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Research article

Students’ intention to participate in scientific competitions – The scientific students' associations conference in Hungary

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A R T I C L E I N F O

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A B S T R A C T

Universities face increasing challenges in cultivating the next generation of scientists. One promising strategy for addressing this issue is engaging students in scientific competitions. Understanding the determinants of students' intention to participate in such competitions is essential for improving participation. This study investigates these determinants using the Theory of Planned Behaviour (TPB). To address our research questions, we conducted an online questionnaire survey in Hungary in 2023. Participants were recruited in person, provided with verbal and written information about the study, and completed the questionnaire voluntarily and anonymously. The measurement items were specifically developed by the authors, who adapted original TPB items to assess students' intentions to participate in the Scientific Students' Associations Conference (in Hungarian: Tudományos Diákköri Konferencia, TDK), the largest and most prestigious scientific competition in Hungary. Statistical analyses were performed on a sample of 292 students using SPSS, and the research hypotheses were examined using structural equation modelling (SEM) in AMOS. The findings indicate that subjective norms and perceived behavioural control significantly affect students' intentions, whereas attitude does not. The results suggest that increasing student participation in scientific competitions requires more than a focus on attitude-based campaigns. Instead, there should be a strong emphasis on mentorship and the development of individual skills.

1. Introduction

The twenty-first century is defined by rapid transformation and pervasive uncertainty, characterised by the continuous emergence of novel technologies and complex social issues [1]. The “knowledge triangle” framework emphasises the essential role of higher education, highlighting the interdependence of education, research, and innovation - three pillars critical to cultivating a knowledge-based economy [2].

The knowledge triangle serves as a guiding principle for enhancing the performance of higher education institutions by aligning and integrating these three critical functions, thereby fostering a more cohesive approach to knowledge production and dissemination [3]. Student participation in scientific competitions can be seen as a concrete operationalisation of this framework. Such activities simultaneously support educational development, the acquisition of research skills, and innovation-oriented thinking. Scientific competitions therefore represent an institutional interface where the three dimensions of the knowledge triangle converge at the individual student level.

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Nowadays, universities must adopt adaptive and forward-looking approaches to adequately equip students for this dynamic environment. Student competitions can play a role in this by engaging students in innovation and research activities [4].

In the current educational landscape, academic competitions are key elements in promoting student engagement and academic excellence [5]. They catalyse students to delve deeper into their fields of study, drive innovation, and facilitate the practical application of theoretical knowledge [6]. Students' motivation to engage in academic competitions not only demonstrates their enthusiasm for their respective disciplines but also serves as a meaningful indicator of their dedication to academic and professional development.

The rivalry for talented individuals among universities and the business sector has been intensifying. However, in some Central and Eastern European countries, universities struggle to attract students for research careers due to factors such as underfinancing and poor media coverage [7]. Especially in Hungary, companies often attract exceptionally gifted graduates by offering higher salaries and accelerated career advancement opportunities [8]. As a result, the cultivation and retention of talent have become critical priorities for higher education institutions [9]. To address this challenge, universities must identify talented students at the earliest possible stage and actively engage them in extracurricular activities that foster their potential. Participation in scientific competitions is an effective strategy for engaging these students, enhancing their skills, and equipping them to navigate future challenges.

Higher education in Hungary has represented the highest standard of scientific excellence for 658 years, since the founding of the first university in Pécs. The Hungarian higher education system currently comprises 64 accredited domestic institutions and 4 licensed foreign higher education institutions operating within Hungary. These institutions span a diverse spectrum, ranging from smaller universities of applied sciences to prominent research-intensive universities [10]. In the 2023/24 academic year, the number of students enrolled in full-time education was 214,765, while the number of teaching staff totalled 27,410 [11].

Significant changes have taken place in Hungarian higher education over the past few years. One of the most notable is the transition to a new governance model, which involved transforming previously public universities into private foundation-operated institutions [7]. Another major change has been the push toward internationalisation, with the aim of enhancing the global visibility of Hungarian universities and increasing the number of international students and faculty members [12,13]. As a result, 11 Hungarian universities are now featured in the QS World University Rankings (2025) [14], and 11 in the Times Higher Education (THE) 2025 rankings. A third significant development has been the widespread adoption of dual education programs, modelled on the German system, to increase the practical orientation of academic training [15].

Higher education in Hungary is characterised by a longstanding tradition of academic competitions, with the Scientific Students' Associations Conference (in Hungarian: Tudományos Diákköri Konferencia, TDK) representing its most significant scientific 'mega-event' since 1951 [16]. The selection of the TDK as the object of analysis is justified by its unique institutional embeddedness, multidisciplinary scope, and decisive role in talent identification within Hungarian higher education. Unlike ad hoc or discipline-specific competitions, the TDK functions as a system-level mechanism that directly links undergraduate and graduate education to academic research careers, making it a particularly suitable case for examining student participation through a behavioural framework analysis. At the biennial national competition, the students who produced the highest-quality scientific research papers in the preceding institutional TDK rounds present their research findings. Although smaller-scale competitions are organised for university students in many academic fields in Hungary, no competition comparable to TDK exists in terms of size (number of papers, sections, and academic disciplines it encompasses). The most recent event, the 36th National Scientific Students' Associations Conference, took place between April 3 and April 27, 2023, across 11 cities. It featured 16 scientific sections and 540 divisions, showcasing 4867 research papers, which were evaluated by a professional jury comprising over 3000 professors [16]. In terms of importance and scale, TDK is comparable to the ACM Student Research Competition (SRC), organised by the Association for Computing Machinery, which is widely regarded as the world's largest university-level research contest in computing and annually attracts several hundred participants from various ACM conferences [17]. While competitions such as the ACM Student Research Competition and the Three Minute Thesis (3 MT) share the objective of enhancing students' research communication skills, they differ substantially from the TDK in disciplinary coverage, participant eligibility, and evaluation depth. Unlike the SRC, which is discipline-specific, or the 3 MT, which emphasises brevity and public engagement, the TDK requires extended written research outputs and specialist-level oral presentations across a wide range of academic fields. However, the TDK encompasses not just one but multiple academic disciplines, similar to the Three Minute Thesis (3 MT) competition [18].

The TDK, a key arena for talent development in Hungarian higher education, provides students with a public venue to present research that exceeds standard curriculum requirements and adheres to rigorous scientific standards. Universities actively support students with significant research potential to participate in the TDK, fostering their development in both scientific and professional domains while promoting critical thinking and scholarly discourse [19]. Outstanding student performance in the TDK not only enhances the prestige of Hungarian universities but also influences their funding opportunities and, most importantly, contributes to talent retention by attracting the most gifted students into PhD programs, creating a pool of well-trained future university employees [20]. This is particularly relevant for the model-shifting universities in Hungary, where achievements in academic competitions play an integral role in institutional recognition and financial sustainability.

Understanding the factors that influence students' intentions to participate in scientific competitions is critical for educational institutions seeking to cultivate a robust talent pipeline and maintain a competitive advantage. Despite the longstanding tradition and institutional importance of scientific student competitions in Hungary, there is limited empirical evidence on the factors influencing students' willingness to participate in these activities. Little is known about how individual attitudes, perceived social expectations, and self-assessed competencies interact to affect participation decisions. Addressing this gap is essential, as student engagement in scientific competitions plays a key role in strengthening the research pillar of higher education institutions and ensuring the long-term sustainability of academic talent development. However, to the best of our knowledge, no studies have investigated students' intention to participate in scientific competitions such as the TDK. Therefore, the main objective of our study is to fill this research gap.

Regarding the primary research questions, our study aimed to investigate whether a model can be developed to explain the factors influencing student participation in scientific competitions, the strength and direction of relationships among these factors, and whether the Theory of Planned Behaviour can be applied effectively for this purpose. Therefore, this study, grounded in the TPB framework, seeks to address the following specific research questions: (RQ1) How do attitudes toward scientific competitions influence students' intentions to participate in the TDK (Scientific Student Conferences)? (RQ2) To what extent do subjective norms shape students' intentions to engage in student competitions? and (RQ3) How does perceived behavioural control impact students' willingness to participate in the TDK? By exploring these questions, the research aims to identify and analyse the various dimensions that influence students' intentions to participate in academic competitions. Accordingly, the study offers valuable insights for universities seeking to better support and promote student involvement, which will ultimately strengthen their image and cultivate a culture of excellence.

The findings of this research have significant implications for the academic sector. The significance of this research lies in its ability to deepen our understanding of students' willingness to participate in scientific competitions, thereby informing the development of more effective strategies to promote these events and, in turn, enhance student engagement. Furthermore, this study contributes to the theoretical advancement of TPB by extending its application to academic competitions. By validating the model's predictive relevance for student participation in this context, the research provides new insights into the broader applicability of TPB in educational settings, thereby enriching its utility beyond conventional frameworks.

2. Literature review

2.1. Scientific competitions in higher education

Universities currently encounter numerous challenges in attracting and retaining young talent. Clark et al. [21] identify a critical issue prevalent in many higher education institutions: the absence of effective career planning. This shortcoming undermines efforts to nurture and retain emerging scientists, ultimately jeopardising the institution's capacity to maintain its academic and research excellence. Nevertheless, as Mueller et al. [22] observe, academic institutions possess a comparative advantage over private enterprises, as individuals with an inclination toward intellectual pursuits and science-oriented roles are often drawn to the opportunities provided by universities and research institutions. Participation in scientific competitions enhances the likelihood of enrolling in doctoral programs, which serve as a gateway to an academic career [23].

Extracurricular activities, such as student competitions, play a crucial role in motivating students to develop their academic and professional skills [24]. These events provide a platform for participants to showcase their knowledge, competencies, and abilities. Cunningham [25] emphasises that mentoring programs in business schools are primarily designed to prepare students for professional careers. Within this framework, student competitions function as an extension of mentoring initiatives, offering practical, hands-on experiences that complement formal education and contribute to students' holistic development.

Moreover, these competitions enhance the academic environment by fostering a culture of excellence and innovation, thereby indirectly improving the respective institutions' performance in global and national ranking systems. While achievements in student competitions are not explicitly considered as ranking criteria in prominent systems such as THE [26] and QS [27], their positive outcomes - such as a strengthened academic reputation and closer ties with industry - can influence ranking metrics, including employer reputation, research impact, and academic citations. In Hungary, the HVG360 [28] ranking of universities explicitly considers student participation and performance in competitions as an important factor.

Consequently, universities strive to increase the number of students participating in academic competitions and to ensure that these participants achieve the best possible outcomes.

2.1.1. The benefits of student participation in scientific competitions

Student-centred teaching methods and competitions help students turn information into knowledge and encourage them to apply textbook theories and practical skills in a real business context, bringing reality into the classroom [29]. The motivation and skills that students acquire during competitions are unique and provide them with a significant advantage in the labour market [30]. Given that children are naturally competitive, it is logical to use competitions as a tool for teaching [31]. The educational benefits and impacts of competition have also been successfully harnessed in online environments, suggesting that competition-based techniques may be useful in the further development of educational technologies [32].

Business case competitions are commonly held in business schools, but little academic and applied research has addressed this phenomenon [33]. Bigelow et al. [34] also acknowledge the limited number of empirical studies on student competitions. Case study competitions are an ideal pedagogical strategy for developing students [35]. According to Sachau and Naas [36], case competitions are crucial for the later improvement of managerial skills. Employers value teamwork, critical thinking, and communication skills, all of which are fostered through case study competitions [35]. According to students who have already participated in competitions, the former may be a more valuable university experience than completing the prerequisites for professional certifications [37]. Compared to non-participants, participants in science competitions demonstrated less work avoidance, fewer performance-avoidance goals, and a stronger focus on learning goals [38]. In their study of knowledge sharing between mentors and strategic management students preparing for international business case competitions, Damnjanovic et al. [33] found that the extracurricular mentoring of business case competitors has recursive effects on the development of mentoring activities. The results of Damnjanovic and Mijatovic's research [39] indicate that the six most important benefits for students from engaging in case competitions are the development of skills, knowledge, contacts, self-realisation, job opportunities, and mentorship roles. A major obstacle to student participation in innovation competitions, exhibitions, and training programs is limited time and awareness [40].

Bigelow et al. [34] identified both the benefits and detriments associated with participation in student competitions within the field of construction management. The benefits include enhanced confidence, an improved ability to integrate knowledge, increased industry engagement, the development of leadership skills, motivation, networking opportunities, enhanced presentation skills, problem-solving abilities, real-world experience, teamwork, and time management. On the other hand, negative impacts may arise from unrealistic expectations and resource and time constraints. Despite the challenges students may face in such competitions, these experiences significantly contribute to their personal and professional development. By learning to navigate both successes and setbacks, students cultivate resilience and adaptability - key skills for future endeavours.

2.1.2. The motivation for student participation in scientific competitions

Abernathy and Vineyard [41] explored the motivations driving high school students' participation in competitions and identified several key reasons: pleasing their parents and teachers, meeting peers from other schools, exchanging ideas, attracting media attention, learning about the scientific method, spending time at the university, collaborating with their coach, engaging in team activities, competing against others, preparing for the future, winning prizes, having fun, and acquiring new knowledge. Expanding on this perspective, Kolář [42] examined the motivations for high school students' participation in physics competitions, finding that the primary motivations were a general interest in the subject, a desire to improve, and the challenge of solving complex problems. Sternberg and Baalsrud-Hauge [43] concluded that competitions with monetary rewards had the greatest motivational impact on students who were already highly motivated, and that competition is an effective means of increasing students' eagerness to learn.

According to Liu [44], students' motivation to learn can be enhanced through both competition and collaboration with peers, which in turn strengthens their intention to engage in future learning opportunities [45–47]. The experience of participating in a competition can increase talented students' motivation to pursue subsequent academic endeavours, such as doctoral programs, and can also foster entrepreneurial intentions by demonstrating their competencies and boosting confidence in their ability to succeed in a challenging environment. Mueller et al. [22] found that students' motivation to pursue a PhD is primarily driven by intrinsic aspirations related to the enjoyment of learning, the creation of new knowledge, and the intellectual challenge it entails. However, extrinsic motivations, such as aspirations for status and material gain, also play a role. Additionally, the study highlights that a clear understanding of the requirements of a PhD program encourages high-achieving students to express greater interest in pursuing a doctoral degree.

The situation in Hungary, however, differs, as academics are relatively underpaid compared to industry professionals. According to the Hungarian Central Statistical Office, even university professors are not among the 15 highest-paid occupations in Hungary in 2023 [48].

Padilla-Angulo's [49] analysis of the relationship between student associations and entrepreneurial intention suggests that students participate in specific extracurricular activities to gain knowledge that extends beyond the scope of traditional classroom instruction. This holistic approach to learning, which integrates theoretical knowledge with practical application and emotional intelligence, contributes to a well-rounded educational experience that equips students to navigate the complexities of the real world after graduation. Similarly, Herrera-Limones et al. [50] reflect this holistic learning approach in their research, which emphasises the need to reorganise teaching networks within departmental structures.

The transition from motivation to intention, particularly in the context of participation in competitions, represents a critical shift in understanding student engagement. Motivation, often driven by the benefits and personal development opportunities that competitions offer, serves as the initial catalyst for sparking interest and the desire to participate. As motivation evolves, it becomes a concrete intention to engage, reflecting a deeper, more strategic commitment to achieving personal goals.

Huang et al. [51] conducted a study on elementary, middle, and high school students in Taiwan, finding that students' attitudes toward problem-solving positively correlate with their perception of the development of their knowledge and thinking skills. Furthermore, their intention to participate in future competitions is also positively influenced by the perceived benefits. Utilising Ajzen's [52,53] Theory of Planned Behaviour (TPB model), Jang et al. [54] examined how students' intentions affect their enrolment in extracurricular entrepreneurship courses. They found a significant relationship between perceived expectations of a favourable outcome (TPB: attitude toward the behaviour) and personality traits (EEM: desire), which, in turn, influenced students' intention to engage in voluntary service.

2.2. The scientific students' associations conference

The history of the Scientific Students' Associations Conference dates back to the 1950s, with the first national conference held in 1955. It has since become one of the most important talent development initiatives in Hungarian higher education [55]. The increasing significance of the TDK is reflected in the growing number of universities participating in the initiative [56]. The challenges posed by COVID-19 did not deter students; the online National Scientific Students' Associations Conference (OTDK) held during the pandemic saw significantly higher participation, with at least twice as many attendees as at the previous event. The virtual format allowed greater accessibility, enabling not only the participants but also their families, mentors, and even former students or those living abroad to engage more easily with the event [20].

The TDK movement has developed into the most effective means of talent development in Hungarian higher education. It serves as a platform for self-directed learning, elite education, and research training, providing talented students - those receptive to the stimulating and democratic environment created by distinguished scholars and mentors - with their first experiences of academic success [57].

Students work closely with a faculty mentor and engage in scientific research, tackling unique problems and creating innovative solutions. The outcome is a research paper that extends beyond the taught curriculum, presenting the topic with scientific rigour and offering new perspectives. Producing such a paper requires extensive learning, research, and several months of close collaboration between the dedicated mentor and student. To showcase the results of these research efforts, universities regularly organise institutional TDK conferences. Participation requires submitting a research paper and delivering an oral presentation, both of which are evaluated and scored by a professional jury of professors. The best papers are eligible for the OTDK, the country's largest scientific event, where the top students from universities present their research papers [16].

Students can test their research and presentation skills in a competitive environment, while developing the mindset and skills that are also highly valued in the labour market. The results achieved at TDK are of significant prestige and value, not only for an academic or research career but also for a corporate career path. Such achievements are also taken into account during the admission process for master's programs and doctoral schools [20].

2.2.1. The process of participating in the scientific students' associations conference

The process of engaging in the TDK involves several steps, from selecting a research topic to presenting findings to a professional audience. Students begin by identifying a research area that interests them and aligns with their academic goals, and they select a mentor who will support them throughout the research process. This mentor can help refine the research question, provide academic guidance, and offer expertise to ensure the project aligns with scholarly standards. Students may seek out instructors or researchers within their institution who have relevant expertise and are open to collaboration. The next phase is conducting research, the core of the TDK process. Students delve deeply into their chosen topic, gather and analyse data, and test hypotheses. This phase emphasises critical thinking and the exploration and validation of ideas, often leading to new insights or supporting existing theories. The research findings are presented in a formal paper, typically 20–50 pages long. This document outlines the research objectives, methodology, and results. Students submit their research papers to their institution's TDK conference, which is held semi-annually or annually at universities across Hungary and neighbouring regions. These conferences provide a platform for initial presentations and are overseen by institutional coordinators who guide students through the application process. Finally, students present their research findings at the institutional TDK conference, sharing their results with a professional audience. This stage not only showcases their work but also fosters academic discourse and the exchange of critical feedback among peers and experts. Exceptional presentations may qualify for participation in the OTDK, the most prestigious national competition. Through this comprehensive process, the TDK offers students a unique opportunity to enhance their research, analytical, and presentation skills while contributing to their academic and professional development [16].

2.2.2. The benefits of participating in the TDK for students

Engagement in the Scientific Students' Associations Conference confers numerous benefits, significantly contributing to students' academic and professional development. It allows students to deepen their expertise in a chosen field and develop critical competencies through hands-on research experience. Students can access dedicated mentors who provide invaluable professional guidance and career-development insights, helping them navigate academic and professional challenges. Involvement in the TDK facilitates the building of meaningful connections with esteemed professors and researchers, enriching students' professional networks. Feedback from expert juries provides students with constructive criticism and actionable insights, which are instrumental in refining their research and presentation skills. Outstanding work can earn accolades and awards, enhancing a candidate's academic and professional prospects and career. The research project often serves as the basis for students' theses or doctoral dissertations, providing a strong foundation for future academic success. Beyond academic benefits, participation in the TDK conferences is an enriching and enjoyable experience, fostering a sense of community and accomplishment [16].

2.2.3. The distinctive and universal aspects of TDK

To situate the TDK within the broader landscape of scientific student competitions, it is necessary to briefly compare its structure and objectives with other internationally recognised formats. This comparison enables the identification of both the distinctive features of the TDK and those characteristics that align it with universal principles of scientific competitions in higher education.

The most distinctive feature of the Scientific Students' Associations Conference is that it can be regarded as a "*Hungarikum*". This is a collective concept that denotes values deserving distinction and recognition for their unique, exceptional, and high-quality characteristics that epitomise the pinnacle of Hungarian achievement [58]. TDK represents the peak of talent development in Hungarian higher education. It is the oldest, the largest, and most prestigious multidisciplinary science competition, encompassing all fields of research. The conference primarily involves Hungarian students and faculty members from both Hungary and neighbouring countries with Hungarian populations, and its principal language of communication is Hungarian. Unlike other scientific student competitions, participation in the competition does not involve any monetary awards.

Since the TDK is so unique that, to the best of our knowledge, no comparable multidisciplinary academic competition exists, it is not possible to conduct a comparative analysis of the TDK with other scientific competitions. The Three Minute Thesis (3 MT) competition is somewhat similar to the TDK; however, it differs significantly in several key aspects. In the 3 MT, only PhD students may participate, each of whom has 3 min to present their research in a language appropriate to a non-specialist audience. In contrast, the TDK is open to all university students, including PhD candidates, and participants have 20 min to deliver an oral presentation to a specialist audience, followed by 5 min for questions and answers.

From another perspective, the TDK is universal, as the submitted papers and scientific presentations adhere to universally accepted scientific standards and address topics of interest not only to the Hungarian academic community but also to the global scientific community. Like many other scientific student competitions, it follows a multi-stage format, where the national finals are preceded by a series of qualifying rounds. Additionally, the written paper and its presentation are evaluated separately. In recent years, as Hungarian higher education has internationalised, the pool of participants has expanded. Today, international students studying at Hungarian universities can also participate with their English-language papers and presentations. It should be noted, however, that the number of such participants remains marginal.

From a comparative perspective, the TDK can therefore be regarded as distinctive in its institutional role and cultural embeddedness, while remaining universal in its adherence to internationally accepted scientific standards for research design, peer evaluation, and academic presentation.

2.3. Theoretical framework

The original Theory of Planned Behaviour (TPB) model proposed by Ajzen (Fig. 1) serves as a psychological framework linking beliefs to actions. This theory posits that an individual's behavioural intentions are influenced by three core components: attitudes, subjective norms, and perceived behavioural control. According to TPB, behavioural intention is the most immediate and significant predictor of human social behaviour [53].

In this model, attitudes toward behaviour, subjective norms, and perceived behavioural control converge to generate behavioural intention. Specifically, perceived behavioural control is believed not only to directly impact actual behaviour but also to exert indirect influence through behavioural intention. According to TPB, a student's intention to engage in a behaviour, such as teamwork or academic success, is influenced by their attitude towards that behaviour [59].

Attitude pertains to the extent to which an individual favourably or unfavourably evaluates or appraises a behaviour. In the context of students' intention to participate in scientific competitions, attitude encompasses their positive or negative beliefs and feelings regarding such participation. A student's attitude toward participating in science competitions is shaped by several factors, including their perceptions of the benefits and challenges associated with these events. A positive attitude may arise from the belief that participation will expand their knowledge, enhance their research skills, provide networking opportunities, and strengthen their academic and professional resume. Conversely, a negative attitude may result from concerns about the time commitment required, fear of failure, or the perceived difficulty of the competition.

Subjective norms, as conceptualised within TPB, refer to the perceived social pressures or normative influences that affect an individual's intention to perform a given behaviour [59,60]. In the context of students, these norms encompass the expectations and influences exerted by peers, family, and parents, which play a critical role in shaping their decisions about participation in science competitions.

In the context of students' intentions to participate in science competitions, the subjective norm component encompasses the perceived expectations and opinions of influential individuals and groups within their social and academic environments. These social pressures and perceived expectations significantly influence students' decision-making and behaviour. When students perceive that professors, family members, and other influential figures in their academic and social spheres view participation in science competitions positively and provide support, they are more likely to feel motivated to engage in such activities. This social support may take various forms, including encouragement from professors, praise from peers with prior participation experience, and expectations from family members who value academic achievement. Conversely, when these influential figures express disinterest or view participation as unimportant, students are less inclined to engage in these competitions.

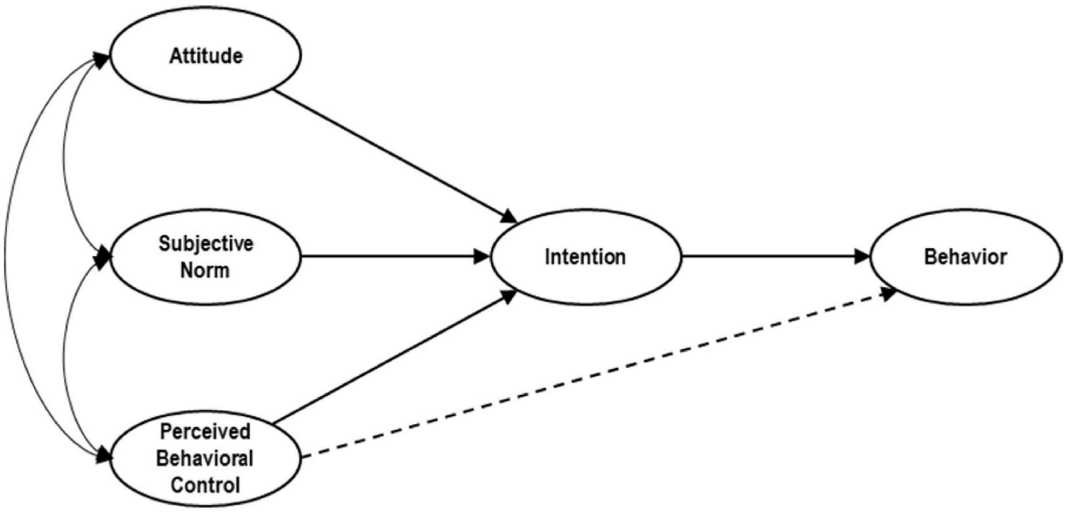

Fig. 1. The TPB model.
Source: Ajzen [53]

Perceived behavioural control refers to a student's assessment of their ability to perform a behaviour and the factors that might facilitate or impede that behaviour. For instance, willingness to perform academically is influenced by perceived control over learning behaviour [59]. This component involves the student's confidence in their capabilities and their perception of available resources or obstacles that could affect their participation in a given activity, such as science competitions. This component concerns the individual's belief in their ability to perform the behaviour and is influenced by both internal (e.g., skills and abilities) and external (e.g., resources and opportunities) factors. In the context of students' intention to participate in science competitions, perceived behavioural control encompasses their confidence in their own competencies and the availability of necessary support and resources to successfully participate.

In relation to students' intention to enter a scientific competition, perceived behavioural control also encompasses their assessment of the feasibility of participation. This includes their confidence in possessing the necessary knowledge, skills, and abilities to effectively compete, as well as their access to essential resources such as time, funding, mentorship, and institutional support. When students believe they have strong research skills, can adequately prepare, and have the support of their university, they are more likely to consider participating in a competition. This positive perception can significantly enhance their intention to participate. Conversely, if students feel they lack the necessary skills, are constrained by time pressure, or do not receive sufficient support, they may perceive low behavioural control, thereby reducing their intention to participate.

Bán et al. [57] provide a comprehensive overview of the factors that motivate or hinder participation in scientific student competitions. According to their findings, motivating factors include the recognition of the TDK paper as a thesis in the given study programme, its applicability to study requirements, contributions to scholarship eligibility, benefits for career development, monetary rewards, and personal motivations. These personal motivations include agreement with parents, moral approval, self-esteem enhancement, curiosity, competitive spirit, a desire for challenge, a drive for research, and the pursuit of a personal research topic. Conversely, hindering factors include excessive workload, disinterest, laziness, perceived irrelevance for career advancement, lack of time, insufficient motivation, low self-confidence, fear of failure, a preference for earning money over academic pursuits, disinterest in an academic career, difficulty finding a supervisor, and lack of information.

Summarising the literature review, the application of TPB for assessing students' intentions may be presented as follows:

- Cheng [61]: students' intention to participate in online group work.

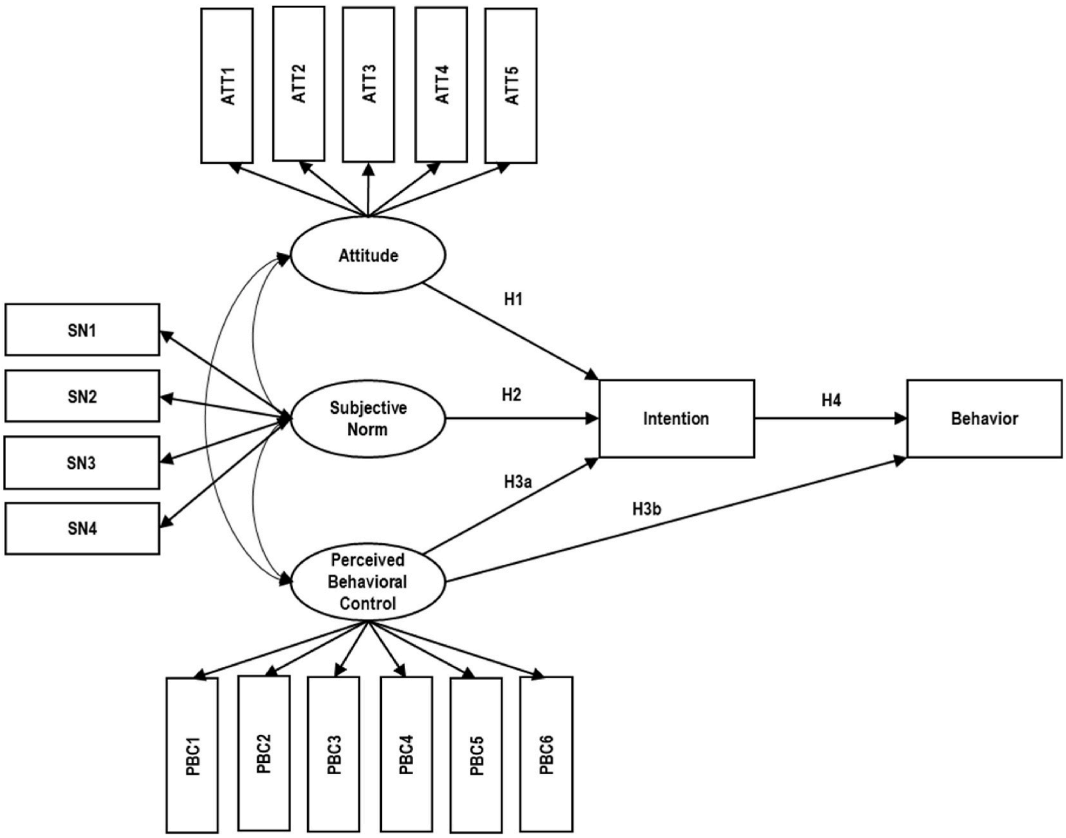

Fig. 2. The conceptual model.
Note: The abbreviations in the figure (ATT …, SN …, PBC …) denote the measurement items associated with the constructs in the model, which are listed in Table 2. The labels H1, H2, H3a, H3b and H4 represent our hypotheses.

- Paimin and Alias [62]: intention to achieve success among engineering students.
- Mosbah, Al-Jubari and Talib [63]: students' intention to pursue postgraduate studies.
- Skoglund et al. [64]: students' intention to attend lectures.
- Roslan, Ch'ng and Chuan [65]: students' intention to engage in deep learning.
- Wang, Peng and Song [66]: the impact of students' mathematical attitudes on intentions, behavioural engagement, and mathematical performance.
- Ngonda and Ngonda [59]: entrepreneurial intention of engineering students.

Students may participate in Hungarian science competitions either individually or in pairs. In collaborative settings, students' intentions to engage in online group work are influenced by components of TPB, including prior experience and perceived behavioural control. These observations underscore the applicability of the TPB framework to explaining collaborative behaviours, particularly in academic contexts such as science competitions [61].

In summary, TPB provides a useful framework for understanding the variables that influence students' attitudes, subjective norms, and perceived behavioural control, with implications for classroom practice and behaviour change interventions. However, it also has limitations when it comes to predicting specific behaviours and may not adequately reflect the complexity of individual variation and cognitive processes [66]. Despite these limitations, TPB remains a valuable tool for exploring the determinants of student behaviour and for designing interventions to promote positive educational outcomes.

3. Conceptual model and hypotheses

Drawing on a thorough examination of related literature and the envisioned relationships among variables, we introduce a research framework, depicted in Fig. 2, to explore students' inclination to participate in scientific competitions. This conceptual model is derived from the foundational TPB model.

On the basis of the supposed relationships, the following hypotheses were formulated:

- *Hypothesis 1 (H1): Attitude positively influences students' intention to participate in scientific competitions.*
- *Hypothesis 2 (H2): Subjective norms positively influence students' intention to participate in scientific competitions.*
- *Hypothesis 3a (H3a): Perceived behavioural control positively influences students' intention to participate in scientific competitions.*
- *Hypothesis 3b (H3b): Perceived behavioural control positively influences actual behaviour.*
- *Hypothesis 4 (H4): Students' intention to participate in scientific competitions positively influences actual behaviour.*

Based on a detailed literature review, we conclude that TPB has not yet been applied to investigate students' intentions to participate in scientific competitions, the main objective of our research.

4. Method

4.1. Study participants

The target population for this research comprised full-time students enrolled in the Faculty of Economics at the University of Miskolc, totalling 1683 at the time of the survey. Data collection was conducted using a voluntary survey, from which 292 valid responses were obtained and included in the final analysis. Thus, the difference between the population size (N = 1683) and the final sample size (n = 292) is due to the fact that not all members of the target population participated in the survey, and only completed and useable responses were retained for analysis. The detailed composition of both the population and the sample is presented in Table 1.

Based on demographic data for the full-time student population, our sample of 292 students is representative with respect to gender and level of education.

Table 1
Composition of population and sample.

		Sample (n)	Population (N)
Gender	Male	116 (39.8%)	671 (39.9%)
	Female	176 (60.2%)	1012 (60.1%)
Level of education	Higher vocational training	53 (18.2%)	317 (18.8%)
	B.A./B.Sc	202 (69.3%)	1141 (67.8%)
	M.A./M.Sc	37 (12.5%)	225 (13.4%)
Study progress	First semester/year (At the beginning)	85 (29.1%)	N/A
	In the middle	132 (45.2)%	N/A
	Last semester/year (At the end)	75 (25.7%)	N/A
Form of financing	Self-funded	102 (34.8%)	N/A
	State-financed	190 (65.2%)	N/A
Total		**292 (100.0%)**	**1683 (100.0%)**

Table 2
Constructs and measurement instruments.

Construct	Measurement item	Code
Attitude (ATT)	Participating in scientific competitions like the TDK is a good thing.	ATT1
	Writing a TDK paper is useful.	ATT2
	Participating in competitions like the TDK helps me to improve professionally.	ATT3
	Writing and presenting a TDK paper is something I enjoy.	ATT4
	I enjoy conducting scientific research and disseminating my findings.	ATT5
Subjective Norm (SN)	I want to meet the expectations of my teachers by participating in the TDK.	SN1
	I want to meet my own expectations by participating in the TDK.	SN2
	My fellow students expect me to participate in the TDK.	SN3
	The university/faculty expects me to write a TDK paper.	SN4
Perceived Behavioural Control (PBC)	It is not difficult for me to write a TDK paper.	PBC1
	I am able to write a TDK paper of high scientific standards.	PBC2
	I have excellent research skills.	PBC3
	I am an excellent presenter.	PBC4
	I can easily review the related literature in English.	PBC5
	I am proficient in math and statistics.	PBC6
Intention (INT)	I intend to participate in the TDK by writing a paper.	INT
Behaviour (BEH)	I am already writing a TDK paper.	BEH

4.2. Questionnaire design and validation

The questionnaire utilised in this study was designed to systematically assess students' engagement with the Scientific Student Associations Conference and the underlying factors influencing their participation. The instrument comprised three distinct sections, each serving a specific purpose within the broader research framework. The first section comprised introductory questions designed to assess respondents' familiarity with the TDK and their level of engagement. Participants were asked whether they had previously heard of the TDK, the sources through which they became aware of it, their experience in writing a TDK paper, their intentions to submit one in the future, and the academic term in which they intended to participate in such a conference. These questions provided a foundational understanding of students' prior exposure to and interest in TDK activities, serving as essential context for subsequent analyses. The second section included 17 items (as detailed in Table 2) designed to measure students' intent to participate in TDK activities. These items were developed based on TPB, a widely accepted theoretical framework used to predict and explain intentional behaviour. The original TPB constructs - attitudes, subjective norms, and perceived behavioural control - were adapted to the specific context of students' participation in scientific competitions. A seven-point Likert scale was employed to measure responses, ranging from 1 ("strongly disagree") to 7 ("strongly agree"), thereby capturing nuanced variations in students' attitudes and perceptions.

The third section collected demographic information, including gender, level of education, study progress, form of financing, faculty, and major. These variables enabled examination of potential differences in responses according to demographic characteristics, providing insights into how various student groups perceive and engage with the TDK.

To ensure the validity and reliability of the questionnaire, a multi-step validation process was employed. First, content validity was established through expert review. A panel of scholars with expertise in educational research and behavioural science assessed the questionnaire to verify that the items effectively measured the intended constructs and were appropriately adapted from the TPB framework. Following expert validation, a pilot study was conducted with a small sample of university students (n = 30) who represented the target population. This was designed to assess the clarity of the questions, the internal consistency of the measurement items, and the overall structure of the questionnaire. Participants provided feedback on ambiguities or difficulties in responding to specific items, prompting minor revisions to improve comprehensibility and ensure precise alignment with the research objectives. Finally, after incorporating necessary refinements based on the validation steps, the finalised questionnaire was administered to the full sample. The rigorous validation process ensured the instrument's robustness, enhancing the credibility of the study's findings and supporting the reliability of the conclusions drawn from it.

4.3. Data collection procedure

Respondents were recruited through direct personal engagement. Students enrolled as full-time learners at the Faculty of Economics were invited to participate in the study before or after their scheduled classes. To ensure informed consent, all potential respondents received a comprehensive verbal briefing on the research objectives, followed by an opportunity to review a participant information sheet included at the beginning of the questionnaire. Prior to completing the survey, participants were required to provide explicit consent by confirming their agreement via checkboxes in the consent declaration section. The questionnaire was administered on a voluntary and anonymous basis to safeguard respondents' privacy and encourage candid responses.

Data collection took place during November and December 2023 via an online survey hosted on Google Forms. Given the absence of an adequate sampling frame, a quota sampling method was employed to approximate a representative sample of the student population. Quota sampling was employed to ensure that key demographic and academic characteristics of the target population were represented proportionally in the dataset. The criteria for quota stratification were determined based on available institutional data, thereby aligning the sample composition as closely as possible with the overall student body with respect to relevant factors such as year of study and gender distribution. This approach mitigated the limitations associated with non-probability sampling while enhancing the external validity of the findings.

Following data collection, the responses were exported from Google Forms and subsequently processed using MS Excel, SPSS 28, and AMOS 21. A rigorous data validation procedure was implemented to verify coding accuracy, ensure completeness, and identify any missing values. This methodological rigour in data processing contributed to the reliability of the dataset and reinforced the robustness of the study's analytical framework.

Statistical analyses were conducted in SPSS, and research hypotheses were tested using structural equation modelling (SEM) in AMOS. SEM enables the examination of complex relationships among variables, which is crucial for understanding the theoretical framework and the factors influencing students' intentions to participate in academic competitions. Marsh et al. [67] proposed a minimum sample size of 200 for SEM in AMOS, and the actual sample size of 292 respondents met this criterion.

5. Results

The initial model (Fig. 2) included three latent constructs - attitude (ATT1–ATT5), subjective norms (SN1–SN4), and perceived behavioural control (PBC1–PBC6) - as well as intention and behaviour. The initial model exhibited poor data fit (CMIN/DF = 5.196; $p = 0.001$; GFI = 0.778; CFI = 0.839; RMSEA = 0.120; HOELTER .05 = 70). Therefore, the parameter estimates of the initial model were not interpreted, and the model was subsequently refined.

Following Byrne's [68] methodological recommendations and Osborne's [69] guidance on model evaluation and refinement, the measurement models were further examined. The refinement process considered the psychometric properties and factor loadings of the indicators, together with the results of the preceding measurement analyses. Based on this assessment, five indicators were excluded: ATT4 and ATT5 from the attitude construct, SN1 from subjective norms, and PBC1 and PBC6 from perceived behavioural control. The modifications were restricted to the measurement models; no structural paths or hypothesised relationships between the constructs were removed or modified.

The revised model was subsequently re-estimated using the remaining indicators: ATT1–ATT3 for attitude, SN2–SN4 for subjective norms, and PBC2–PBC5 for perceived behavioural control. The revised model demonstrated substantially improved and acceptable fit (CFI = 0.97, TLI = 0.96, RMSEA = 0.06) and was therefore retained as the final model (Fig. 3). In accordance with Kline's [70]

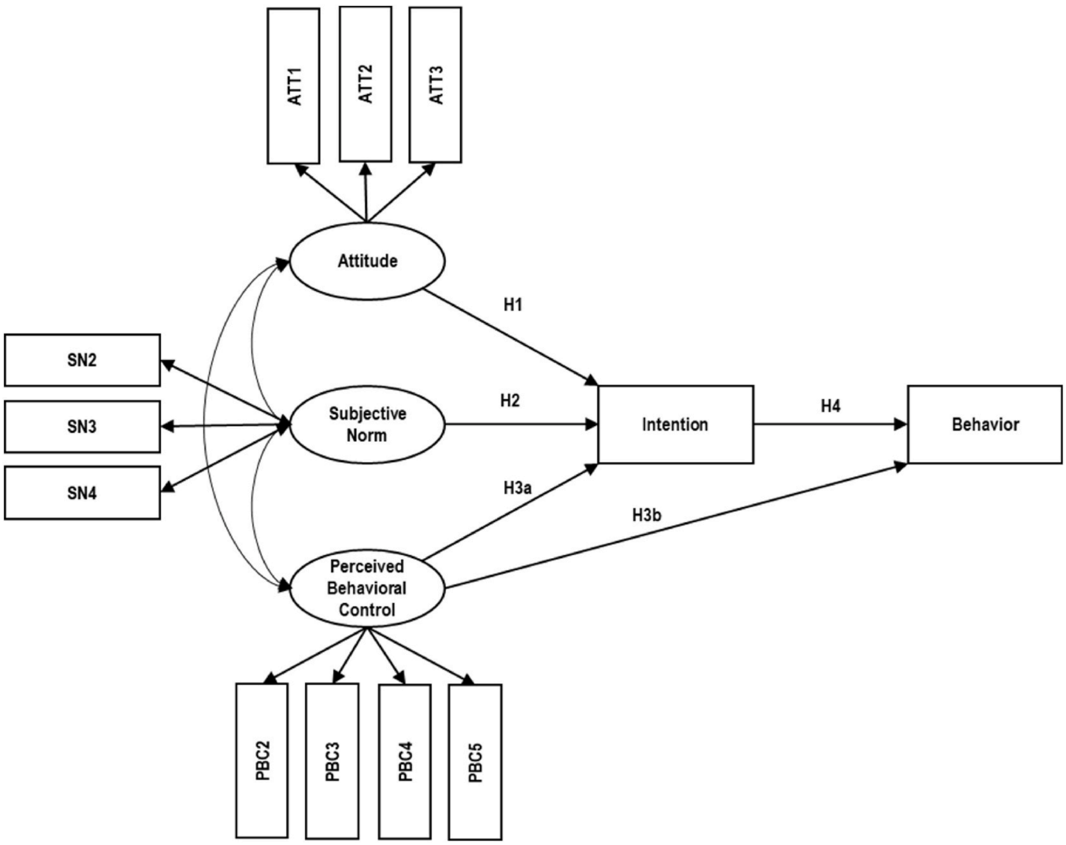

Fig. 3. The nested model.
Note: The abbreviations in the figure (ATT ..., SN ..., PBC ...) denote the measurement items of the constructs in the model, which are listed in Table 2. The labels H1, H2, H3a, H3b and H4 represent our hypotheses.

recommendations, the adequacy of the sample size was also considered in relation to the complexity of the final model. The final model comprised 10 observed indicators, three latent constructs, and five structural paths. The structural specification remained unchanged from the initial model; only the measurement indicators were refined.

5.1. Validity

We evaluated both convergent and discriminant validity for our nested model. Following the Fornell-Larcker criterion [71], convergent validity requires the Average Variance Extracted (AVE) to surpass 0.5. Additionally, in line with Hair et al.'s [72] recommendations, AVE should exceed 0.5, standardised factor loadings of all items should surpass 0.5, and Composite Reliability (CR) should be above 0.7. Our nested model successfully fulfilled all these criteria, as indicated in Table 3.

Our nested model demonstrates satisfactory discriminant validity, as none of the correlations exceeded the threshold of 0.85, which Henseler et al. [73] consider indicative of poor discriminant validity. The observed correlations are as follows: ATT*SN = 0.79; ATT*PBC = 0.55; SN*PBC = 0.68.

5.2. Reliability

We assessed the precision and consistency of the nested model through four reliability tests based on Confirmatory Factor Analysis (CFA): factor loadings (Indicator Reliability), Cronbach's alpha (α), the Average Variance Extracted index (AVE), and Composite Reliability (CR). A measurement model is deemed acceptable when all estimates are significant, factor loadings exceed 0.5 (with values above 0.7 considered excellent), α is greater than 0.5 or ideally 0.7, and AVEs for all constructs are above 0.5 [71], and CRs for all constructs are above 0.7 [74]. As presented in Table 3, all constructs exhibited factor loadings ranging from 0.52 to 0.96, Cronbach's alphas of 0.72 or higher, AVE scores exceeding 0.51, and CRs surpassing 0.76. These results indicate that the reliability of the measurement model is optimal.

5.3. Model fit

We assessed both absolute and relative model fits, and all absolute measures were statistically significant, indicating a favourable fit. Specifically, the Chi-square test yielded a statistic of 100.75 (df = 49), with a p-value of 0.000. Additionally, the CMIN/DF ratio was 2.06, GFI 0.94, AGFI 0.91, RMSEA 0.06, and SRMR 0.05.

For the evaluation of relative model fit, we employed TLI/NNFI, GFI, AGFI, NFI, IFI, and CFI, all of which exhibited either acceptable or commendable values (TLI/NNFI = 0.96; GFI = 0.94; AGFI = 0.91; NFI = 0.95; IFI = 0.97; CFI = 0.97). Following Bentler and Bonett's [75] Guidelines: values exceeding 0.9 indicate an acceptable fit, whereas values exceeding 0.95 indicate a good fit. Both absolute and relative model fit tests indicated that the structural nested model is well-suited to the analysis and interpretation of parameter estimates.

5.4. Hypothesis testing and estimates

The nested structural model was employed to test hypotheses and to derive insights into students' inclination to participate in scientific competitions. The outcomes of the hypothesis tests, encompassing direct, indirect, and total effects as measured within the model, are succinctly presented in Table 4.

Fig. 4 displays the standardised estimates and loadings depicting the relationships between the constructs and the observed indicators. Confirmation of a statistically significant relationship in the predicted direction led to the acceptance of the corresponding hypothesis.

Table 3
Summary table of means, standard deviations, validity and reliability measures.

		M	SD	Loading	Alpha	AVE	CR
Attitude (ATT)	ATT1: Participating in scientific competitions like the TDK is a good thing.	5.12	1.55	0.91	0.92	0.81	0.93
	ATT2: Writing a TDK paper is useful.	5.11	1.55	0.96			
	ATT3: Participating in competitions like the TDK helps me to improve professionally.	4.98	1.58	0.82			
Subjective Norm (SN)	SN2: I want to meet my own expectations by participating in the TDK.	5.03	1.73	0.69	0.72	0.51	0.76
	SN3: My fellow students expect me to participate in the TDK.	3.60	1.68	0.76			
	SN4: The university/faculty expects me to write a TDK paper.	4.96	1.71	0.69			
Perceived Behavioural Control (PBC)	PBC2: I am able to write a TDK paper of high scientific standards.	4.11	1.63	0.84	0.79	0.52	0.81
	PBC3: I have excellent research skills.	3.54	1.48	0.84			
	PBC4: I am an excellent presenter.	3.87	1.65	0.65			
	PBC5: I can easily review the related literature in English.	3.85	1.83	0.52			
Intention (INT)	INT: I intend to participate in the TDK by writing a paper.	3.71	2.02	-	-	-	-
Behaviour (BEH)	BEH: I am already writing a TDK paper.	2.16	1.98	-	-	-	-

Table 4
Direct, indirect, total effects, and hypothesis testing.

Hypothesis	Relationship	P	St. direct eff.	St. indirect eff.	St. total eff.	Result
H1	ATT - > INT	0.145	-	-	-	rejected
H2	SN - > INT	0.019	0.321	0.000	0.321	accepted
H3a	PBC - > INT	0.001	0.285	0.000	0.285	accepted
H3b	PBC - > BEH	0.195	-	-	-	rejected
H4	INT - > BEH	<0.001	0.574	0.000	0.574	accepted

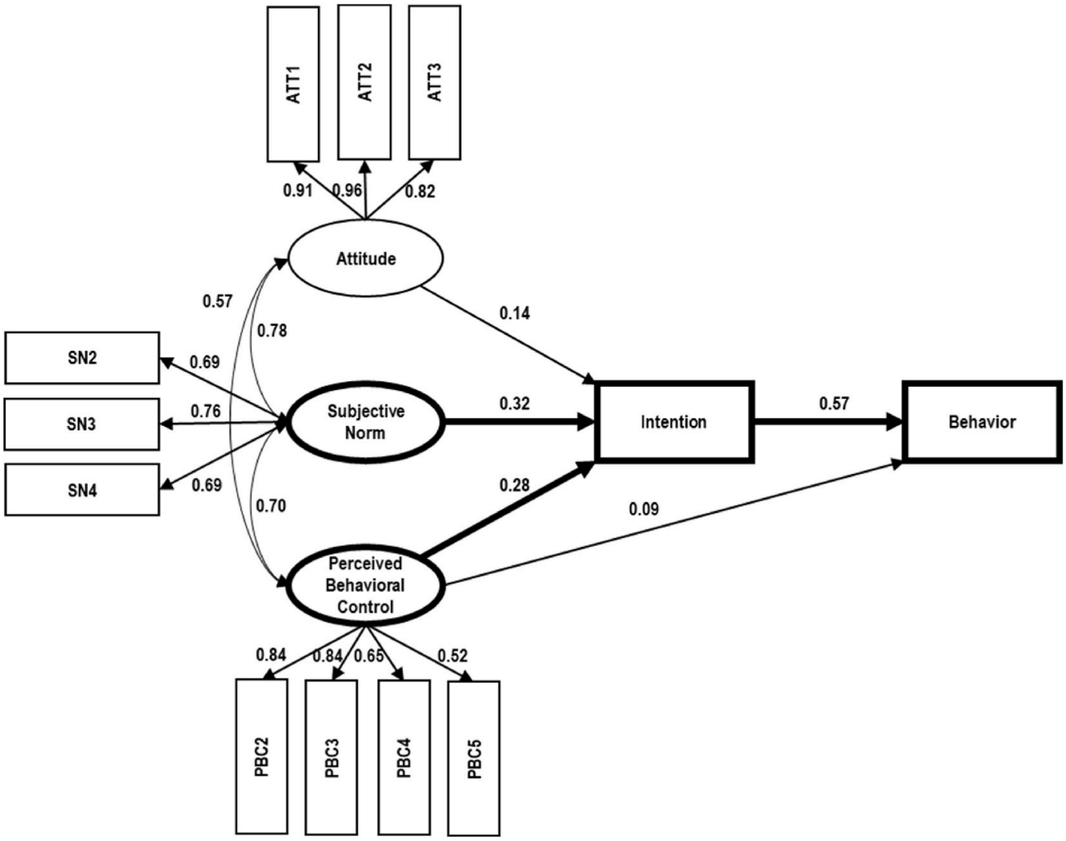

Fig. 4. Parameter estimates of the nested model.
Note: The abbreviations in the figure (ATT …, SN …, PBC …) denote the measurement items of the constructs in the model, which are listed in Table 2.

We hypothesised that attitude has a direct, positive effect on the intention to participate in scientific competitions (Hypothesis 1). Based on the results, we rejected H1 ($\beta = 0.140$, $p = 0.145$).

Hypothesis 2 was formulated to show the effect of subjective norms on intention. Based on the results of the model test, H2 was confirmed ($\beta = 0.321$, $p = 0.019$).

Hypothesis 3 was divided into two sub-hypotheses. The first related to the effect of students' perceived behavioural control on intention (Hypothesis 3a), and the second to the effect of students' perceived behavioural control on actual behaviour (Hypothesis 3b). H3a was confirmed ($\beta = 0.285$, $p = 0.001$), while H3b was rejected ($p = 0.195$).

The fourth hypothesis (H4) regarding the effect of intention on behaviour was confirmed ($\beta = 0.574$, $p < 0.001$).

6. Discussion

One of our principal findings, the rejection of Hypothesis 1, indicates that attitude does not have a significant direct impact on students' intention to participate in scientific competitions. This suggests a lack of intrinsic motivation in this domain. While students may perceive participation in scientific competitions, such as the TDK, as beneficial - acknowledging that writing a TDK paper is useful and that involvement in such competitions enhances professional development - these positive perceptions and beliefs are insufficient to motivate them to act. This result implies that fostering a positive attitude through promotional campaigns alone is inadequate to encourage student participation in scientific competitions. Developing a positive attitude among students does not directly translate into intended or actual behaviour. This result contradicts our assumptions and previous research that indicated a positive effect of attitude on behavioural intention in different student contexts [59,61–65]. A possible explanation for this discrepancy is that while attitudes generally influence behaviour, their impact may be contingent on the perceived effort, risk, and expected rewards associated with the activity in question [76]. In the case of scientific competitions, even students with favourable attitudes toward participation may hesitate due to concerns about competitiveness, the time commitment required, or uncertainty about personal benefits [77]. Unlike other academic activities in which attitude has been shown to be a strong predictor of engagement, scientific competitions often involve voluntary participation, which may require an additional level of self-motivation that a positive attitude alone does not guarantee. Furthermore, while some studies suggest that attitudes positively influence participation in extracurricular academic activities, our findings highlight the complexity of this relationship in the context of scientific competitions. One possible explanation is that while students recognise the value of participation in theory, they may not see immediate, tangible benefits that align with their personal academic or career goals [78,79]. Previous research suggests that students are more likely to engage in activities they perceive as directly affecting their future success, whereas activities perceived as requiring significant effort with uncertain rewards may fail to attract participants despite positive attitudes. This may be particularly relevant for scientific competitions, where students may weigh the opportunity cost against other academic obligations or extracurricular engagements. These findings suggest that strategies to promote student participation in scientific competitions should extend beyond fostering positive attitudes. While previous research emphasises the importance of attitude in shaping behavioural intention, our results indicate that additional motivational and structural factors must be considered. Addressing perceived barriers - such as time constraints, fear of failure, or uncertainty about the benefits - may be necessary to bridge the gap between attitude and action. Future research could explore how interventions such as mentorship programs, peer influence, or incremental engagement opportunities might better align participation with students' intrinsic motivations. Understanding these nuances could yield more effective strategies for increasing student engagement in scientific competitions and help reconcile the observed divergence from prior findings.

The acceptance of Hypothesis 2 indicates that subjective norms play a crucial, positive role in shaping students' intentions to participate in scientific competitions. This finding reinforces the notion that social influences - particularly the expectations of teachers and peers - are significant determinants of student participation. The fulfilment of personal expectations significantly affects willingness to participate, suggesting that students who perceive strong social support are more likely to form the intention to participate in such competitions. Consequently, those who receive encouragement from their academic environment, including teachers and peers, tend to exhibit a stronger motivation to participate than those who lack such support. This result also emphasises the importance of mentoring as a key facilitator in this process [80–82]. The role of mentorship is particularly critical in fostering participation, as prior research suggests that students are more likely to participate in scientific competitions when they feel adequately supported and guided [83,84]. Effective mentorship not only provides intellectual guidance but also helps alleviate concerns related to competition pressure and workload management. Additionally, fostering a strong sense of academic community - such as through specialised colleges and student organisations - further reinforces positive social norms that encourage participation [85,86]. Such communities provide students with peer support, collaborative learning opportunities, and shared motivation, all of which contribute to greater engagement. The pivotal role of positive social support and mentorship in influencing students' intentions highlights the broader significance of interpersonal relationships in educational settings [87]. Beyond encouragement, peers and mentors serve as sources of validation, helping students recognise their potential and reinforcing their confidence in pursuing scientific challenges [88]. This social reinforcement not only strengthens their academic identity but also provides practical assistance in navigating the complexities of competition preparation [89]. The influence of subjective norms in this context aligns with prior findings that emphasise the role of mentorship in shaping academic motivation and performance [90]. Mentors provide valuable expertise, resources, and encouragement, equipping students with the skills needed to overcome challenges and enhance their competencies [91,92]. By fostering a nurturing learning environment and providing personalised support, mentors help bridge the gap between intention and action, empowering students to pursue their academic and professional aspirations with greater enthusiasm and determination [93,94].

Our research findings suggest that students' perceived behavioural control significantly and positively influences their intention to participate in scientific competitions (H3a). When students feel capable and confident in their abilities - such as possessing strong research and presentation skills, being able to review relevant literature, and writing a TDK paper of high scientific standards - their intention to engage in these activities increases. This finding aligns with previous studies that highlight the role of self-efficacy in academic engagement, where students with greater confidence in their abilities are more likely to undertake challenging tasks [95,96]. However, despite this positive relationship, our results indicate that perceived behavioural control does not directly translate into the actual behaviour of writing a TDK paper (H3b). This discrepancy suggests that, although students may feel competent, external or psychological barriers may prevent them from translating intention into action. One possible explanation for this divergence is the presence of situational constraints, such as time limitations, competing academic obligations, or uncertainty about the benefits of participation. While perceived behavioural control is an important predictor of intention, previous research has shown that actual behaviour is influenced by additional factors, including institutional support, external pressures, and personal motivation [97–99]. The positive effect of students' perceived behavioural control on their intention nonetheless underscores the crucial role of skill development in fostering readiness for scientific competitions. This connection is closely linked to the principles of talent management, in which structured training programs aim to equip students with the competencies necessary to succeed in scientific endeavours [100]. Effective training should prioritise not only the development of research, presentation, language, and literature review skills but also strategies for overcoming barriers to participation [101]. Furthermore, our findings suggest that skill development alone may not be sufficient; it must be complemented by ongoing mentorship [102]. Mentors play a pivotal role in reinforcing students' confidence, offering practical guidance, and providing continuous feedback tailored to individual needs [103]. The integration of mentoring with skill-development initiatives enhances students' competence and motivation, increasing the likelihood that they will follow through on their intention to participate in competitions. Prior research indicates that students who receive structured mentorship are more likely to persist in academic challenges, suggesting that mentorship can bridge the gap between intention and actual participation [104]. By adopting an integrated approach that combines skill development with mentorship, educators can create an environment that fosters both readiness and sustained engagement. Since intention strongly correlates with actual behaviour in many educational contexts, interventions that enhance students' perceived competence while addressing external barriers can significantly increase participation in scientific competitions. Expanding participation in these competitions not only nurtures individual talent but also contributes to the development of a new generation of skilled scientists. This, in turn, helps educational institutions ensure a continuous flow of talent into research and innovation, addressing global challenges and advancing scientific progress.

The acceptance of Hypothesis 4 indicates a strong and positive correlation between students' intention to participate in scientific competitions and their actual engagement in scientific activities, which aligns with previous research findings [53]. Specifically, students who express a strong intention to participate are more likely to engage in related academic pursuits, such as writing a TDK paper. This result reinforces established behavioural models that suggest intention is a key predictor of action. Although this relationship is well documented, our findings highlight potential moderating factors that may weaken or obstruct the translation of intention into actual behaviour. Several external and internal barriers may contribute to this gap, including overwork, time constraints, lack of interest, and procrastination [57]. Even students with a strong initial motivation to participate may struggle to follow through due to competing academic responsibilities, perceived difficulty in meeting competition requirements, or shifting priorities. This discrepancy aligns with previous studies that emphasise the role of self-regulation, perseverance, and institutional support in bridging the intention–behaviour gap. Furthermore, the influence of external incentives - such as career benefits, scholarships, or faculty recognition - may determine whether students ultimately act on their intentions. These findings suggest that fostering student participation in scientific competitions requires not only strategies to strengthen intention but also interventions that address behavioural execution. Educational institutions could support students by providing structured guidance, clearer pathways to participation, and incentives that reinforce long-term engagement. Future research could further explore how factors such as academic workload management, peer influence, and structured mentorship affect the likelihood that students follow through on their intentions. A greater understanding of these elements could help identify more targeted solutions to enhance student participation in scientific competitions and to promote sustained engagement in research activities.

7. Conclusion

This study explored the factors influencing students' participation in scientific competitions, with particular emphasis on the Theory of Planned Behaviour framework. The findings provide important insights while underscoring areas for further investigation and practical application.

7.1. Summary of findings

The rejection of Hypothesis 1 highlights that a positive attitude towards participation in scientific competitions does not directly translate to an intention to engage. This suggests that intrinsic motivation is insufficient in this context. While students recognise the benefits of participation, such as skill development and professional growth, these perceptions alone are insufficient to drive action. Additional strategies, beyond promoting benefits, are necessary to address barriers such as perceived competitiveness, fear of failure, and misalignment with students' goals. Acceptance of Hypothesis 2 confirms the significant role of social influences, such as teacher and peer support, in shaping students' intentions. Effective mentorship and the creation of supportive communities enhance students' willingness to participate. These findings highlight the importance of fostering interpersonal relationships and providing personalised guidance to inspire confidence and a sense of belonging. While perceived behavioural control positively influences students' intention to participate, it does not necessarily lead to actual behaviour. This underscores the need for targeted skill development initiatives to bridge the gap between intention and action. Providing students with the necessary competencies - such as research and presentation skills - and integrating mentorship into these efforts are critical for converting intentions into tangible engagement in scientific activities. The positive correlation between intention and actual behaviour reaffirms the importance of intention as a determinant of action. However, it also reveals potential barriers, including overwork, time constraints, and procrastination, that impede the realisation of students' intentions.

7.2. Practical and social implications

Practically, the identification of subjective norms, particularly the positive influence of social support and encouragement from peers and mentors, underscores the importance of fostering supportive environments within educational institutions. Implementing mentoring programs where experienced students, faculty members, and professionals provide guidance and encouragement can cultivate a culture of participation in scientific competitions. Moreover, establishing specialised communities, colleges or clubs dedicated to scientific endeavours can facilitate peer support and collaboration, further enhancing students' motivation to engage in such activities. From a social perspective, prioritising skill development alongside mentoring is essential. Investing in educational initiatives that enhance students' research, presentation, language, and literature review skills can equip them with the tools necessary to excel in scientific competitions. By nurturing these competencies, educational institutions can not only empower students to pursue their academic and professional aspirations but also contribute to the broader goal of fostering a scientifically literate society.

Furthermore, applying the TPB model to university students' participation in scientific competitions represents a significant theoretical advancement. This demonstrates the adaptability and utility of behavioural theories in understanding and influencing complex human behaviours. By leveraging theoretical frameworks like TPB, professors, academics, and policymakers can develop targeted interventions and strategies to promote desirable behaviours, such as increased participation in scientific activities, thereby contributing to the advancement of science and technology.

7.3. Research limitations

One limitation of our study lies in its generalisability. The research was conducted exclusively among full-time students of the Faculty of Economics in a Hungarian university. Although efforts were made to ensure a representative sample, the findings may not be generalisable to students in other faculties, disciplines, universities, or countries. Variations in cultural, educational, and institutional factors could influence students' attitudes, subjective norms, and perceived behavioural control differently, thus affecting their intention to participate in scientific competitions. Expanding the research to include diverse student populations from various academic backgrounds and geographic locations could provide a more comprehensive understanding of the factors influencing participation in science competitions. Additionally, given potential differences in educational systems and cultural norms, future studies should aim to replicate the findings across contexts to enhance the validity and reliability of the results. By addressing this limitation, researchers can better ascertain the universality of the identified factors and their impact on students' participation in scientific competitions.

Another notable limitation concerns the narrow focus on a single scientific competition, the TDK. While this competition is a valuable case study given its prominence in the Hungarian academic landscape, its unique format, objectives, and cultural relevance may not reflect the dynamics of other scientific competitions. The findings, therefore, may not fully capture the diversity of factors influencing participation in competitions with different structures or objectives. This specificity limits the broader applicability and impact of the study's conclusions. To address this limitation, we emphasise that our findings are most relevant to contexts similar to the one studied, such as scientific competitions with comparable cultural and institutional characteristics. Future research should investigate a range of competitions across disciplines, formats, and international contexts to determine whether the same motivational factors hold true or whether additional variables emerge. This expanded perspective would help establish the extent to which the findings can be generalised and provide a richer understanding of the determinants of student participation in scientific activities globally.

7.4. Originality

Our study represents the first application of the Theory of Planned Behaviour to university students' participation in scientific competitions. By adapting a well-established theoretical framework to a novel context, we contribute to theoretical advancement in understanding human behaviour within educational settings. While research on factors influencing academic performance and engagement exists [105–109], our study specifically targets students' intention to participate in scientific competitions. This focus provides unique insights into the motivations and barriers associated with extracurricular scientific activities, which are critical for nurturing future scientists and innovators. Overall, the originality of our study lies in its theoretical contribution, its focus on a specific aspect of student engagement, the integration of key factors, its contextual specificity, and its practical implications for educational institutions. Through these contributions, our study advances understanding and offers guidance for fostering a culture of scientific participation among university students.

CRediT authorship contribution statement

László Molnár: Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Methodology, Investigation, Formal analysis, Conceptualization. **Noémi Hajdú:** Writing – review & editing, Writing – original draft, Conceptualization, Methodology. **Szabolcs Nagy:** Writing – review & editing, Writing – original draft, Validation, Supervision, Methodology, Conceptualization, Software.

Data availability statement

Data will be made available on request. For requesting data, please write to the corresponding author.

Ethics and consent statement

Review and/or approval by an ethics committee was not required for this study, as participation in the survey was voluntary and anonymous.

All participants provided informed consent by confirming their agreement via checkboxes in the consent declaration section at the beginning of the online questionnaire.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2026.e45433.

References

[1] Z. Bochniarz, How should higher education respond to 21st century challenges? Some practical comments. 2019 IEEE 18th Int. Conf. Cogn. Inform. Cogn. Comput. ICCICC, 2019, pp. 335–341, https://doi.org/10.1109/ICCICC46617.2019.9146094.
[2] M. Unger, W. Polt, The knowledge triangle between research, education and innovation – a conceptual discussion, Foresight-Russ 11 (2017) 10–26, https://doi.org/10.17323/2500-2597.2017.2.10.26.
[3] M. Cervantes, Higher education institutions in the knowledge triangle, in: D. Meissner, E. Erdil, J. Chataway (Eds.), Innov. Entrep. Univ., Springer International Publishing, Cham, 2018, pp. 115–142. http://link.springer.com/10.1007/978-3-319-62649-9_6. (Accessed 3 February 2025).
[4] E. Sjoer, B. Nørgaard, M. Goossens, From concept to reality in implementing the knowledge triangle, Eur. J. Eng. Educ. 41 (2016) 353–368, https://doi.org/10.1080/03043797.2015.1079812.
[5] P. Peña, J. Riley, N. Davis, Increasing student engagement & contributions: introducing the semester-long participation competition, Mark. Educ. Rev. 34 (2024) 99–106, https://doi.org/10.1080/10528008.2024.2337345.
[6] P. Moreno, C. Puentes, E. Ferrándiz, E. Flores, M. Acosta, D. Coronado, AN Academic Competition to Enhance Students' Performance in the Classroom, 2014.
[7] D. Georgiev, A. Antonova, E. Gourova, The place of academia in the knowledge triangle: how students recognize the role of scientists for building an innovation ecosystem, Eur. Conf. Knowl. Manag. 24 (2023) 58–66, https://doi.org/10.34190/eckm.24.1.1498.
[8] P. Limboo, The Power of Lucrative Salaries & Promising Career Advancement, 2023. https://www.linkedin.com/pulse/power-lucrative-salaries-promising-career-advancement-ps-limboo/.
[9] K.M. Chethana, S.D. Noronha, Impact of talent management practices in higher educational institutions. https://doi.org/10.5281/ZENODO.8183935, 2023.
[10] Tempus Public Foundation, Study in Hungary - Higher Education in Hungary, (n.d.). https://studyinhungary.hu/study-in-hungary/menu/studying-in-hungary/higher-education-in-hungary.html (accessed February 9, 2025).
[11] KSH, Főbb felsőoktatási adatok az intézmény székhely vármegyéje és régiója szerint, (n.d.). https://www.ksh.hu/stadat_files/okt/hu/okt0041.html (accessed February 9, 2025).
[12] S. Vincze, Z. Bács, International students in Hungarian higher education, Appl. Stud. Agribus. Commer. 14 (2020) 113–132, https://doi.org/10.19041/APSTRACT/2020/2-3/13.
[13] J. Lannert, A. Derényi, Internationalization in Hungarian higher education. Recent developments and factors of reaching better global visibility, Hung. Educ. Res. J. 10 (2021) 346–369, https://doi.org/10.1556/063.2020.00034.
[14] QS World University Rankings 2025, Top univ. https://www.topuniversities.com/world-university-rankings, 2025. (Accessed 9 February 2025).
[15] M. Pogátsnik, Dual education: connecting education and the labor market, Opus Educ 8 (2021), https://doi.org/10.3311/ope.466.
[16] Otdk. https://otdk.hu/, 2024.
[17] ACM, About the Student Research Competition, (n.d.). https://src.acm.org/about (accessed February 9, 2025).
[18] The University of Queensland, Higher degrees by research. Start Your 3MT Journey Here, 2017. https://threeminutethesis.uq.edu.au/higher-degrees-researchstart-your-3mt-journey-here. (Accessed 9 February 2025).
[19] A. Kaloudis, A. Aspelund, P.M. Koch, T.A. Lauvås, M.T. Mathisen, Ø. Strand, R. Sørheim, T. Aadland, How universities contribute to innovation: a literature review-based analysis. https://www.ntnu.edu/documents/1272711283/1276140112/Rapport_How+universities+contribute+to+innovation_web.pdf/86b6a699-0499-820e-0f52-35a7b7101de5?t=1574848729613, 2019.
[20] ITBUSINESS, A jövőbe mutat a tudományos diákkörök története. https://itbusiness.hu/technology/aktualis-lapszam/path/a-jovobe-mutat-a-tudomanyos-diakkorok-tortenete/, 2021.
[21] C. Clark, M. Cluver, J.J. Selingon, Trend no. 4: talent management becomes a strategy. https://www2.deloitte.com/uk/en/insights/industry/public-sector/articles-on-higher-education/talent-management-in-higher-education.html, 2023.
[22] E.F. Mueller, M. Flickinger, V. Dorner, Knowledge junkies or careerbuilders? A mixed-methods approach to exploring the determinants of students' intention to earn a PhD, J. Vocat. Behav. 90 (2015) 75–89, https://doi.org/10.1016/j.jvb.2015.07.001.
[23] Z. Olvasztó, K. Dajnoki, TDK részvétel motivációi a debreceni Egyetem Tehetséggondozó Programjában résztvevő hallgatók körében, Acta Med, Sociol 15 (2024) 78–101, https://doi.org/10.19055/ams.2024.05/28/5.
[24] K. Chilingaryan, R. Gorbatenko, Students' professional contests as a tool for motivation outside the classroom, Procedia - Soc. Behav. Sci. 214 (2015) 559–564, https://doi.org/10.1016/j.sbspro.2015.11.760.
[25] A.C. Cunningham, Developing marketing professionals: what can business schools learn? J. Mark. Educ. 17 (1995) 3–9, https://doi.org/10.1177/027347539501700202.
[26] World University Rankings, Methodology. https://www.timeshighereducation.com/world-university-rankings/world-university-rankings-2022-methodology, 2022.
[27] C. Ocallaghan, QS World University Rankings methodology: using rankings to start your university search. https://www.topuniversities.com/qs-world-university-rankings/methodology, 2023.
[28] HVG-rangsor: Változnak Az Egyetemek Értékelésének Szempontjai, Hvg.Hu, 2022. https://hvg.hu/360/20221124_HVG_Diploma_2023_egyetemek. (Accessed 10 May 2024).
[29] F.Y. Gibson, D.H. Kincade, P.Y. Frasier, Using classroom competitions to prepare students for the competitive business world, J. Eff. Teach. 13 (2013) 64–77.
[30] S. Shah, S. Al-Badri, S. Hasan, Use of business competitions to enhance student employability in higher education, in: Recent Adv. Educ. Technol. Proc. 2015 Int. Conf. Educ. Mod. Educ. Technol. EMET 2015, WSEAS, Greece, 2015, pp. 140–147.
[31] T. Verhoeff, The role of competitions in education, Future world: Educating for the 21st century (1997) 1–10.
[32] C. Hanna, A.M. Johnson, D. Belliveau, Fostering student motivation through competition: how competing in online tournaments in teams affects the performance related outcomes of participants, ubiquitous learn, Int. J. 7 (2015) 19–40, https://doi.org/10.18848/1835-9795/CGP/v07i3-4/40411.
[33] V. Damnjanovic, W. Proud, M. Milosavljevic, Mentoring development at student international business case competitions, EuroMed J. Bus. 16 (2021) 154–170, https://doi.org/10.1108/EMJB-12-2018-0092.
[34] B.F. Bigelow, S. Glick, A. Aragon, Participation in construction management student competitions: perceived positive and negative effects, Int. J. Constr. Educ. Res. 9 (2013) 272–287, https://doi.org/10.1080/15578771.2013.809037.

[35] M.G. Burke, J.D. Carter, A.W. Hughey, The use of case Study competitions to prepare students for the world of work, Ind. High. Educ. 27 (2013) 157–162, https://doi.org/10.5367/ihe.2013.0156.
[36] D.A. Sachau, P.A. Naas, The consulting challenge: a case competition, J. Manag. Educ. 34 (2010) 605–631, https://doi.org/10.1177/1052562909358556.
[37] M.K. Ali, J.M. Grund, J.P. Koplan, Case competitions to engage students in global health, Lancet 377 (2011) 1473–1474, https://doi.org/10.1016/S0140-6736(10)62186-1.
[38] T.N. Höffler, V. Bonin, I. Parchmann, Science vs. sports: Motivation and self-concepts of participants in different school competitions, Int. J. Sci. Math. Educ. 15 (2017) 817–836, https://doi.org/10.1007/s10763-016-9717-y.
[39] V. Damnjanovic, I. Mijatovic, Student perception of benefits from being engaged in international case Study competitions, Manag. Sustain. Bus. Manag. Solut. Emerg. Econ. 22 (2017) 61, https://doi.org/10.7595/management.fon.2017.0017.
[40] S. Kulturel-Konak, A. Konak, N. Webster, P.K. Murphy, Building inclusive student innovation competitions, exhibitions, and training programs, in: Proc. 56th Annu. Hawaii Int. Conf. Syst. Sci. HICSS 2023, IEEE Computer Society, 2023, pp. 4745–4754.
[41] T.V. Abernathy, R.N. Vineyard, Academic competitions in science: what are the rewards for students? Clear. House A J. Educ. Strategies, Issues Ideas 74 (2001) 269–276, https://doi.org/10.1080/00098650109599206.
[42] K. Kolář, Sources of motivation of high school students for participation in physics competitions, J. Phys., Conf. Ser. 1286 (2019) 012067, https://doi.org/10.1088/1742-6596/1286/1/012067.
[43] H. Sternberg, J. Baalsrud-Hauge, Does Competition with Monetary Prize Improve Student Learning? – an Exploratory Study on Extrinsic Motivation, 2015.
[44] I.-F. Liu, The impact of extrinsic motivation, intrinsic motivation, and social self-efficacy on English competition participation intentions of pre-college learners: differences between high school and vocational students in Taiwan, Learn, Motive 72 (2020) 101675, https://doi.org/10.1016/j.lmot.2020.101675.
[45] J.C. Burguillo, Using game theory and competition-based Learning to stimulate student motivation and performance, Comput. Educ. 55 (2010) 566–575, https://doi.org/10.1016/j.compedu.2010.02.018.
[46] W.-H. Huang, W.-Y. Huang, J. Tschopp, Sustaining iterative game playing processes in DGBL: the relationship between motivational processing and outcome processing, Comput. Educ. 55 (2010) 789–797, https://doi.org/10.1016/j.compedu.2010.03.011.
[47] N. Park, S. Lee, J.E. Chung, Uses of cellphone texting: an integration of motivations, usage patterns, and psychological outcomes, Comput. Hum. Behav. 62 (2016) 712–719, https://doi.org/10.1016/j.chb.2016.04.041.
[48] E. Kusnyerik, Best-Paying Jobs in Hungary as of 2023, 2023. https://dailynewshungary.com/15-best-paying-jobs-in-2023/.
[49] L. Padilla-Angulo, Student associations and entrepreneurial intentions, Stud. High Educ. 44 (2019) 45–58, https://doi.org/10.1080/03075079.2017.1336215.
[50] R. Herrera-Limones, J. Rey-Pérez, M. Hernández-Valencia, J. Roa-Fernández, Student competitions as a learning method with a sustainable focus in higher education: the university of Seville "Aura Projects" in the "Solar Decathlon 2019,", Sustainability 12 (2020) 1634, https://doi.org/10.3390/su12041634.
[51] N.-T.N. Huang, L.-J. Chiu, J.-C. Hong, Relationship among students' problem-solving attitude, perceived value, behavioral attitude, and intention to participate in a science and technology contest, Int. J. Sci. Math. Educ. 14 (2016) 1419–1435, https://doi.org/10.1007/s10763-015-9665-y.
[52] I. Ajzen, From intentions to actions: a theory of planned behavior, in: J. Kuhl, J. Beckmann (Eds.), Action Control, Springer Berlin Heidelberg, Berlin, Heidelberg, 1985, pp. 11–39, https://doi.org/10.1007/978-3-642-69746-3_2.
[53] I. Ajzen, The theory of planned behavior, Organ. Behav. Hum. Decis. Process. 50 (1991) 179–211, https://doi.org/10.1016/0749-5978(91)90020-T.
[54] Y. Jang, B. Hadley, J. Son, C. Song, Determinants of students' entrepreneurial intention to compete in a fast-pitch competition, J. Educ. Bus. 94 (2019) 359–368, https://doi.org/10.1080/08832323.2018.1540389.
[55] S. Cziráki, P. Szendrő, Hat évtized, harminc OTDK – Változatlan célok, növekvő tekintély, Magy, Tud 173 (2012) 235–244.
[56] E. Koósné Török (Ed.), A TDK Vonzásában, Akadémiai Kiadó, Budapest, 2021.
[57] E. Bán, E. Ilyésné Molnár, E.M. Jármai, J.B. Vágány, Tehetséggondozás a magyar gazdasági felsőoktatásban : fókuszban a Tudományos Diákköri Konferencia és a Közgazdaságtudományi Szekció, Veztud, Bp. Manag. Rev. 54 (2023) 105–120, https://doi.org/10.14267/VEZTUD.2023.07-08.08.
[58] évi XXX. törvény a magyar nemzeti értékekről és a hungarikumokról - hatályos Jogszabályok Gyűjteménye. 2012. https://net.jogtar.hu/jogszabaly?docid=A1200030.TV. (Accessed 9 February 2025).
[59] T. Ngonda, V. Ngonda, Entrepreneurial intentions of engineering students from a South African TVET college, World Trans. Eng. Technol. Educ. 21 (2023) 223–227.
[60] J. Haegele, S. Hodge, D. Shapiro (Eds.), Routledge Handbook of Adapted Physical Education, Routledge, London, 2020, https://doi.org/10.4324/9780429052675.
[61] E.W.L. Cheng, Students Working Online for Group projects: a Test of an extended theory of planned behaviour model, Educ. Psychol. 37 (2017) 1044–1056, https://doi.org/10.1080/01443410.2016.1150424.
[62] A.N. Paimin, M. Alias, The role of attitude, subjective norms, and perceived behavioural control in promoting the intention to achieve success among engineering students, Theory Plan. Behav. New Res. (2017) 165–180.
[63] A. Mosbah, I. Al-Jubari, Z.M. Talib, S. Alam, Intention to pursue postgraduate studies in Malaysian universities, Int. J. Innov. 5 (2019).
[64] E. Skoglund, J. Fernandez, J.T. Sherer, E.A. Coyle, K.W. Garey, M.L. Fleming, A.K. Sofjan, Using the theory of planned behavior to evaluate factors that influence PharmD students' intention to attend lectures, Am. J. Pharm. Educ. 84 (2020) 7550, https://doi.org/10.5688/ajpe7550.
[65] T.R.N. Roslan, C.K. Ch'ng, F. Chuah, Understanding Students' Intention to Engage in Deep Learning: Application of the Theory of Planned Behaviour, vol. 20, 2021, pp. 490–501, https://doi.org/10.17051/ilkonline.2021.04.54.
[66] L. Wang, F. Peng, N. Song, The impact of students' mathematical attitudes on intentions, behavioral engagement, and mathematical performance in the China's context, Front. Psychol. 13 (2022), https://doi.org/10.3389/fpsyg.2022.1037853.
[67] H.W. Marsh, J.R. Balla, R.P. McDonald, Goodness-of-fit indexes in confirmatory factor analysis: the effect of sample size, Psychol. Bull. 103 (1988) 391–410, https://doi.org/10.1037/0033-2909.103.3.391.
[68] B.M. Byrne, Structural Equation Modeling with AMOS: Basic Concepts, Applications, and Programming, third ed., 0 ed., Routledge, 2016 https://doi.org/10.4324/9781315757421.
[69] J. Osborne, Best Practices in Quantitative Methods, SAGE Publications, Inc., Thousand Oaks California 91320 United States of America, 2008, https://doi.org/10.4135/9781412995627, 2455 Teller Road.
[70] R.B. Kline, Principles and Practice of Structural Equation Modeling, fourth ed., The Guilford Press, New York London, 2016.
[71] C. Fornell, D.F. Larcker, Evaluating structural equation models with unobservable variables and measurement error, J. Mark. Res. 18 (1981) 39, https://doi.org/10.2307/3151312.
[72] J.F. Hair (Ed.), Multivariate Data Analysis, sixth ed., Pearson Prentice Hall, Upper Saddle River, N.J, 2006.
[73] J. Henseler, C.M. Ringle, M. Sarstedt, A new criterion for assessing discriminant validity in variance-based structural equation modeling, J. Acad. Mark. Sci. 43 (2015) 115–135, https://doi.org/10.1007/s11747-014-0403-8.
[74] A. Malkanthie, Structural equation modeling with AMOS. https://doi.org/10.13140/RG.2.1.1960.4647, 2015.
[75] P.M. Bentler, D.G. Bonett, Significance tests and goodness of fit in the analysis of covariance structures, Psychol. Bull. 88 (1980) 588–606, https://doi.org/10.1037/0033-2909.88.3.588.
[76] Z.H. Wan, J.C.K. Lee, Hong Kong secondary school students' attitudes towards science: a study of structural models and gender differences, Int. J. Sci. Educ. 39 (2017) 507–527, https://doi.org/10.1080/09500693.2017.1292015.
[77] Y. Zhu, How Chinese students' scientific competencies are influenced by their attitudes? Int. J. Sci. Educ. 41 (2019) 2094–2112, https://doi.org/10.1080/09500693.2019.1660926.
[78] P. Tschisgale, A. Steegh, M. Kubsch, S. Petersen, K. Neumann, Towards a more individualised support of science competition participants–identification and examination of participant profiles based on cognitive and affective characteristics, Int. J. Sci. Educ. (2024), https://doi.org/10.1080/09500693.2023.2300147.

[79] T. Goto, K. Nakanishi, K. Kano, A large-scale longitudinal survey of participation in scientific events with a focus on students' learning motivation for science: antecedents and consequences,, Learn. Indiv. Differ. 61 (2018) 181–187, https://doi.org/10.1016/j.lindif.2017.12.005.
[80] H.M. Sunderman, J. Orsini, Introduction to leading from the middle in higher education: mentoring, J. Leadersh. Stud. 17 (2023) 40–44, https://doi.org/10.1002/jls.21869.
[81] G. Crisp, I. Cruz, Mentoring college students: a critical review of the literature between 1990 and 2007, Res. High. Educ. 50 (2009) 525–545, https://doi.org/10.1007/s11162-009-9130-2.
[82] J.W. Colvin, M. Ashman, Roles, risks, and benefits of peer mentoring relationships in higher education, Mentor. Tutoring Partnersh. Learn. 18 (2010) 121–134, https://doi.org/10.1080/13611261003678879.
[83] R.G. Carmel, M.W. Paul, Mentoring and coaching in academia: reflections on a mentoring/coaching relationship, Policy Futur, Educ. Next 13 (2015) 479–491, https://doi.org/10.1177/1478210315578562.
[84] R.V. Nata, Progress in Education, 2023.
[85] L.C. Ehrich, B. Hansford, L. Tennent, Formal mentoring programs in education and other professions: a review of the literature, Educ. Adm. Q. 40 (2004) 518–540, https://doi.org/10.1177/0013161X04267118.
[86] A. Darwin, E. Palmer, Mentoring circles in higher education, High Educ. Res. Dev. 28 (2009) 125–136, https://doi.org/10.1080/07294360902725017.
[87] G. Hagenauer, F. Muehlbacher, M. Ivanova, "It's where learning and teaching begins – is this relationship" — insights on the teacher-student relationship at university from the teachers' perspective, High. Educ. 85 (2023) 819–835, https://doi.org/10.1007/s10734-022-00867-z.
[88] G. Hagenauer, S.E. Volet, Teacher-student relationship at university: an important yet under-researched field, Oxf. Rev. Educ. 40 (2014) 370–388, https://doi.org/10.1080/03054985.2014.921613.
[89] A.M. Klem, J.P. Connell, Relationships matter: linking teacher support to student engagement and achievement, J. Sch. Health 74 (2004) 262–273, https://doi.org/10.1111/j.1746-1561.2004.tb08283.x.
[90] M. Jacobi, Mentoring and undergraduate academic success: a literature review, Rev. Educ. Res. 61 (1991) 505–532, https://doi.org/10.3102/00346543061004505.
[91] W. Nuis, M. Segers, S. Beausaert, Conceptualizing mentoring in higher education: a systematic literature review, Educ. Res. Rev. 41 (2023), https://doi.org/10.1016/j.edurev.2023.100565.
[92] J. Fountain, K.E. Newcomer, Developing and sustaining effective faculty mentoring programs, J. Public Aff. Educ 22 (2016) 483–506, https://doi.org/10.1080/15236803.2016.12002262.
[93] A. Nora, G. Crisp, Mentoring students: conceptualizing and validating the multi-dimensions of a support system, J. Coll. Stud. Retent. Res. Theory Pract. 9 (2007) 337–356, https://doi.org/10.2190/CS.9.3.e.
[94] S. Gershenfeld, A review of undergraduate mentoring programs, Rev. Educ. Res. 84 (2014) 365–391, https://doi.org/10.3102/0034654313520512.
[95] D.G. Collings, K. Mellahi, Strategic talent management: a review and research agenda, Hum. Resour. Manag. Rev. 19 (2009) 304–313, https://doi.org/10.1016/j.hrmr.2009.04.001.
[96] A. Al Ariss, W.F. Cascio, J. Paauwe, Talent management: current theories and future research directions, J. World Bus. 49 (2014) 173–179, https://doi.org/10.1016/j.jwb.2013.11.001.
[97] R.E. López-Hernández, E. Vázquez-Reyes, Manage the talent of university actors through leadership and interest Researchers and management positions, Hum. Rev. Int. Humanit. Rev. Rev. Int. Humanidades 11 (2022), https://doi.org/10.37467/revhuman.v11.4058.
[98] R. Musakuro, Talent management PRACTICES in a selected SOUTH AFRICAN higher education institution, Probl. Perspect. Manag. 20 (2022) 532–542, https://doi.org/10.21511/ppm.20(1).2022.42.
[99] R.N. Musakuro, F. De Klerk, Academic talent: perceived challenges to talent management in the south african higher education sector, SA J. Hum. Resour. Manag. 19 (2021) 1–13, https://doi.org/10.4102/SAJHRM.V19I0.1394.
[100] J.-M. Sáez-López, M.-C. Domínguez-Garrido, M.-C. Medina-Domínguez, F. Monroy, R. González-Fernández, The competences from the perception and practice of university students, Soc. Sci. 10 (2021) 1–12, https://doi.org/10.3390/socsci10020034.
[101] C. Neumann, K.M. Stroud, S. Bailey, K. Allison, S. Everts, 21st-century competencies in higher education: a practitioner's guide, in: Handb. Res. Barriers Teach. 21st-Century Competencies Impact Digit, 2021, pp. 293–315, https://doi.org/10.4018/978-1-7998-6967-2.ch016.
[102] J.L. Terrion, D. Leonard, A taxonomy of the characteristics of student peer mentors in higher education: findings from a literature review, Mentor. Tutoring Partnersh. Learn. 15 (2007) 149–164, https://doi.org/10.1080/13611260601086311.
[103] T.A. Campbell, D.E. Campbell, Faculty/student mentor program: effects on academic performance and retention, Res. High. Educ. 38 (1997) 727–742, https://doi.org/10.1023/A:1024911904627.
[104] K. Arnesson, G. Albinsson, Mentorship–a pedagogical method for integration of theory and practice in higher education, Nord. J. Stud. Educ. Policy 3 (2017) 202–217, https://doi.org/10.1080/20020317.2017.1379346.
[105] A.M.D. Nunez, D.C.R. Adrian, M.B.L. Aponte, E.G. Choquehuanca, I. Iraola-Real, The engaged have better qualifications? The academic engagement roll in the academic performance. https://doi.org/10.1109/EDUNINE48860.2020.9149482, 2020.
[106] C. Serrano, S. Murgui, Y. Andreu, Improving the prediction and understanding of academic success: the rol of personality facets and academic engagement, Rev. Psicodidáctica 27 (2022) 21–28, https://doi.org/10.1016/j.psicod.2021.11.002.
[107] D.-F. Chang, W.-C. Chien, W.-C. Chou, Meta-analysis approach to detect the effect of student engagement on academic achievement, ICIC Express Lett 10 (2016) 2441–2446.
[108] J.A. Fredricks, P.C. Blumenfeld, A.H. Paris, School engagement: potential of the concept, state of the evidence, Rev. Educ. Res. 74 (2004) 59–109, https://doi.org/10.3102/00346543074001059.
[109] W.B. Schaufeli, I.M. Martínez, A.M. Pinto, M. Salanova, A.B. Barker, Burnout and engagement in university students a cross-national study, J. Cross Cult. Psychol. 33 (2002) 464–481, https://doi.org/10.1177/0022022102033005003.