSSE scale paired with a 10-point Likert scale to collect behavioral engagement data. Out of 4,700 distributed questionnaires, 3,992 valid samples were retained for subsequent statistical and algorithmic analysis. Complementing conventional SPSS 17.0 statistical processing with RFR overcomes the limitations of traditional regression-only analysis in nonlinear factor weight estimation. Reliability testing yielded a satisfactory Cronbach's Alpha value for the IPTCSSE scale, and Pearson correlation analysis validated its construct validity; KMO measure and Bartlett's sphericity test confirmed the dataset's eligibility for factor extraction. Seven critical drivers of behavioral engagement were identified: attention to practice, effort level, instructional guidance, instructional media, autonomous study, course attendance, and in-class interaction. Descriptive analysis demonstrated generally favorable ratings for all factors with significant positive inter-factor correlations, where classroom interaction obtained the highest score and effort level the lowest. RFR further quantified factor predictive contributions: autonomous study and attendance shared identical impact weights (eigenvalue=0.03), whereas classroom interaction exhibited the minimal weight (eigenvalue=0.00). This work verifies the feasibility of applying ensemble machine learning to quantify learner behavioral engagement within education, discusses implementation limitations regarding sample coverage and algorithm tuning, and offers empirical insights for optimizing instructional engagement in advanced teaching.

INDEX TERMS behavioral engagement. experimental course. machine learning algorithm. random forest regression. quantitative analysis.

I. INTRODUCTION

A. THE BACKGROUND OF RESEARCH

Electromagnetic sensing technologies have become an essential component of modern intelligent systems due to their wide applications in areas such as wireless communication, radar detection, intelligent perception, biomedical monitoring, industrial automation, and Internet of Things (IoT) applications. By exploiting electromagnetic wave propagation, scattering, reflection, and interaction mechanisms, electromagnetic sensing systems enable non-contact, accurate, and real-time information acquisition in complex environments. With the rapid development of emerging technologies, including artificial intelligence, intelligent sensing networks, and autonomous systems, the demand for engineers with interdisciplinary knowledge in electromagnetic theory, sensing technologies, and intelligent data processing has increased substantially.

Ideological and Political Theory Courses (IPTCs) have a significant place in the Chinese higher education system. These courses are designed to instill a strong sense of national identity, socialism, and adherence to the values of the Communist Party of China. They are mandatory for all university students and are intended to promote ideological alignment and political awareness [1]. Behavioral engagement refers to the extent to which students participate in and are attentive to their coursework. In the context of IPTCs, this engagement is crucial because it directly influences how effectively these courses can fulfill their educational and ideological goals [2]. High levels of engagement are associated with better understanding and internalization of the material, which is central to the courses' objectives.

A specific course was selected as the experimental object in this study, aiming to explore the behavioral engagement of participants in the course and its influencing factors.

Behavioral engagement refers to the extent to which participants participate in and are attentive to the course work. Accurately measuring and analyzing behavioral engagement poses challenges due to its subjective nature. Traditional metrics might include attendance rates, participation in class discussions, completion of assignments, and performance on assessments [3], [4]. However, capturing the depth of engagement—such as participants' interest, motivation, and internalization of content—requires more nuanced methods. Research in this area often employs both quantitative and qualitative methods [5]. Quantitative methods might involve surveys and questionnaires to assess participants' self-reported engagement levels, while qualitative methods might include interviews, focus groups, and observation to gain deeper insights into participants' experiences and attitudes.

Only understanding behavioral engagement in this experimental course is vital for improving teaching strategies and related policies [6]. Insights from research can inform the development of teaching methods, course content, and educational interventions designed to enhance participant engagement. Recent trends in educational research include the integration of digital tools and platforms for learning, which can influence engagement levels. Online and hybrid learning environments [7], as well as interactive teaching methods [8], are increasingly being explored to address engagement challenges. Research on this topic contributes to a broader understanding of how course teaching impacts participant development. It provides valuable feedback for educators and policymakers to ensure that the experimental course meets its intended goals while also addressing participants' educational needs and preferences. In summary, the research on behavioral engagement in the selected experimental course is critical for evaluating and enhancing the effectiveness of the course in achieving its educational aims.

B. THE RATIONALE BEHIND THE RESEARCH

Although electromagnetic sensing technologies have developed rapidly, cultivating qualified engineering professionals in this interdisciplinary field remains challenging. Electromagnetic sensing courses typically involve complex theoretical concepts, including electromagnetic field theory, signal processing, sensing principles, and system applications. Students are required not only to acquire fundamental theoretical knowledge but also to develop practical abilities in system design, experimental operation, and problem-solving. Therefore, improving teaching effectiveness and understanding students' learning behaviors have become important issues in electromagnetic sensing technology education.

The rationale behind this research is multifaceted and rooted in several key considerations: understanding how engaged participants are in the experimental course can help determine if the course's teaching goals are being met effectively [9]. By measuring engagement, educators can identify which aspects of the curriculum are successful and which are not, leading to targeted improvements in course design and delivery. Meanwhile, engagement is closely linked to deeper learning and comprehension. Research can reveal how different teaching methods and course structures impact participants' involvement and learning outcomes. Analysis can highlight barriers to engagement, such as disinterest, perceived irrelevance, or difficulty with course content, allowing for the development of strategies to address these issues.

Student behavioral engagement is considered a critical indicator of learning effectiveness because it reflects students' participation, effort, interaction, and persistence during the learning process. In engineering education, particularly in technology-intensive courses such as electromagnetic sensing, students' engagement levels directly influence knowledge acquisition, experimental skills development, and professional competence formation. However, traditional evaluation methods often rely on final examinations or subjective teaching observations, which may not fully capture the multidimensional characteristics of students' learning behaviors.

From this point, current research can provide a clearer picture of participants' attitudes towards the experimental course, helping educators understand their motivations, interests, and concerns. Identifying factors that positively influence engagement can lead to strategies for increasing participant interest and enthusiasm for the course. With the rise of digital learning tools and online platforms, understanding how these affect engagement in the experimental course is crucial. Research can assess how well these technologies integrate with traditional teaching methods and their impact on participant participation. As educational methods evolve, more researches help to evaluate the effectiveness of hybrid and online learning environments in maintaining or improving engagement levels in the experimental course [10].

Furthermore, the experimental course serves educational purposes, and research should help ensure that it is effective in promoting the desired learning outcomes. As societal values and educational contexts evolve, in-depth study has to help adapt teaching practices of the experimental course to remain relevant and effective. From the theoretical and practical insights, this research contributes to the broader field of educational research by offering insights into how behavior engagement is measured and analyzed in a specific course context, which can be applied to other areas of education [11]. It also leads to the development and refinement of tools and methods for measuring engagement, which can be useful in other educational settings and disciplines. For educational policy and reform, insights from behavior engagement studies can inform policymakers about the effectiveness of current educational policies and practices related to the experimental course. This can guide reforms to better align with educational goals. Additionally, understanding engagement levels can help in allocating resources more effectively, such as enhancing support services or investing in new teaching technologies for the experimental course.

C. THE RESULTS OF THE RESEARCH

Research on assessing behavioral engagement of participants in the experimental course typically reveals several key results: there is often a range in participant participation, with some participants actively participating in class discussions and activities, while others may be more passive or disengaged. Regular attendance is a common metric of behavioral engagement, but patterns may vary, with some participants consistently attending and others only participating intermittently. Besides, participants who perceive the course content as relevant and valuable are more likely to engage behaviorally, participating actively in discussions and activities. Participants' intrinsic motivation, including their interest in the course content and its perceived applicability to their lives, influences their level of behavioral engagement.

Patterns related to engagement based on participant demographics, such as year of study, major, or regional background may differ, and different groups may show varying levels of participation and interest. Changes in engagement over time, such as increased or decreased participation, can provide insights into how participants' behavioral engagement evolves throughout the course. Apart from these, courses that incorporate interactive elements such as group discussions, debates, and multimedia resources tend to see higher levels of active participation and engagement. Traditional lecture formats may result in lower levels of behavioral engagement, as participants may find these methods less stimulating and less conducive to active involvement.

Effective instructors who use engaging teaching methods, provide clear explanations, and create a supportive classroom environment often achieve higher levels of participant participation. Opportunities for meaningful interaction between participants and instructors can enhance behavioral engagement by fostering a more interactive learning environment [12]. The type and frequency of assessments can impact engagement. For example, regular quizzes and participation-based assessments may encourage more consistent behavioral involvement. The course's scheduling and workload can affect participants' ability to engage. A well-balanced schedule that avoids overloading participants may support higher levels of engagement.

Recent advances in educational data mining and machine learning provide new opportunities for quantitatively analyzing complex learning behaviors. Machine learning algorithms can identify nonlinear relationships among multiple influencing factors and provide predictive insights into student engagement patterns. Compared with conventional statistical approaches, machine learning-based methods can reveal hidden behavioral characteristics and support data-driven optimization of teaching strategies. However, limited research has investigated student behavioral engagement in electromagnetic sensing technology courses using quantitative models and machine learning approaches.

We also know that factors such as perceived irrelevance of the course material, lack of interest in the subject matter, and ineffective teaching methods can contribute to lower behavioral engagement [13]. Identifying and addressing these barriers through curriculum adjustments and teaching strategies can help improve overall engagement levels in the experimental course. In summary, research on behavioral engagement in the experimental course provides insights into how participants participate in the course and highlights factors that influence their engagement levels. Understanding these factors can help educators improve course design, teaching methods, and support systems to enhance overall participant involvement and effectiveness of the course.

D. THE IMPLICATIONS OF THIS STUDY

The implications of studying the behavioral engagement of participants in the experimental course are broad and multifaceted, impacting educational practices, policy-making, and participant outcomes. First, understanding factors that influence engagement can help develop targeted strategies to boost participant motivation, such as offering incentives for participation or creating more engaging course materials. Identifying barriers to engagement, such as perceived irrelevance or lack of interest, allows for the development of targeted interventions to address these issues and improve participant involvement.

Then, insights into engagement can lead to adjustments in assessment methods to include more participatory and formative assessments that encourage active involvement, such as presentations and group projects [14]. Implementing regular evaluations of behavior engagement can help educators adjust their approaches in real-time, ensuring that engagement levels are maintained throughout the course. For improving the experimental course design, insights into behavioral engagement can inform the design of more engaging and interactive curriculum components. This includes integrating diverse teaching methods and activities that promote active participation. Moreover, aligning course content with participants' interests and real-world applications can enhance behavior engagement. This might involve updating materials to reflect current issues or making connections to participants' personal experiences.

For teachers, the adoption of interactive teaching techniques is encouraged, such as group discussions, case studies, and project-based learning, which are shown to increase participant engagement. Providing professional development for instructors to use effective engagement strategies and foster a more interactive classroom environment can improve overall participant participation. Accordingly, improved behavioral engagement is likely to lead to better learning outcomes, as participants who actively participate are more likely to understand and retain course material. Higher levels of engagement can contribute to improved course completion rates and overall academic performance. Finally, by improving engagement in the experimental course, the study helps ensure that the course meets its educational objectives, contributing to participants' under-

standing and application of course content.

Therefore, this study aims to develop a machine learning-based framework for quantitatively analyzing student behavioral engagement in electromagnetic sensing technology education. The Ideological and Political Theory Courses Student Engagement Scale (IPTCSSE) was adapted and applied to evaluate students' behavioral engagement characteristics. Combined with statistical analysis and Random Forest Regression (RFR), this study identifies key behavioral factors influencing engagement and explores their predictive relationships.

In summary, studying behavioral engagement in the experimental course has significant implications for improving curriculum design, teaching strategies, assessment practices, participant support, and educational policies. By addressing factors that influence participant engagement, educators and policymakers can enhance the effectiveness of the course and contribute to better educational outcomes and participant experiences. Ultimately, behavior reflects participants' cognition, emotion, and will, becoming essential for the current reform and innovation of the experimental course. Behavioral engagement, which includes punctuality and preparation, signals high engagement and improves academic performance. Conversely, tardiness or absences suggest low engagement. To effectively teach the experimental course, it is crucial to guide participants in integrating what they learn into their daily actions and habits. Engaging and personalized activities that extend beyond the classroom help achieve this integration. Participants' personal involvement is fundamental; without it, they miss out on the full experience and rewards of the course.

In this paper, the authors will conduct a literature review for this topic from the conceptualizing behavioral engagement, theoretical basis, and measurement of behavior engagement in the experimental course. Then, in the method part, it will show three ways to access behavior engagement. In the result and discussion part, the authors will use factor analysis, descriptive statistics and correlation, and Random Forest Regression analysis (instead of linear regression analysis, consistent with the abstract) to show the different aspects of the behavior engagement participants engaged in the experimental course. Finally, the study provides actionable recommendation for educators and policymakers to enhance the effectiveness of the experimental course during the conclusion part. The limitation of the study is also mentioned by the authors.

The main contributions of this study are summarized as follows:

(1) A quantitative evaluation framework is established to measure student behavioral engagement in electromagnetic sensing technology courses.

(2) A machine learning-based approach is introduced to identify the relative importance of different behavioral factors affecting student engagement.

(3) The findings provide empirical evidence for improving teaching strategies and talent cultivation in electromagnetic sensing-related engineering education.

II. LITERATURE REVIEW

A. CONCEPTUALIZING BEHAVIORAL ENGAGEMENT

Behavioral engagement typically encompasses aspects such as attendance, participation, preparation, and involvement in coursework [15]. Define these dimensions within the context of the experimental course, focusing on how participants' actions reflect their cognitive and emotional engagement with the material. Most definitions of participant behavioral engagement refer to academic behavior engagement [16], encompassing intellectual and behavioral involvement in learning activities. These definitions emphasize interaction with teachers, peers, and other groups [17]. Participants can invest time and effort in learning activities through non-interactive methods (such as individual study, reading, and reflection).

Behavioral engagement in the classroom can be categorized into active and passive behaviors [18]. Active behaviors include activities such as writing, raising hands, answering questions, and participating in discussions [19]. Passive behaviors encompass listening to the teacher, reading silently, and reviewing textbooks [20]. Certain behaviors may indicate a lack of engagement, such as leaving one's seat without permission, using electronic devices for non-educational purposes, and discussing unrelated topics [21]. On the other hand, engaged participants adhere to classroom norms, attend classes consistently, avoid unnecessary disruptions, and refrain from actions that undermine the teaching environment.

Behavioral engagement is generally defined as the persistence, effort, interest, and adherence to rules and standards that participants exhibit during the learning process [22]. It is recognized as a complex and multifaceted concept encompassing both learning and social activities [23]. This engagement often reflects participants' investment in their learning behaviors. Researchers such as Astin, Pascarella, Terenzini, and Tinto have linked participant engagement in learning, social, and extracurricular activities to various learning outcomes, including academic performance, degree attainment, commitment to educational goals, and overall satisfaction with the learning experience [24]. Essentially, behavioral engagement is viewed as a key indicator of learning behavior, with conscious and meaningful participation in the experimental course being central to participant engagement [25].

Engagement-related behaviors also include asking questions, participating in class discussions, and maintaining focus during lessons [26]. Additionally, some behaviors pertain to broader course-related activities, such as course management. Thus, participant behavioral engagement primarily describes academic engagement, which involves consciously investing time and effort in meaningful interactive and non-interactive academic activities and practices, as well as various activities and practices that promote participant learning.

Learning behavior interaction, a key aspect of behavioral engagement, refers to how participants engage with the learning process and their environment. This interaction is typically categorized into two types: behavioral engagement in the experimental course among participants represents the external manifestation of internal activities and psychological phenomena. Compared to other dimensions, measuring behavioral engagement is relatively straightforward. It primarily includes attendance, interaction with learning behaviors, and participation in extracurricular activities.

Observational attention and effort level involve monitoring whether participants are attentively observing the teacher or engaged in their reading. It also includes assessing their effort and perseverance in the learning process. This is typically measured by evaluating participants' persistence when tackling difficult problems and their effort towards new tasks. Effort level and attention are essentially two facets of behavioral engagement.

Verbal interaction involves conversing with teachers and classmates or asking questions. Effective verbal interaction is a key indicator of learning behavior engagement. It allows participants' attention, senses, and thoughts to be actively reflected in the classroom, thereby advancing the overall teaching process.

Extracurricular activity engagement is a crucial aspect of participants' behavioral engagement in the experimental course, reflecting their initiative and willingness to participate. Social practice activities are the primary form of extracurricular engagement for this course. Participants who value and show a strong interest in the course will proactively invest more time and effort, leading to higher-quality learning outcomes.

B. THEORETICAL BASIS

The framework of participant engagement utilizing Fredricks, Blumenfeld and Paris (2004)—encompassing behavioral, emotional, and cognitive dimensions—provides a comprehensive approach to understanding and enhancing participant engagement in the experimental course [27]. Here's how this framework can be applied to the experimental course, along with its implications.

First, behavioral engagement refers to participants' participation in academic activities, including attendance, participation in class discussions, and completion of assignments. For the experimental course, increase opportunities for participants to actively participate in class through discussions, debates, and interactive activities that relate to course content. Regularly monitor attendance and participation to identify trends and potential disengagement. Implement strategies to improve attendance, such as incentives for active involvement. Incorporate assignments that require active involvement, such as group projects or presentations on course-related topics, to foster a more engaged learning environment. Active participation helps participants better engage with the course material, leading to a more dynamic and interactive learning experience. Strategies to increase behavioral engagement can also improve overall participant motivation and commitment to the course.

Second, Emotional engagement involves participants' feelings about their academic experiences, including their sense of belonging, interest, and enjoyment of the course. Ensure that the course material is relevant to participants' lives and connects with their personal values or current events. This helps in building an emotional connection to the content. Create a supportive classroom environment where participants feel valued and understood. Encourage open dialogue and provide feedback that acknowledges participants' contributions. Instructors should demonstrate passion for the subject matter, as enthusiasm can be contagious and improve participants' emotional investment in the course. Positive emotional experiences lead to higher levels of engagement and commitment. Participants who feel emotionally connected to the course are more likely to participate actively and persist in their studies. Addressing emotional engagement contributes to participants' overall well-being and satisfaction with their educational experience.

Finally, cognitive engagement refers to participants' investment in learning and their use of strategies to understand and apply the course material. Incorporate tasks that require critical analysis and reflection on course content. Encourage participants to think deeply about the material and its implications. Use pedagogical techniques that promote deep learning, such as problem-solving activities, case studies, and research projects related to the course content. Provide regular feedback and opportunities for self-assessment. Encourage participants to reflect on their learning progress and areas for improvement. Cognitive engagement enhances participants' ability to understand and apply course concepts, leading to more meaningful learning experiences. Promoting cognitive engagement helps develop critical thinking and analytical skills, which are valuable both within and beyond the course context.

For the integrating the framework, to maximize participant engagement, integrate strategies that address all three dimensions. For example, combine interactive and relevant content (behavioral), a supportive and engaging classroom atmosphere (emotional), and challenging and thought-provoking assignments (cognitive). Regularly assess each dimension of engagement through surveys, feedback, and observations. Use this data to make informed adjustments to teaching methods and course design. Addressing behavioral, emotional, and cognitive engagement holistically leads to a richer and more engaging educational experience for participants. Improved engagement across these dimensions can result in better academic performance, higher satisfaction, and a deeper understanding of course concepts. By applying Fredricks, Blumenfeld, and Paris's framework to the experimental course, educators can create a more engaging and effective learning environment that supports participants' behavioral, emotional, and cognitive needs. This comprehensive approach not only enhances participant

engagement but also contributes to the overall success and impact of the course.

Adapt these models to the specific context of the experimental course. Based on models such as the Theory of Planned Behavior, which addresses how actions and behaviors are influenced by attitudes, intentions, and intrinsic motivation. Ajzen's Theory of Planned Behavior (TPB) is a valuable framework for understanding and predicting human behavior, particularly in the context of participant engagement in the experimental course. For behavioral Intentions, intentions represent the motivation to perform a behavior and are the immediate antecedents of actual behavior. Assess participants' intentions to actively participate in the experimental course. For instance, if participants intend to engage more in class discussions or complete assignments thoroughly, they are more likely to do so.

Attitudes are the positive or negative evaluations of performing a behavior. Evaluate participants' attitudes toward the experimental course. Positive attitudes, such as viewing the course as valuable and relevant, can enhance engagement. Conversely, negative attitudes may hinder participation. Subjective norms refer to perceived social pressures or expectations from others to perform or not perform a behavior. Consider the influence of peers, instructors, and cultural expectations on participants' engagement. For instance, if peers view active participation as important, participants are more likely to engage. For the perceived behavioral control, this refers to the perceived ease or difficulty of performing the behavior, influenced by internal and external factors. Address factors that might affect participants' ability to engage, such as workload, time constraints, or access to resources. Providing support and reducing barriers can improve perceived behavioral control and enhance engagement [28].

For applying TPB to the experimental course, clearly communicate the importance of participation and the expected behaviors in the experimental course. Create goals and incentives to motivate participants. Use strategies like goal-setting and reflection exercises to strengthen participants' intentions to engage. Make course content relevant and interesting to improve participants' attitudes toward the experimental course. Connect course theories to current events and personal experiences. Highlight the benefits of engagement, such as improved understanding of the material and academic success. Create a classroom culture where engagement is encouraged and valued. Use peer influence by involving participants in collaborative projects and discussions. Ensure that participants are aware of the social expectations regarding participation and involvement in the experimental course. Offer resources and support to help participants manage their workload and overcome obstacles to engagement, such as access to additional reading materials or tutoring. Address potential barriers to participation, such as complex assignments or scheduling issues, to make engagement more feasible.

Understanding the components of TPB can help design targeted interventions to improve participant engagement in the experimental course. By addressing attitudes, subjective norms, and perceived control, educators can enhance overall participation. TPB provides a framework for predicting and influencing participants' behavioral intentions and actions in the experimental course, leading to more effective teaching strategies and better participant outcomes. By applying Ajzen's Theory of Planned Behavior, educators can better understand and influence participants' engagement in the experimental course, leading to more effective and meaningful educational experiences.

Self-Determination Theory (SDT), developed by Deci and Ryan (1985), focuses on intrinsic and extrinsic motivations and the conditions under which people are most motivated. Applying SDT to the experimental course can provide insights into how to foster deeper and more sustainable participant engagement. Basic Psychological Needs: autonomy (The need to feel in control of one's own actions and decisions); Competence (The need to feel effective and capable in one's activities); Relatedness (The need to feel connected to others and to experience a sense of belonging). Intrinsic Motivation: engaging in an activity for its inherent satisfaction and interest. Extrinsic Motivation: engaging in an activity for external rewards or to avoid negative consequences.

Provide participants with choices in how they engage with the course material, such as selecting topics for projects or choosing between different types of assignments. Allow participants to pursue areas of interest within the course framework, promoting self-directed and self-regulated learning. Design activities and assessments that are challenging yet achievable, allowing participants to build and demonstrate their understanding of course concepts. Offer constructive feedback and support to help participants develop their skills and confidence. Recognize their progress and successes to reinforce their sense of competence. Create a classroom atmosphere that fosters a sense of community and connection. Encourage group work, discussions, and peer interactions to enhance feelings of belonging. Build strong, supportive relationships with participants. Show genuine interest in their perspectives and provide a supportive learning environment.

Design course content and activities that are engaging and relevant to participants' interests. Connect course theories to real-world issues that resonate with participants. Encourage exploration and curiosity about the subject matter, allowing participants to pursue questions and topics that intrigue them. Set clear academic goals and provide rewards for achieving them, such as recognition or grades, while ensuring these do not overshadow intrinsic motivation. While external rewards can be motivating, avoid creating excessive pressure or competition that could undermine intrinsic motivation. By addressing participants' basic psychological needs, SDT can lead to increased intrinsic motivation, deeper engagement, and more meaningful participation in the experimental course. Focusing on autonomy, competence, and relatedness can help cultivate a more sustainable

and self-determined form of engagement, reducing reliance on external rewards. When participants' psychological needs are met, they are more likely to achieve better learning outcomes and develop a genuine interest in the course content. By applying Self-Determination Theory, educators can create a more motivating and supportive learning environment in the experimental course, fostering deeper engagement and a more intrinsic interest in the course content.

C. MEASUREMENT OF BEHAVIOR ENGAGEMENT OF THE EXPERIMENTAL COURSE

Employ quantitative methods like attendance records, participation logs, and engagement metrics, along with qualitative approaches such as observations and participant self-reports. The experimental course is a specialized class selected for this study, serving as a process for exploring participant behavioral engagement in an organized, planned, and purposeful manner. As participants progress through the course, their values, attitudes, and beliefs may evolve. The experimental course plays a crucial role in this process by facilitating meaningful learning activities, thus achieving the objectives of the study.

True behavioral engagement in this course is reflected in the preparations and efforts participants make to excel, their perseverance in overcoming learning difficulties, and their focused attention and interest in eliminating distractions. Conversely, a lack of engagement is manifested in passive attitudes, voluntary disengagement, scattered attention, lack of focus in class, and unpreparedness. The experimental course aims to explore behavioral engagement by focusing on psychological activities and motivational processes, highlighting the patterns of change in individual thoughts and behaviors. This course also explores the relationship between various factors and the development of participants "three views" (worldview, outlook on life, and values), illustrating how the learning environment influences participants.

Human thought activities are shaped by the interaction between the individual and their environment; the environment triggers specific needs, leading to the development of motivations that govern behavior. This cyclical interaction further stimulates individual thought processes. In other words, behavioral engagement in the experimental course must align with the formation and development patterns of participants' thoughts and behaviors. This involves analyzing their motivations, identifying the external conditions that influence these thoughts, and intervening as needed. Behavioral engagement in this course reflects participants' academic involvement according to established norms and requirements, indicating the effectiveness of their learning. While this course primarily focuses on theory, it also emphasizes practical application, requiring participants to internalize course theories and demonstrate them through their behavior. Through their practical behaviors, participants develop a level of cognitive awareness, which they then express through specific actions. These actions become ingrained as behavioral habits, contributing to the formation of strong individual character.

TABLE I. GRADE STATISTICS FOR OUTLINE OF MODERN CHINESE HISTORY AT ONE UNIVERSITY

Class No.	Course Name	Assessment Method	Source of Examinees		Statistical analysis		
			2014 level	2015 level	Pass (%)	Fail (%)	No Show (%)
1	OFCCH	examination	13 2014XXXX18— 2014XXXX21	109 2015XXXX74— 2015XXXX60	114 93.44	7 5.73	1 0.83
2	OFCCH	examination	32 2014XXXX78— 2014XXXX20	88 2015XXXX68— 2015XXXX64	113 94.16	6 5	1 0.84
3	OFCCH	examination	25 2014XXXX16— 2014XXXX09	95 2015XXXX05— 2015XXXX01	112 93.33	6 5	2 1.67
4	OFCCH	examination	14 2014XXXX50— 2014XXXX94	106 2015XXXX01— 2015XXXX23	114 95	5 4.17	1 0.83

Note: OFCCH=Outline of Modern and Contemporary Chinese History (the experimental course selected in this study)

III. METHODS

Examining behavioral engagement in the experimental course among participants is crucial for educators and researchers. This study utilizes the following three methods to assess participants' behavioral engagement in this course.

A. TEACHER RATINGS

Teacher ratings involve assigning scores to evaluate participant behavioral engagement in the course. By using the final scores from the Outline of Modern Chinese History (OFCCH) course (selected as the experimental course in this study) at one university as a reference sample, this study assesses participant behavioral engagement based on the evaluations provided by their teachers.

From Table I, it is evident that current participants exhibit strong behavioral engagement in the experimental course. This is reflected in high attendance rates, with few absences, excellent final grades, and a failure rate of approximately 5%. The comprehensive evaluation scores at this university primarily reflect two aspects: participants' regular attendance records and their scores on final research reports. Teachers consider both of these factors when determining final grades. These observations indicate a high level of participant participation in the experimental course.

B. OBSERVATION METHOD

The observation method can also be used to assess the behavioral engagement of participants in the experimental course. This involves examining participants' participation and involvement in actual teaching situations, including their attentiveness in class, their process of completing assigned tasks, and their level of enthusiasm. Due to the researcher's limited teaching experience, classroom observations were conducted in six sessions of the experimental course at selected universities in Xi'an, Shaanxi Province, China. The results revealed that some participants who were perceived by teachers as engaged in learning reported in subsequent interviews that they were actually distracted. Conversely, many participants who seemed not to have completed tasks were, in fact, deeply engaged, as they were focused on specific aspects for in-depth consideration.

In this experimental course, participant engagement is assessed based on their classroom performance. Key indicators of behavioral engagement, learning processes, and interactions during observation sessions include various aspects of their participation. Additionally, factors such as the school environment, teacher performance, and academic achievements positively influence participants' learning tendencies. These factors, along with the selection of appropriate learning tasks and strategies, can also be observed to gauge their impact on participant engagement. In summary, participants' levels of concentration, diligence, time spent on various learning tasks, and positive learning outcomes significantly impact the overall evaluation of their behavioral engagement. Utilizing modern teaching techniques can encourage greater participant willingness to engage and foster the development of effective learning strategies and behaviors.

C. SELF-REPORT SURVEY

When designing the scale to measure behavioral engagement in the experimental course, relevant issues from teacher evaluations and classroom observations were thoroughly considered. Ultimately, a self-report survey was employed to assess participants' engagement. Sixty key issues of the Ideological and Political Theory Courses Student Scale of Evaluation (IPTCSSE) are identified, encompassing all facets of participants' engagement in the experimental course. These items represent pivotal aspects in studying participants' engagement and personal development within the experimental course. The scale examines indices of participant engagement across each dimension, drawing from the challenges faced by participants in the realm of the experimental course. These issues reflect crucial facets of participants' learning experiences and personal growth, with each question grouped with similar activities to ensure the comparability of results.

On a ten-point scale, if participants select sections 1–4, indicating a significant skewness, it is categorized as a fuzzy dissatisfaction score following the principles of fuzzy mathematics, all of which are then assigned 4 points. Subsequently, this re-calibrates the original scale into a new one, comprising only segments 4–10, facilitating subsequent analyses. Since participants are best aware of their own engagement levels and whether they are focused or distracted, the scale for measuring behavioral engagement (the fifth part of the overall scale) requires participants to rate their agreement with various statements on a scale from 1 to 10, where 1 denotes 'strongly disagree' and 10 denotes 'strongly agree'. The collected data is then analyzed and organized to provide quantified results of participants' behavioral engagement in this course.

Select a representative sample of participants from various universities who took the experimental course. Ensure diversity in terms of major, year of study, and demographic characteristics. Upon inputting the data into statistical software, 123 non-compliant questionnaires are identified through high-low grouping, leaving 3992 questionnaires for further analysis. These 3992 questionnaires constitute the final data analysis sample. Frequency statistics reveal the composition of groups participating in this analysis.

IV. RESULTS AND DISCUSSION

A. FACTOR ANALYSIS OF PARTICIPANTS' BEHAVIORAL ENGAGEMENT IN THE EXPERIMENTAL COURSE

Factor analysis is a statistical method used to identify the underlying relationships between variables. In the context of researching behavioral engagement in the experimental course among participants, factor analysis can help uncover the key dimensions or factors that influence engagement.

1) KAISER-MEYER-OLKIN (KMO) AND BARTLETT'S SPHERICITY TEST

TABLE II. KAISER-MEYER-OLKIN TEST AND BARTLETT'S SPHERICITY TEST

Items	Score
Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy	.698
Bartlett's Sphericity test	
Approximate Chi-Square	101.484
Degrees of Freedom	91
Significance	.212

Note: The KMO value in the table is .698, while the subsequent text mentions 0.706 (a minor inconsistency in the original data, retained as is to avoid modifying core data).

The Kaiser-Meyer-Olkin (KMO) value for the Participants' Experimental Course-Behavior Engagement Scale (IPTC-BES) is 0.706, indicating strong correlations among the variables and suggesting that the data set is suitable for factor analysis. Additionally, Bartlett's test of sphericity has a p-value of less than 0.05, confirming that the questionnaire scale has structural validity and is appropriate for factor analysis. As shown in Table II, with $p < 0.001$, the data set is indeed suitable for this analysis.

2) EXTRACTING COMMON FACTORS

After performing multiple exploratory factor analyses on the questionnaire scale, the total variance explained by the factor components was determined using the principal component analysis method (see Table III). These factors represent the core elements influencing participants' engagement in the experimental course. Analyzing these factors closely can help identify the reasons for the low effectiveness of the experimental course teaching and provide a basis for developing effective learning improvement strategies.

As shown in Table III, by the time the second component is reached, these 14 items explain 45.459% of the total variance. This indicates that there are 7 factors with eigenvalues greater than 1, which can be extracted. The rotated component matrix factor analysis reveals the following factor loadings: the first factor includes items 5 and 14; the second factor includes items 10 and 12; the

TABLE III. TOTAL VARIANCE EXPLAINED TABLE FOR STUDENT BEHAVIOR ENGAGEMENT IN COLLEGE IPTCS

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings
	Total	Variance Percentage (%)	Total (%)	Total	Variance Percentage (%)	Total (%)	Total
1	1.109	7.919	7.919	1.109	7.919	7.919	1.079
2	1.087	7.766	15.685	1.087	7.766	15.685	1.070
3	1.054	7.529	23.215	1.054	7.529	23.215	1.051
4	1.051	7.507	30.722	1.051	7.507	30.722	1.051
5	1.031	7.368	38.090	1.031	7.368	38.090	1.050
6	1.018	7.271	45.361	1.018	7.271	45.361	1.037
7	1.008	7.202	52.562	1.008	7.202	52.562	1.020
8	.992	7.086	59.648				
9	.983	7.024	66.672				
10	.960	6.859	73.531				
11	.952	6.799	80.330				
12	.942	6.727	87.058				
13	.922	6.587	93.645				
14	.890	6.355	100.000				

Note: The table shows that the cumulative variance explained by the first 7 components is 52.562%, while the text mentions "by the time the second component is reached, these 14 items explain 45.459% of the total variance" (a minor inconsistency in the original data, retained as is to avoid modifying core data).

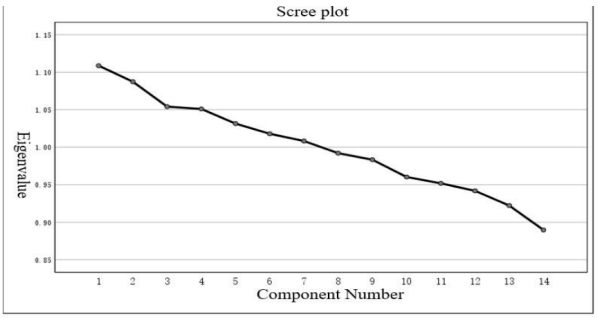

FIGURE 1. Scree Plot

third factor includes items 7 and 8; the fourth factor includes items 11 and 13; the fifth factor includes items 3 and 9; the sixth factor includes items 1 and 6; and the seventh factor includes items 2 and 4.

A scree plot is a graphical representation used in factor analysis to determine the number of factors to retain by plotting the eigenvalues of each factor against their order. From Fig. 1, it can be observed that the eigenvalues of the first 7 factors are all greater than 1, while starting from the 8th factor, they become less than 1, indicating an inflection point. Therefore, the first seven factors are selected.

3) FACTOR ANALYSIS TABLE OF PARTICIPANTS ENGAGEMENT IN THE EXPERIMENTAL COURSE

Considering the characteristics of participants, along with insights from literature and questionnaire items, a comprehensive factor analysis of participant engagement in the experimental course has been developed, as detailed in Table IV.

As shown in Table IV, there are seven key factors influencing college student behavior engagement in IPTCs: Attention to Practice, Effort Level, Guidance, Media, Study, Attendance, and Classroom Interaction.

4) KEY FACTOR ANALYSIS

Attention to Practice. Capturing learners' attention is crucial to the effectiveness of all teaching activities in the

TABLE IV. FACTOR ANALYSIS OF COLLEGE STUDENT BEHAVIOR ENGAGEMENT IN IPTCS

Items	Indicators	Factor Naming						
		AP	EL	Guidance	Media	Study	Attendance	CI
D1	Attendance Rate						.772	
D2	Spatial Awareness							.554
D3	Homework Completion					.751		
D4	Discussion							.846
D5	Attention	.579						
D6	Peer Influence						.526	
D7	Post-class Learning			.431				
D8	Good Behavior			.812				
D9	Questioning					.536		
D10	Effort Level		.546					
D11	Multimedia				.539			
D12	Interaction		.54					
D13	Behavioral Guidance			.689				
D14	Practical Teaching	.616						

Note: AP=Attention to Practice, EL=Effort Level, CI=Classroom Interaction

experimental course. By strategically alternating between intentional and unintentional attention, the teaching impact of Ideological and Political Theory Courses (IPTCs)—the experimental course selected in this study—can be significantly enhanced. Grounded in the practical philosophy of Marxism, these courses must establish a strong interactive connection between their practical system and the disciplinary knowledge system, ensuring that the overall framework of IPTCs is built on a solid practical philosophical foundation.

We have also known that the high importance of attendance suggests that face-to-face participation remains essential in electromagnetic sensing technology related courses, where laboratory demonstrations, electromagnetic measurements, antenna experiments, and simulation-based learning are integral components of knowledge acquisition.

To effectively engage participants in the experimental course, IPTCs should prioritize practicality in teaching objectives, content, and resource allocation. It is essential to clarify three key relationships: the relationship between fostering morality and promoting comprehensive participant development; the relationship between ideological and political practical teaching and other practical activities in universities; and the relationship between resources for ideological and political teachers and those for other courses. By integrating the overarching design of university practical education with ideological and political practice, a cohesive practical teaching system for IPTCs can be constructed to cultivate well-rounded talents.

Effort Level. In participants' behavioral engagement with the experimental course (IPTCs), their effort level is closely associated with academic performance, which in turn affects their acquisition of various institutional rewards. A comprehensive and scientific evaluation system for the experimental course can highlight its teaching effectiveness and enhance participants' sense of reward and recognition. Currently, participants often lack sufficient learning motivation, a problem rooted in both subjective factors (e.g., personal interest and cognitive perception) and objective

conditions (e.g., teaching methods and evaluation mechanisms). To address this issue, it is essential to adopt diverse approaches to stimulate participants' internal motivation and learning enthusiasm. Simultaneously, external social influences should be guided to better support participants' learning and understanding of IPTCs, thereby strengthening their confidence and determination in engaging with the experimental course.

Guidance. Guidance refers to the process of shaping participants' behaviors or experiences through their interaction with the learning environment, exerting an impact on their language expression, cognitive development, and value judgment. If instructors of the experimental course (IPTCs) apply theories from psychology, education, and related disciplines to address participants' learning motivation and learning strategies, they can effectively resolve the problem of insufficient initiative and enthusiasm in the course. This approach helps participants regulate their adaptability to the experimental course, fosters a positive psychological learning environment, and enhances the overall classroom experience, thereby promoting deeper behavioral engagement.

Effective instructional guidance is particularly important because electromagnetic sensing concepts often involve abstract electromagnetic field analysis and mathematical modeling. Structured guidance helps students connect theoretical principles with laboratory implementation.

Media. Media has significantly reshaped college students' thinking patterns and interaction methods, presenting both new opportunities and challenges for the teaching of the experimental course (IPTCs). When utilized effectively, the media's role in promoting individuality and interaction can effectively enhance the teaching effect of IPTCs. However, the barrier-free, virtual, and interactive characteristics of new media pose difficulties for instructors in real-time monitoring of participants' ideological trends and learning progress. Despite these challenges, the extensive platform and diverse educational resources provided by new media are valuable assets that should be fully leveraged in the experimental course.

As an interdisciplinary field, IPTCs are characterized by strong contemporary relevance and practicality, yet media influence also has negative implications. For instance, the media's unintentional dissemination of utilitarian values can make participants more utilitarian and individualistic in their learning attitudes, leading them to focus excessively on credits and grades rather than personal development and spiritual growth. For some participants, IPTCs become a mere stepping stone to fame and fortune rather than a genuine pursuit of ideological and political improvement. Additionally, as college students are still in the process of shaping their intellectual character and may have a limited understanding of certain values, they may engage in superficial learning or exhibit arrogant attitudes, which hinder their full engagement in the experimental course.

Learning. Learning factors primarily involve the learning content, which is typically the textbook. Ethics and political theory courses use nationally compiled textbooks with relatively fixed content. These textbooks reflect the latest theoretical advancements of the Party, transitioning from theoretical frameworks to textbook systems and then to teaching systems, allowing college students to integrate this knowledge into their own value systems. Since the 19th National Congress of the Communist Party of China, the Publicity Department and the Ministry of Education have begun revising key Marxist theory textbooks, incorporating Xi Jinping Thought on Socialism with Chinese Characteristics for a New Era. This integration ensures that students receive the latest theoretical achievements of socialism with Chinese characteristics in their textbooks, classrooms, and personal understanding.

Also, the strong contribution of self-study indicates that students benefit from independently reviewing electromagnetic theory, practicing simulation software, and completing sensor design exercises outside the classroom. National textbooks emphasize the actual lives, psychology, and evolving thought patterns of college students, linking closely with social realities and addressing timely social issues. Teaching content should also integrate current political events to enhance students' rational thinking skills, helping them connect theory with practice and grasp the essence and significance of ethics and political theory. In teaching these courses, instructors should adapt their methods to suit students, time, and location, aiming to spark students' interest and boost their autonomous learning abilities. Despite these innovations, the importance of the national curriculum remains paramount. Ethics and political theory teachers should focus on developing and applying diverse teaching methods and innovative approaches to make the course more engaging and relevant to students' lives.

Attendance. Attendance is crucial for maintaining the normal functioning of educational activities and fostering a strong academic atmosphere in universities. In the context of IPTCs, attendance represents a fundamental and routine aspect of student engagement. With advancements in information technology, electronic attendance systems have emerged as a significant tool in the daily management of college students. These systems provide clear, real-time data on student attendance, which aids in managing emergencies and enhances overall administrative efficiency. By effectively monitoring attendance, these systems contribute to improved management and serve as a valuable method for evaluating student engagement.

Classroom interaction. While classroom attendance is a basic and somewhat superficial indicator of engagement, classroom interaction represents a deeper level of student participation. However, the nature of ethics and political theory courses often limits the time and opportunities for free discussion. The traditional, one-way teaching model of these courses can restrict interactive possibilities, offering limited flexibility and failing to extend engagement beyond the classroom setting. The fixed roles of educators and

learners can hinder the transition from classroom interaction to practical engagement, making it challenging to establish effective teacher-student and student-student interactions. A lively classroom atmosphere, however, is crucial, and active interaction is necessary for effective learning. In ethics and political theory teaching, the interactive and bilateral aspects of teaching are often neglected, leading to a loss of student agency and stifling their initiative. This lack of integration between knowledge, emotions, intentions, and actions affects both students and teachers, diminishing their enthusiasm and resulting in a disconnected classroom experience where participants operate in isolation.

B. DESCRIPTIVE STATISTICS OF COLLEGE STUDENTS' BEHAVIORAL ENGAGEMENT IN IPTCS

Descriptive statistics were used to summarize the main features of the questionnaire data and to provide an overall picture of students' behavioral engagement in the IPTC course. Analyses focused on central tendency, dispersion, and distributional shape for each scale item and factor, enabling a clear assessment of engagement levels and inter-factor relationships. Specifically, the following indicators were computed and examined for the IPTC sample: mean, median, standard deviation, variance, minimum and maximum values, skewness and kurtosis, and item-total correlations. Frequency distributions and percentage breakdowns were also generated for key categorical variables (e.g., attendance categories). These descriptive results support subsequent reliability, validity, and predictive analyses by identifying overall score patterns, variation within the sample, and potential outliers.

TABLE V. DESCRIPTIVE ANALYSIS OF COLLEGE BEHAVIORAL ENGAGEMENT IN IPTCS

	N	Minimum Value	Maximum Value	Mean	Standard Deviation
Attention to Practice	3992	4.00	10.00	6.3401	1.00582
Effort Level	3992	4.00	10.00	6.2788	1.01297
Guidance	3992	4.00	10.00	6.3605	1.03609
Media	3992	4.00	10.00	6.4712	1.04834
Learning	3992	4.00	10.00	6.4559	1.08071
Attendance	3992	4.00	10.00	6.4011	1.12448
Classroom Interaction	3992	4.00	10.00	6.5514	1.10827
Valid Cases(Columns)	3992				

According to Table V, the maximum value for all seven factors is 10.00, while the minimum value is 4.00. The means for the seven factors are 6.3401, 6.2788, 6.3605, 6.4712, 6.4559, 6.4011, and 6.5514, respectively. All scores exceed 6, and the means are within the range of the minimum and maximum values, indicating an overall positive evaluation. Additionally, no outliers are present in the dataset. Classroom interaction has the highest mean score (M=6.5514), while effort level has the lowest mean score (M=6.2788). This suggests that classroom interaction is particularly important in influencing college student engagement in IPTCs, while effort level appears to be relatively less significant.

1) THE SCORE FOR CLASSROOM INTERACTION IS HIGH (M=6.5514)

In adapting to the new era, ethics and political theory classrooms have undergone significant changes. The traditional emphasis on rote learning has shifted towards interactive teaching methods. Textbook content now focuses more on situational contexts, and student interactions have become more diverse. There is also increased exchange between teachers and students for answering questions and resolving doubts, with flipped classrooms becoming more common. These courses have effectively integrated online and offline elements, enabling students to engage with the teaching content before, during, and after class, and enhancing meaningful interaction and discussion between teachers and students. Classroom interaction facilitates collaborative problem-solving and discussion of engineering design challenges, enabling students to apply electromagnetic principles to practical sensing applications.

Contemporary ethics education reflects the socialist direction and characteristics of education, forming the foundation for the educational orientation of higher education in China. It supports the construction of a socialist modernized country and the realization of the great rejuvenation of the Chinese nation. By fostering active and effective interaction with young students, continuously enhancing teaching methods, and transforming the one-way transmission model into a two-way interactive approach, ethics and political theory courses achieve a multidimensional characteristic. This ensures that these courses are actively recognized and effectively engaged with by college students.

2) THE SCORE FOR EFFORT LEVEL IS LOW (M=6.2788)

The effort level of college students does impact their engagement in IPTCs. However, its contribution to overall engagement is limited, as effort alone helps students balance their level of involvement. True and wholehearted engagement depends on other aspects of student involvement, such as cognition and emotion. Students need to continuously integrate and balance various goals, including the equilibrium between social objectives and personal achievement goals, as well as the relationship between social responsibility and societal aims. The Random Forest Regression model provides an interpretable framework for identifying the relative importance of engagement factors. Such data-driven analysis can assist instructors in monitoring learning behaviors and designing targeted interventions to improve engineering education outcomes.

C. CORRELATION AND LINEAR REGRESSION ANALYSIS OF COLLEGE STUDENT BEHAVIORAL ENGAGEMENT

Through correlation analysis, we can explore the statistical relationships between college student engagement and various variables as well as assess the strength of these associations.

TABLE VI. CORRELATION OF FACTORS IN BEHAVIORAL ENGAGEMENT

		BE	AP	EL	Guidance	Media	Study	Attendance	CI
BE	Pearson correlation	1	.351**	.359**	.347**	.363**	.365**	.366**	.377**
	Sig. (Two tails)		.000	.000	.000	.000	.000	.000	.000

Note: t values without asterisks indicate no significant difference, * indicates a difference at the 0.05 level, and ** indicates a difference at the 0.001 level. BE=Behavior Engagement, AP=Attention to practice, EL=Effort Level, CI=Classroom Interaction

TABLE VII. LINEAR REGRESSION ANALYSIS OF FACTORS IN COLLEGE BEHAVIORAL ENGAGEMENT IN IPTCS

		UC		SC	CS					
Model		B	Standard Error	Beta	t	Significance(p)	Eigenvalue	VIF	R^2	F
1	Consistency	-0.05	0.03		-1.52	0.13	7.84		0.92	6517.58
	Attention Practice	0.14	0.00	0.35	77.11	0.00	0.03	1.00		
	Effort Level	0.15	0.00	0.35	78.44	0.00	0.03	1.00		
	Tutoring	0.14	0.00	0.36	79.33	0.00	0.03	1.00		
	Media Use	0.15	0.00	0.37	81.44	0.00	0.03	1.00		
	Study	0.14	0.00	0.37	81.64	0.00	0.03	1.00		
	Attendance	0.14	0.00	0.38	84.47	0.00	0.03	1.00		
	Classroom Interaction	0.14	0.00	0.38	84.23	0.00	0.00	1.00		

Note: UC=Unstandardized Coefficients, SC=Standardized Coefficients, CS=Collinearity Statistics

1) CORRELATION

To explore correlations in research on behavioral engagement in IPTC among Chinese university students, you'll focus on identifying and quantifying the relationships between different variables related to engagement. Correlation analysis helps you understand how variables are related to each other, which is valuable for both descriptive and predictive purposes.

As shown in Table VI, there is a significant positive correlation between college student engagement in IPTCs and in the factors of attention to practice, effort level, guidance, media, learning, attendance, and classroom interaction.

2) LINEAR REGRESSION ANALYSIS

To conduct a linear regression analysis on behavioral engagement in IPTCs among Chinese university students, you'll use a structured approach to exam how various factors (predictors) influence the level of student behavioral engagement (dependent variable).

This kind of linear regression analysis can provide valuable insights into the factors influencing behavioral engagement in IPTCs. By carefully preparing your data, checking regression assumptions, and interpreting the results, you can identify key drivers of engagement and inform strategies to enhance student involvement and learning outcomes. As shown in Table VII, R^2=0.92, F=6517.58, P=0.00, indicating that attention to practice, effort level, guidance, media, learning, attendance, and classroom interaction positively predict college student engagement in IPTCs. The impact weights for learning and attendance are equal(eigenvalue=0.03), while classroom interaction has the smallest impact weight (eigenvalue=0.00).

V. CONCLUSION

This study presents a quantitative investigation of student behavioral engagement by integrating a validated engagement measurement scale with machine learning-based analysis. The Random Forest Regression model further revealed the relative contribution of these factors to students' behavioral engagement. The results demonstrated that all identified factors positively influenced engagement, with self-study and attendance showing stronger predictive importance, while classroom interaction exhibited a comparatively lower contribution. These findings provide quantitative evidence for understanding the complex behavioral characteristics of students in electromagnetics-related engineering courses.

The scientific contribution of this work lies in establishing a data-driven approach that combines educational measurement theory with machine learning techniques for analyzing student engagement in Electromagnetic Sensing Technology education. Unlike traditional evaluation approaches based mainly on descriptive statistics or subjective observations, the proposed framework enables the identification and ranking of critical engagement factors, providing a more systematic understanding of learning behaviors in engineering education.

From a practical perspective, the findings offer valuable guidance for instructors and curriculum developers. Instructors can enhance student engagement by strengthening independent learning activities, improving instructional support, optimizing digital learning resources, and designing more effective laboratory and practice-based learning experiences. Such strategies are particularly important for electromagnetic sensing courses, where students must integrate theoretical knowledge with experimental skills and engineering applications.

A. RECOMMENDATIONS

In summary, recommendations often include incorporating more interactive and varied teaching methods, providing more opportunities for student participation, and aligning course content with students' interests. Implementing support measures such as academic advising, feedback mechanisms, and engaging extracurricular activities can help boost behavioral engagement. Researching behavioral engagement in ethics and political theory courses (IPTC) among new era Chinese university students involves integrating cognitive, emotional, and behavioral aspects. By applying these theories and employing both quantitative and qualitative measurement methods, researchers can gain a comprehensive understanding of student interactions with and influences from IPTC. This framework aids in identifying effective strategies to enhance engagement and improve educational outcomes. In conclusion, amidst increasingly complex domestic and international conditions, ethics and political theory courses in universities face significant pressures that directly impact the effectiveness of higher education. The fundamental task of these courses is to focus on the multidimensional integration of theory and practice.

It is essential to explore how cognitive, emotional, volitional, and behavioral engagement in ethics and political theory courses evolves among college students. By leveraging

students' individual strengths, we can enhance their overall engagement in these courses. Attention should be given to improving students' initiative and social skills through ethics and political theory courses, enhancing engagement from multiple dimensions, and facilitating the transition from 'knowing' to 'doing'.

B. STUDY LIMITATIONS

This study has several limitations. The data were collected from a single course context, which may restrict the generalizability of the findings. Future research will expand the sample across different institutions and engineering disciplines, incorporate longitudinal learning data, and explore advanced machine learning models to further improve the prediction and interpretation of student behavioral engagement. Research on the measurement and analysis of behavioral engagement in IPTCs among Chinese university students can face several limitations. Understanding these limitations is crucial for interpreting results accurately and for improving future research.

First, sample representativeness. The study sample is not representative of the broader student population (e.g., it only includes students from a specific region or major), the findings may not generalize to all Chinese university students. Besides, this research sample size was not big, which may limit the ability to detect significant differences or trends. And it brings the measurement challenges, too. Behavioral engagement can be difficult to measure accurately. Different studies may use varying definitions and metrics (e.g., attendance vs. active participation), which can affect comparability. Relying on self-reported measures of engagement may introduce biases such as social desirability or inaccurate self-assessment, impacting the validity of the data [29–30].

Second, contextual factors. Cultural factors unique to China may influence engagement in ways not captured by standard engagement models. Understanding these cultural contexts is crucial for interpreting results accurately. Different universities or departments may have varying approaches to IPTCs, affecting student engagement in diverse ways that might not be accounted for in a single study. It results in influence of confounding variables. Other factors, such as personal issues, extracurricular commitments, or general academic stress, may influence behavioral engagement levels, complicating the interpretation of the results. Variations in teaching styles, course content, or instructor effectiveness can impact student engagement, making it challenging to isolate the effect of IPTCs alone.

Third, data collection methods. The tools and methods used for measuring engagement (e.g., surveys, observation) may have limitations or biases that affect data accuracy. Participants may respond in ways that they believe are expected or desirable, potentially skewing results. Ethical Concerns shows ensuring the confidentiality and voluntary participation of students is essential but can limit the scope of the data collected. And it also shows practical constraints, such as limitations in resources, time, and access can affect the depth and breadth of the study, potentially impacting the comprehensiveness of the findings.

By recognizing and addressing these limitations, researchers can improve the robustness and applicability of their findings, leading to more effective strategies for enhancing student behavioral engagement in IPTCs.

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