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Tables, graphs and illustrations should be drawn using a suitable drawing package. Colour may be used. Place all diagrams and tables where you wish them to appear in the paper. Ensure your diagrams fit within the margins and are resizable without distortion.

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We are pleased to present you the third issue of the year 2023 (vol. 16, no. 3). This issue includes eight articles by authors from the Czech Republic, Indonesia, Hungary, Mexico, Poland, Portugal, Slovakia, and Turkey. The published articles deal with ethical issues in education, mathematics education, evaluation of the Covid-19 pandemic impact on education, investments in training, among other topics.

In the first article "Examination of the Correlation Between Ethical Attitudes and Dark Triad Personality Traits Among University Students", Barizsné Hadházi, Roland Filep, Péter Miklós Kőmíves, András István Kun, Mária Ujhelyi and Krisztina Dajnoki assessed the relationship between ethical attitudes of university students and their Dark Triad personality traits. For this purpose, the authors used the Ludlum's questionnaire to measure ethical attitudes, and the Dirty Dozen measurement tool to evaluate the Dark Triad traits. The linear correlation factor and regression analyses evaluated responses from 347 students attending Faculty of Economic and Business, Faculty of Natural Sciences and Faculty of Medical Sciences at a Hungarian university. The research revealed that the students' most unethical behaviour is Divulging confidential information, Passing blame for their errors to an innocent co-worker, and Claiming credit for someone else's work. Furthermore, the dark triad personality score is lower for female students compared to their male classmates.

In the second article "How Much to Invest and What Degree to Get? Education As a Strategy on the Labour Market Scale", Luis Antonio Andrade Rosas and Perla Lomelí applied game theory concepts and subjective beliefs to show the workers' best response when facing the uncertainty of whether companies value training. The analysis is based on a population of employed workers with incomplete secondary school in Mexico. The authors observed that when a company sends signals, through a low audit, that it will consider training to grant an incentive, workers could invest 75% of their income in training. With such an investment, workers would prefer studying only if they achieve at least a master's degree. On the other hand, if the company's audit is intense, workers will not exceed more than 30% of their income to continue the education. Finally, the opportunity cost of studying for a worker decreases as companies are more intense in auditing and distinguishing through wages.

In the third article "Exploring Students' Mathematical Beliefs: Gender, Grade, and Culture Considerations", Achmad Hidayatullah and Csaba Csíkos assessed students' beliefs about mathematics education in the Indonesian context in relation to student's gender, grade and culture. The authors used and extensive sample of 536 students of 8-9 grades from east-java province. The result of the study revealed that students view their mathematics teachers' effort to make mathematics lessons interesting. The students expressed their intention to continue expanding further their knowledge. Regarding students' gender, boys hold stronger beliefs that they can understand the most difficult mathematical tasks. In addition, eight-grade students have higher beliefs compared to ninth-grade students. Finally, considering students' cultural background, Javanese students hold stronger beliefs in mathematics performance than Madurese students.

In the fourth article "Identifying the Factors Influencing Mathematics Teachers' Grading Practices Regarding Students' In-Class Performance: A Reliability and Validity Study", Osman Birgin and Murat Yılmaz aimed to develop a scale to identify the factors influencing mathematics teachers' grading practices regarding students' in-class performance. The analysis is based on responses from 180 secondary and 140 high school mathematics teachers from the southwestern region of Turkey. The scale covers eight factors: mathematical knowledge and skills, social behaviors, affective skills, effort, homework performance, follow-up test results, academic exam results, and external benchmarks. The scale's construct validity was determined using item analysis, exploratory factor analysis and confirmatory factor analysis. The presented scale provides a valid and reliable instrument that may be used in determining the factors influencing mathematics teachers' grading practices.

In the fifth article "Digital Storytelling in Economics Subjects and its Effectiveness on Student Learning Outcomes by Gender and Different Economic Knowledge", Jana Nunvarova, Petra Poulova and Pavel Prazak investigated the effectiveness of digital storytelling (DST) on students' learning outcomes in economics. The authors evaluated responses from 856 students from all four grades of business-oriented Czech secondary schools. The results indicated that the use of the DST leads to a higher mean success rate in the post-test for students in the experimental group than

for students in the control group. Moreover, the results also showed that in the group that used the DST, students' gender did not affect the average post-test score, whereas the year of study influenced the average post-test score.

In the sixth article "Technostress and Continuance Intention of Online Learning in Higher Education: Evidence from Indonesia", Mohamad Arief Rafsanjani, Albrian Fiky Prakoso, Eka Indah Nurlaili, Riza Yonisa Kurniawan and Wida Wulandari focused on the continuance intention of online learning among college students in Indonesia after the Covid-19 pandemic recovery. The authors evaluated responses from 466 college students using the partial least square structural equation modeling. The result showed that three types of technostress (techno-overload, techno-invasion, and techno-uncertainty) are confirmed to have a significant negative effect on the continuance intention of online learning. On the other hand, techno-complexity and techno-insecurity do not affect online learning continuance intention. Therefore, the authors stressed the importance of taking the right policies by governments and universities to reduce the negative effect of online learning implementation.

In the seventh article "The Complex Evaluation of the Impact of COVID-19 Pandemic at Universities", a collective of authors led by František Zapletal analyzed the impact of Covid-19 pandemic at selected European universities taking into account the satisfaction of students, teachers, IT staff and management. To obtain a complex view, the analysis aggregates opinions from all interested groups of stakeholders covering periods before, during and after the pandemic. The evaluation model uses fuzzy sets to capture the uncertainty and aggregate different stakeholder groups' opinions. The forced switch to the online environment caused a substantial decrease in satisfaction for most stakeholder groups. However, the overall satisfaction improved at the end of the pandemic. Despite the decrease in overall satisfaction with distance learning, the authors emphasise important benefits related to better support by digital materials, better skills with distant communication, improved software and hardware support.

Finally, in the eight article "Contribution of Locus of Control, Self-Efficacy, and Motivation to Student Achievement", Sayed Masood Haidari, Ayhan Koçoğlu and Sedat Kanadlı investigated whether students' motivation mediates the relationship between self-efficacy, locus of control, and academic achievement. The authors created a review study consisting of 37 studies providing correlation estimates for 40 different samples. The data from these studies were fitted to three models using a two-stage structural equation modelling method. In stage 1, a total correlation matrix was created by combining the correlations, and in stage 2, this matrix was used for examining the models. The results revealed that academic achievement significantly correlates with self-efficacy and motivation; motivation significantly correlates with self-efficacy and locus of control; however, locus of control does not correlate with self-efficacy and achievement.

We would like to thank all authors who have submitted their articles to ERIES Journal and special thanks to all reviewers for their endless effort in revising the articles. We hope that all our readers will find this third issue of the year appealing. You can follow the latest updates related to the ERIES Journal on its LinkedIn page, where we post information about the published articles, highest cited articles, and related upcoming events.

Sincerely

Martin Flégl
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CONTENT

EXAMINATION OF THE CORRELATION BETWEEN ETHICAL ATTITUDES AND DARK TRIAD PERSONALITY TRAITS AMONG UNIVERSITY STUDENTS

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ABSTRACT

The purpose of the present paper is to examine the relationship between the ethical attitudes of university students and their Dark Triad personality traits. Research has suggested that the juvenile attitudes of people predict their later behaviour. Therefore, it is worth exploring this area for future aspects. Both topics are at the center of research, both individually and in terms of the correlations between them. In the present paper, we examined the relationship between ethical attitudes and the Dark Triad personality traits through questionnaires used in international research with background variables. We found that the most unethical behaviour is 'Divulging confidential information,' 'Passing blame for your errors to an innocent co-worker,' and 'Claiming credit for someone else's work.' The least unethical behaviour is 'Eating snacks while at your workstation'. Factor analysis and linear regression analysis were used. Despite our expectations, the revealed relationships between ethical attitudes and Dark Triad personality traits were not clearly positive. According to the regression model, the dark triad personality score is lower if the respondent is female, studies at the commerce-marketing major, and has higher values at the following factors: 'physiological unethicalness', 'overcharge', and 'other ethical attitudes' factors.

KEYWORDS

Organizational behaviour, ethical behaviour, exploratory factor analysis, juvenile attitudes, linear regression, questionnaire survey

HOW TO CITE

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Highlights

- *The most unethical behaviour was 'Divulging confidential information', 'Passing blame for your errors to an innocent co-worker', and 'Claiming credit for someone else's work'. The least unethical was 'Eating snacks while at your workstation'.*
- *We did not find a significant positive linear correlation between unethical attitudes, background variables, and Dark Triad personality traits.*

INTRODUCTION

Currently, one of the most important challenges, on individual, community, organizational, and social levels, is to act more and more ethically because 'Those who deal with business science today will sooner or later face the problem of the ethical representativeness of strictly profit-oriented economic thinking. Social expectations and demands for responsible management are becoming increasingly evident towards companies. It seems less and less true that anything can be done in business life' (Szegedi, 2001: 3). One of the most important areas of ethical behaviour is workplace behaviour, as we spend a significant part of our lives in a workplace environment. As university lecturers and Ph.D. students, we shifted our focus towards the ethical attitudes of our students, keeping in mind that they would become employees in the next phase of their lives. Ethical or responsible behaviour might be influenced by numerous factors, such as personality, upbringing and the resulting scale of values, family background, standard of living, and even the knowledge acquired through education (Fisher, Lovell and Valero-Silva, 2013). Among the many influencing factors in the scope of our research, we examine the relationship between personality and the ethical attitudes of university students towards workplace behaviour. On the one hand, the research was based on the Dark Triad personality theory, and on the other, the ethical questionnaire created by Ludlum et al. (2013). Dark triad traits have been chosen as variables in ethical attitudes research because these traits are frequently associated with counterproductive work behaviour

(Mahmood et al. 2021; Özsoy, 2018; Cohen, 2018), malevolent behaviour (Furnham et al., 2014; Özsoy, 2018) and other antisocial behaviour (Jonason et al., 2012) which are examples for unethical behaviour. In our research, we expect a negative connection between ethical behaviour and Dark triad traits.

In the remainder of our introduction, we provide a scientific literature review of two topics related to our topic. First, we present the characteristics of the Dark Triad personality model, then the research on the ethical attitudes of university students is reviewed. Finally, we present empirical research in which the above topics are interweaved and where others examine the ethical attitudes of individuals or university students.

In our opinion, this approach requires us to be responsible individuals or even organizations, not only towards the natural environment but also towards all of the stakeholders around us. That is, in our private life and as members of an organization (including our workplace), our actions must conform to moral and ethical standards. With the above in mind, researching and measuring the ethical attitudes of our students is worthwhile, and so is incorporating these values and norms into education.

Literature review and hypothesis development

In this section, we overview the literature on Dark Triad personality traits, the theoretical background and empirical results on the ethical attitudes of university students, and the relationship between ethical workplace behaviours and Dark Triad personality traits.

Dark Triad personality traits

In 2002, Paulhus and Williams drew attention to the Dark Triad, three unpleasant but non-pathological personality traits, Machiavellianism, narcissism, and psychopathy, which are conceptually distinct but overlapping according to empirical studies (Furnham, Richards and Paulhus, 2013). These personality traits are present to varying degrees in all people (Robbins and Judge, 2019). This study is also interesting from an organizational point of view because although these traits are undesirable by society, those who are strong in these personality traits often benefit from them. For instance, if these traits are accompanied by intelligence and an attractive appearance, they help the individual acquire leadership positions (Furnham, 2010).

Strong Machiavellian individuals are cynical and unconscientious, believing that manipulation of people is the key to a successful life and they act accordingly (Jones and Paulhus, 2009).

In the case of structured organizations, if the gap between individual desires and organizational profit grows, particular attention needs to be given to the potential Machiavellian personality of the manager, especially if the organization in question applies a performance-based compensation system. Such a bad manager is selfish, non-empathic, focuses solely on the achieved results, and tends to favor so-called 'solo star' employees who are fully willing to subordinate themselves to their personal performance and achieve their set objectives. The employment of such managers poses particular risks to organizations (Myung et al., 2017).

Narcissism is characterized by a sense of self-love, grandeur, entitlement, domination, and superiority (Paulhus and Williams, 2002). Narcissistic personality traits have a positive effect on business-like CSR activities only. Such activities may include protecting consumer rights, product liability, or consumer satisfaction. The narcissistic leader is typically considered a special personality, in which the role of mass media is very important. In fact, media might turn the spotlight towards the negative attributes of certain managers; namely, it can influence the behaviour of the managers of organizations if they seek to achieve the 'star-CEO' status. Managers with such personalities pay less attention to achieving feasible CSR goals concerning employees, the environment, or society (Myung et al., 2017). A personality survey of managers of state-owned South Korean companies showed that the presence of a narcissistic manager positively influences the performance of the state-owned company, which is more due to managerial decisions than corporate income management. However, this effect will only be true in the short term; in the long run, the presence of a narcissistic leader will lead to a deterioration in company performance (Kim, 2018). The expansion of narcissistic individualism is already affecting research performed in the field of holistic spirituality, as the latter phenomenon is typically analyzed within the framework of narcissistic individualism, with particular attention to its economic effects (Clot-Garrell and Griera, 2019). It should also be emphasized that observing information-related abnormalities and the extreme impact of social media is a strong self-regulatory need for all stakeholders (Aznar, 2019), including companies where the presence of a manager with an inadequate personality makes it difficult to avoid unwanted effects.

Psychopaths are characterized by irascibility, excitement-seeking, low empathy (Paulhus and Williams, 2002), and unconsciousness and insensitivity (Hare and Neumann, 2009). They can make a good impression but are emotionally superficial and often lead a parasitic lifestyle. The incidence of psychopathic leaders in the private sector is higher than in the public sector in general. Psychopathic leaders tend to impose greater workloads on their subordinates, more conflicts emerge between them, and they prefer to place organizational constraints on their staff. At the same time, psychopaths can often become real organizational stars, who are often honored. Still, at the same time, they exhibit extreme behaviours such as bullying, threat and intimidation, coercion, and restraint (Myung et al., 2017).

Despite their different origins, the Dark Triad personality types share common characteristics. To a different extent, all three carry a character labeled as socially malicious. These include self-promotion, emotional coldness, insidiousness, and aggression (Paulhus and Williams, 2002).

In the scientific literature, it is relatively easy to find empirical studies measuring university students' Dark Triad personality traits in relation to different factors. Do and Dadvari (2017) found that the Dark Triad personality had a mediating role in Taiwanese students' entrepreneurial attitude orientation and entrepreneurial intention. Giammarco and Vernon (2014), in a study done among Canadian undergraduate students, found that two out of the three Dark Triad personality traits, 'Machiavellianism and psychopathy, were positively correlated with an emotional vengeance but negatively correlated with justice-fairness and justice-legal decisions' (Giammarco and Vernon, 2014:23). Harrison et al. (2018) in their research found that Dark Triad had a positive impact on fraud behaviour. Onyedire et al. (2019) examined the associations of Dark Triad traits with problem gambling among Nigerian undergraduate students. They found that psychopathy and students' age were positive, and narcissism negatively predicted problem gambling. Vedel and Thompsen (2017) compared newly enrolled students' Big Five and Dark Triad traits and found significant differences in different academic majors. The largest difference was measured between economics/business and psychology students. Students choosing economics/business majors had high Dark Triad scores, unlike those in psychology majors, who had low Dark Triad scores. Blais and Pruysers (2017) analyzed the connection between Dark Triad and general personality traits and political ambition. Cannon et al. (2020) compared students in British private schools and British public schools based on Dark Triad personality traits. They found that students in private schools scored higher on Dark Triad personality traits and were less characterized by intellectual humility than students in public schools. Dark Triad personality traits have a negative relationship with intellectual humility, and this relationship was also stronger in private school students than in students in public institutions. Guo et al. (2023), in a survey of a sample of Chinese university students, found that the presence of Dark Triad personality traits has a limited effect on students' creativity levels. Kircaburun et al. (2021) examined the relationships between Dark Triad personality traits and learning addiction involving Turkish university students. They found that for females, only Machiavellianism related – not significantly – positively to study addiction, while for males, all three Dark Triad personality traits were significantly associated with study addiction. Nishant (2019) examined the impact of Dark Triad personality traits of university lectures on students' perceptions of institutional quality. He found that in the case of students studying at elite Indian management schools, the instructors' moderate-level Dark Triad personality traits had a positive effect on perceptions of institutional quality. In contrast, low and high-level Dark Triad personalities had the opposite effect. In a separate chapter, we provide more empirical research results which analyze the impact of personality on ethical attitude and behaviour.

Ethical attitudes of university students

'Attitude is an evaluative statement or opinion about a person, object or event' (Robbins and Judge, 2013: 71). Based on this, judging and commenting on any activity according to moral standards can be defined as an ethical attitude. According to Moosavi et al. (2016), ethical attitudes indicate motivation and practical commitment. They also add that while ethical attitude includes conformity to formal codes of professional ethics, ethical attitudes are more complex than merely following the rules and codes of ethics. They also believe that an ethical attitude is important because regulation alone is unable to answer to and prepare for every ethically dangerous situation. Referring to other sources (Gastmans, 1999; Solomon, 2001; Olthuis and Dekkers, 2003; Olthuis, 2007), it is stated that an ethical attitude can help resolve such ethically dangerous situations. Education at different higher educational institutions can positively affect the students' perception of ethics. The students mostly think universities are ethical places by their nature (Özeltürkay et al., 2018). Bangladeshi students underlined the importance of ethics (and mostly: business ethics) education in university curricula because they associated the managers to follow the different ethical rules if they know their meanings and if their importance is clarified (Adhikary and Mitra, 2015). The ethical content of the education has to be designed carefully, concerning the age specificity of the students. With effectively designed ethical training included in the curricula, the students were more willing to follow the ethical rules (Berkovich and Eyal, 2018). Using movies to demonstrate ethical problems seems to be a successfully used tool in the case of university ethical education (Schwartz, 2017).

McCabe, together with his fellow authors (McCabe and Trevino, 1993, 1996; McCabe and Bowers, 1996; McCabe, Treviño and Butterfield, 2001), attempted in several studies to uncover the values and behaviour of students in relation to cheating. In terms of the 30-year period they studied, it was shown that student participation in university cheating increased, the participation rate of females was higher, and their willingness to cheat was intensified by the accepting attitude of their fellow students (the effect of this was considered particularly strong), or if the students saw their fellow students cheating. Concerning the codes of ethics established by the universities, it has been stated that their preparation is insufficient in itself; its introduction to and acceptance by students and teachers is also required. Earlier research has also found that the environment surrounding a person has a significant effect on the development of behavioural deviations (McCabe and Trevino, 1993; Jordan, 2001). The accepting attitude towards the cheating behaviour of students is still a perceptible and existing phenomenon, and it should also be noted that higher education might enhance the need of students to act on their cheating tendencies, as exams with more attending students increase their willingness to cheat (Király et al., 2018). At the same time, according to a survey conducted among Hungarian students, both teachers and students addressed issues beyond the ethical and disciplinary consequences of cheating on exams, as both lecturers and students mentioned that cheating might significantly undermine the motivation of lecturers towards teaching and working (Csillag et al., 2017). There are some differences in willingness to follow ethical rules by the discipline of the students. Still, most students accept unethical acting because they do not want to be excluded from different social groups just because of their ethical behaviour (Rodzalan and Saat, 2016). Most students reported their unethical behaviour during university classes is mostly related to using different IT and smart equipment for non-learning aims in research completed on a sample of Malaysian students (Ahmad et al., 2017). This research shows the students know that if they deal with topics unrelated to the university lectures during the classes, their behaviour is unethical.

Our own examinations were based on another research activity conducted among students, which can be attributed to Ludlum et al., who first assessed in 2009 and then in 2015 the extent to which their students perceive certain workplace behaviours as unethical (Ludlum and Moskaloinov, 2009; Ludlum, Moskalionov and Ramachandran, 2013; Ludlum et al., 2015). According to their findings, the workplace situations considered the most unethical were the following (Ludlum, Moskalionov and Ramachandran, 2013:15, Ludlum et al., 2015): 'passing blame for your errors to an innocent co-worker'; 'divulging confidential information' (Ludlum, Moskalionov and Ramachandran, 2013:21); 'claiming credit for someone else's work' and 'falsifying reports'. The questionnaire and examination methodology are described in more detail in the scope of the Material and Methods section.

An interesting research question is what sort of thoughts and feelings university students express about CSR (Corporate Social Responsibility). The importance of this topic is underlined by Karácsony (2020), who paid attention to the role of profit-oriented companies causing global social problems and the possibilities of the leaders of minimizing these risks. Since current students once can become leaders at profit-oriented companies, their attitude to CSR will be crucial. Research in CSR has mainly focused on differences between genders, classes, cultures, and generations (Luthar and Karri, 2005; Haski-Leventhal, 2013; Kaifi et al., 2014; Alonso-Almeida, Fernández De Navarrete and Rodriguez-Pomeda, 2015). Reviewing the research findings, the following observations were made: Kaifi and his research group published that there were significant differences between males and females in terms of the priority of social responsibility to the benefit of the latter. There was also a significant difference based on the cultural affiliation of the respondents: people from high-context cultures are more committed to CSR. The members of Generation Y are significantly more sensitive within this area as compared to the members of Generation X (Kaifi et al., 2014). Research related to Haski-Leventhal revealed that ethical corporate behaviour was the most important factor within the CSR pyramid of students, legal compliance was the second important, followed by economic, social, environmental, and last but not least, philanthropic responsibility (Haski-Leventhal, 2013).

According to the above, it can be seen that the student CSR pyramid does not match the order shown in Carroll's (1979, 1991) CSR pyramid. In an article by Alonso-Almeida published in 2015, students were categorized by grades: it was found that second and third-grade students were less sensitive to CSR than their first-year fellow students (Alonso-Almeida, Fernández De Navarrete and Rodriguez-Pomeda, 2015). Luthar and Karri's research (2005) informs us that the expectations of females towards corporate ethical behaviour are higher, and the sensitivity of higher-grade students in this regard is stronger, a fact that contradicts Alonso-Almeida's findings.

One might wonder whether it is relevant to infer the later workplace behaviour of university students from their ethical attitudes. In this regard, Sims demonstrated in a study published in 1993 that there was a connection between the two (Sims, 1993). The research outcomes published by Sims were agreed upon and confirmed by Selvalakshmi and Mutharasi (2017).

Findings of the empirical studies related to the ethical attitudes of university students

Ludlum and Moskaloinov conducted their first research among university students in 2009: they examined how Russian students see the causes of corruption, whether they are involved in corrupt acts of business life, and whether they would report if such a case came to their knowledge. In their study summarizing the research findings (n = 540), they report that according to Russian university students, the three most common causes of corruption are the low level of legal culture and low willingness to comply with laws, inefficient functioning of state institutions and the existence of legal loopholes as well as the greed and immorality of Russian bureaucrats (Ludlum and Moskaloinov, 2009). According to the research findings, about half (47%) of the students are not involved in business corruption, which is quite positive. Still, the situation could be more favorable when it comes to reporting corruption if it came to their attention in any form: 40% of them declared that they would not report it (Ludlum and Moskaloinov, 2009).

Ludlum et al. continued their research in the United States: their study papers, published in 2013 and 2015, examined the ethical attitudes of American university students. The first survey involved 725 people, who said they considered the most unethical the following behaviour: 'divulging confidential information,' 'passing blame for one's errors to an innocent co-worker' and 'falsifying reports'. From an ethical point of view, the most acceptable behaviours were eating snacks at work and falling asleep in church (Ludlum, Moskalionov and Ramachandran, 2013:21). However, the authors also pointed out that different individuals and groups may follow very different ethical values, making it almost impossible to set unified ethical guidelines for everyone in business life (for example, by referring to the code of conduct for companies).

A 2015 study by Ludlum et al. reports on the findings of the second round of research, which involved a narrower scope of only 356 university students. According to their findings, the most unethical workplace situations are the following: 'passing blame for one's errors to an innocent co-worker'; 'to divulge confidential information'; 'to claim credit for someone else's work' and 'falsifying reports', while they labeled one as entirely not ethical at all, namely whether it is ethical to eat snacks at work (Ludlum et al., 2015). Examining gender differences showed that females are more ethical than males, and smokers are more ethical than non-smokers (the latter could not be explained).

The original questionnaire was developed by Ruch and Newstrom (Ruch and Newstrom, 1975), in which 17 workplace situations were formulated. The research involved managers and supervisors completing a test: how unethical is the behaviour described, do describe it to your manager, how often do they do it, and how often do you think your manager does it? (Ruch and Newstrom, 1975: 17-18)

Their main findings:

- Managers perceive degrees of ethics (situations are not only black or white; some things are seen as more or less unethical than others) (Ruch and Newstrom, 1975: 19).
- No ethical standard is accepted universally: this depends on ethical codes and climates of their organizations (Ruch and Newstrom, 1975: 19).
- Another main conclusion: managers see their superiors as an important reference group and tend to align their ethical standards with their bosses' beliefs (Ruch and Newstrom, 1975:20).

In 1996, Deshpande and their colleagues conducted a survey (N = 136) in Sakha Republic of Russia using a questionnaire of Ruch and Newstrom (Deshpande et al., 2000). Significant differences between genders were identified. Female managers reported various activities to be more unethical than their male colleagues. Among other results, we could mention falsely claiming sickness, pilfering organization supplies are more unethical than male managers, and accepting gifts and favors for preferential treatment.

We have already tested the ethical attitudes of domestic university students on a sample of 67 people (Barizsné and Ujhelyi, 2017). According to our findings at the time, our students classified more situations as particularly unethical than their American counterparts: divulging confidential information, passing blame for one's errors to an innocent co-worker, pilfering organization materials, claiming credit for someone else's work, falsifying reports, falling asleep at work, not reporting violations of organization regulations, increasing accounts by more than 10%, and falling asleep in church (the mean score of these statements was higher than 4). However, students did not find it unethical to give gifts for preferential treatment, to use the company's resources for private purposes, not to report others violating company policies, or to eat snacks at work (the mean score of these responses was below 3). Based on our findings, we also concluded that our students had a high degree of agreement (lower standard deviation values) for the behaviours considered particularly unethical. In contrast, in the case of the rest of the statements, the standard deviation was higher. Namely, our students were more divided on these issues (Barizsné and Ujhelyi, 2017).

Examination of the relationship between ethical workplace behaviours and Dark Triad personality traits

In this chapter, we provide a brief overview of empirical research that, similarly to our own research, sought correlations between Dark Triad personality traits and ethical workplace behaviours.

Over the past one and a half decades, there has been an expanding scope of research to uncover the success of Dark Triad personalities from a management science perspective (Vize et al., 2018). This process is in line with the research tendency in international economics that pays increasing attention to unethical, dishonest, and unlawful elements in the operation of companies (Sadaf et al., 2018) - as their emergence is certainly inseparable from the personality of corporate managers. The ethical attitudes of managers significantly influence the quality of the reports submitted by companies as well (Im and Nam, 2019). Consequently, it has been found that individuals belonging to the Dark Triad prefer to use various 'cheater strategies' to achieve their interpersonal and social goals despite their antisocial personality (Fox and Rooney, 2015). Regarding morality, Dark Triad personalities are often called compromising or dysfunctional (Jonason et al., 2015). As a result of the competing nature of competitive relationships, opportunistic behaviours may also intensify in corporate management, providing another great example of how the extreme personality of managers may affect the performance of companies and how it may result in organizations willing to break market rules (Cygler and Sroka, 2017)coopetition is fraught with threats arising mainly from both the coexistence and interaction of streams of cooperation and competition between competitors. Research on a sample of 235 companies operating in the high technology sector (HT. In 2012, Moore's research team examined the relationship between Dark Triad personality traits and unethical organizational behaviour. Based on the findings of multiple surveys, they concluded that the more Machiavellian a person is, the more prone they are to lying, antisocial behaviour, and exploitation of others.

O'Boyle and his fellow researchers (2012) looked for the relationship between the Dark Triad and counterproductive work behaviour. A meta-analysis was conducted by reviewing data from 186 studies, which found that the three Dark Triad traits were related and that all three Dark Triad traits were significantly associated with counterproductive workplace behaviours.

Furnham et al. (2013) analyzed the correlation between the Dark Triad traits and cheating among university students: psychopathy predicted copying the answers at exams, while Machiavellianism predicted plagiarism. As for the subjects involved in the study sample, those heavily psychopathic or Machiavellian students often demanded extra points they had not worked for.

Baughman's research group (2014) examined 462 university students. Their data found that psychopath and Machiavellian traits were positively correlated with cheating in both private life and university situations.

A study published by Roeser et al. (2016) pointed out that, in the case of the studied sample of 196 people (the respondents were students), the Dark Triad personality traits differed regarding unethical behaviour patterns. Machiavellians are involved in complex deception, while psychopaths are more involved in impulsive cheating (Roeser et al., 2016). Cohen's (2015) publication from 2016 confirms the findings of Boyle and his research team, namely that all Dark Triad traits positively correlate with so-called counterproductive workplace behaviour. We also found a source in the literature review that deals with a very actual topic related to business ethics: the management's role regarding the company's ethical operation. Intervention in the ethical side of the company operation can have a counterproductive effect. The aim of a company's management is more likely to create and maintain a milieu for the company that supports the formation of ethical working conditions (Treviño et al., 2006). This practice also supports the top-down flow of ethical norms and norm-creation at companies described by Diochon et al. (2018). In several cases, companies employ ethicist specialists to help the work of the ethical bodies – including, for example, an ethical committee – but applying ethics can also become counterproductive (Emmerich, 2009).

Hypotheses

Ludlum et al. (2015) found that among the interviewed students, the most unethical workplace behaviours out of the 20 behaviours listed by them are: passing blame for one's errors to an innocent co-worker; divulging confidential information; claiming credit for someone else's work and falsifying reports, while the most ethically acceptable form of conduct from the same list is 'Eating snacks while at your work station'. As a reflection of this:

H1: It is assumed that the opinions of our respondents about the unethical nature of the examined behaviours are in line with the findings of Ludlum (Ludlum et al., 2015)

H1.1: Students in the sample considered the following behaviour the most unethical:

- 'Divulging confidential information.'
- 'Passing blame for your errors to an innocent co-worker.'
- 'Claiming credit for someone else's work.'

In their research, Ludlum et al. (2015) identified 'Eating snacks while at your work station' as the most ethically acceptable form of behaviour. This can also be understood as indirectly shortening one's working time. Based on this:

H1.2: We assume that the least unethical form of behaviour in the sample of students is 'Eating snacks while at your work station.'

In her research, Moore (2012) found a link between Machiavellianism, propensity to lie, and antisocial behaviour. O'Boyle et al. (2012) found a significant association between Dark Triad personality traits and counterproductive workplace behaviour. Roeser et al. (2016) could relate those personality traits; we also examined various unethical behaviours. Based on this, we assume that:

H2: A significant positive linear correlation exists between unethical attitudes and Dark Triad personality traits.

H2.1: Acceptance of unethical behaviour suggests high Machiavellian values.

H2.2: Acceptance of unethical behaviour suggests high narcissistic value.

H2.3: Acceptance of unethical behaviour suggests high psychopathic value.

MATERIAL AND METHODS

During our empirical research, we applied questionnaires as data collecting instruments with distinct scales for measuring ethical attitudes and Dark Triad personality.

The measurement tool for identifying ethical attitudes was taken over from previous research by Ludlum's research group (Ludlum, Moskalionov and Ramachandran, 2013). The original questionnaire contains 20 statements to evaluate, 19 describing workplace situations, and one describing a situation outside the workplace (actually in a church). Respondents were asked to rate on a Likert formatted 5-point evaluation scale the degree to which a given statement was considered unethical (5 being very unethical and 1 being very ethical).

Özeltürkay and their colleagues used this questionnaire in 2015: 275 questionnaires were collected at the university in the Mersin region, Turkey between 20 and 31 of July (Özeltürkay et al. 2018). They analyzed the scale's reliability in their study: reliability analysis was done for both full of the items first. Then the scale was divided into two parts, and each part's reliabilities were calculated. The scale used in this study is reliable: both the first and the second half of the scale and the full of the scale have an appropriate Cronbach-alpha (0.781; 0.780; and 0.865) (Özeltürkay et al. 2018:7).

The Dark Triad personality traits were measured using a solid 12-item measurement tool called Dirty Dozen, developed and validated by Jonason and Webster (2010). They designed 4 Studies, involved 1085 respondents, and examined Dirty Dozen's structural reliability, convergent and discriminant validity, and test-retest reliability. This questionnaire contains 4 questions on Machiavellianism, 4 on Narcissism, and 4 on psychopathy. Respondents were asked to mark how much each behaviour is characteristic on a Likert formatted 7-point evaluation scale. Later, 2019 Maneiro et al. (2019) later validated the Spanish version of Dirty Dozen. The number of respondents was 326. The questionnaire showed good internal consistency and acceptable test-retest stability.

Data were collected between February and September 2017 among domestic students of the (*deleted to maintain integrity*) with the permission of the Ethics Committee of the Faculty. The students could fill in the questionnaires anonymously and voluntarily. Several background variables were recorded: gender, year of birth, number of siblings, the course they attended, and whether they attended an ethics course. The sample size is 347, of which 66.0% of respondents are females and 33.1% are males (missing data: 0.9%). The youngest respondent was born in 1999, and the oldest in 1964. 51% (177) of the students were born in 1996-1997. 65.7% (228) of the sample comes from programmes run by the faculty of economics and business, 27.7% (96) from the faculty of natural sciences, 4.6% (16) from the faculty of medical sciences, and the missing value is 2.0% (7).

For testing our hypotheses, linear regression analyses (factors representing ethical variables) were applied besides descriptive statistical methods. The Cronbach-alpha of the ethical full scale (20 items, $N = 297$) is 0.789, while the Dark Triad questionnaire (12 items, $N = 344$) is 0.825. Like Ozelturkay et al. (2018:7), we calculated the Cronbach-alpha for both sample halves. For the first half, it is 0.665 (10 items, $N = 317$); for the second half, it is 0.694 (10 items, $N = 311$). Bivariate linear correlation matrices of the total sample and the regression models reported in table 3 are presented in appendix 4.

RESULTS

In presenting our research results, we first address H1 (H1.1, H1.2) hypothesis through descriptive statistics. Then we focus on the connection between respondents' Dark Triad personality traits and their ethical attitude (H2.1, H2.2, H2.3 hypothesis). We analyzed the ethical attitudes using factor analysis. Then we used these factors in our linear regression model.

Ethical attitudes

Table 1 in Appendix shows the means, standard deviations, medians, and mean ranks of the 20-item ethical attitude questionnaire (Ludlum, Moskalionov and Ramachandran, 2013).

Taking into consideration those responses only that contained answers to all the 20 items ($N = 297$), there were statistically significant differences in the perceived unethicalness of the listed behaviours (Friedman test was conducted; $\chi^2(19) = 2248.8327$, $p < 0.001$). We have found that students considered the following behaviours to be the three most unethical (median = 5): 'EB8. Passing blame for your errors to an innocent co-worker', 'EB5. Divulging confidential information, and 'EB9. Claiming credit for someone else's work'. Wilcoxon signed-rank test was conducted for the consecutive item pairs to examine if the next item significantly differed from the previous one. EB8 and EB5 did not differ significantly ($Z = -0.007$, $p = 0.994$), but the EB5-EB9, EB9-EB15 pairs do ($Z = -3.813$, $p < 0.001$; $Z = -2.738$, $p = 0.006$ respectively). EB15 and EB10 ($Z = -1.533$, $p = 0.125$) did not differ again. The ethically most acceptable behaviour was 'Eating snacks while at your workstation', which had a significantly lower rank then the previous EB7 ($Z = -5.409$, $p < 0.001$).

Factor analysis of the ethical attitudes questionnaire was performed with the exclusion of EB16 ('Falling asleep at church') (item labelling according to Table 1) as it is the only statement that does not represent work-related behaviour, and EB14 ('Authorizing a subordinate to violate organization rules.') as it did not fit to any of the revealed factors. The results of factor analysis with EB14 (KMO = 0.777, Bartlett's score = 1215.873, p<0.001, explained variance = 57.807%) are not presented here for length reasons since we will not work with them further. However, the information in parentheses above shows that the omission of EB14 changed significantly, explaining neither the goodness of the factor analysis nor the proportion. The factor analysis was performed using the Listwise method to avoid possible biases caused by incomplete questionnaires.

The statistics for the Kaiser-Meyer-Olkin Measure of Sampling Adequacy test (0.773), and the Bartlett's test score (1134.775, p < 0.001). Based on the results of the tests, exploratory factor analysis can be performed. The analysis resulted in 6 factors, which together explain 59.355% of the total variance. The factor analysis was conducted using the principal component method, varimax rotation, and Kaiser normalization (Table 2 in Appendix).

The resulting 6 factors were named as follows:

- Factor 1: mixed (EB5, EB8, EB9, EB10, EB15)
- Factor 2: physiological unethicality: (EB12, EB13, EB18, EB19)
- Factor 3: bribery: (EB3, EB17)
- Factor 4: overcharge: (EB2, EB11)
- Factor 5: exploitation of corporate resources: (EB1, EB4, EB6)
- Factor 6: 'honor among thieves': (EB7, EB20)

Testing the connection between Dark Triad personality traits and ethical attitude factors

Regression analyses were performed to reveal linear relationships between the Dark Triad personality traits, ethical attitude factors, and other background variables (Table 3 in Appendix). In the regression model, we will use the following variables:

FEMALE: 1 if the respondent is female, 0 if male.

BIRTHYEAR: the year when the respondent was born

SIBLING_1: 1 if the respondent has 1 sibling, 0 if otherwise (no sibling or more than one).

SIBLING_2: 1 if the respondent has 2 siblings, 0 if otherwise (more or less than two).

SIBLING_3: if the respondent has exactly 3 siblings, 0 if otherwise

SIBLING_4+: if the respondent has 4 or more siblings, 0 if less than 4.

PARTTIME: 1 if the respondent is a part-time student, 0 if otherwise.

2ND_YR: 1 if the respondent is a 2nd year student, 0 if otherwise.

3RD_YR: 1 if the respondent is a 3rd year student, 0 if otherwise.

MAJOR_FA: 1 if the respondent's major is BSc in Finance and Accounting, 0 if otherwise.

MAJOR_CM: 1 if the respondent's major is BSc in Commerce and Marketing, 0 if otherwise.

MAJOR_ML: 1 if the respondent's major is MSc in Management and Leadership, 0 if otherwise.

MAJOR_INT: 1 if the respondent's major is BSc in International Economics, 0 if otherwise

MAJOR_B: 1 if the respondent's major is BSc in Biology, 0 if otherwise

MAJOR_G: 1 if the respondent's major is BSc in Geography, 0 if otherwise

MAJOR_HCM: 1 if the respondent's major is MSc in Health Care Management, 0 if otherwise

ETHICSCLASS: 1 if the respondent has completed an Ethics related course, 0 if has not.

$FACT_n$: The value of the ethics factor *n*.

Based on the results in Table 3, the summarized (total) score of the Dark Triad traits could be described by Equation 1 in the examined sample at a 5% significance level, which model was able to explain about 20.0% of the Dark Triad score.

$$Y_{DARKTRIAD} = 37.525 - 3.447\,(X_{FEMALE}) - 6.581\,(X_{MAJOR\_CM}) - 3.402\,(X_{FACT1}) - 0.668\,(X_{FACT1})^2 - 0.326\,(X_{FACT2})^3 - 1.271\,(X_{FACT4})^3 + \varepsilon \quad (1)$$

ε is the random error term. According to the regression model estimated from the sample, the dark triad personality score is lower if the respondent is a female, studies at the commerce-marketing major, and has higher values of the mixed (FACT1), physiological unethicality (FACT2), and overcharge (FACT4) factors.

The regression model of the Machiavellian personality trait is described in Equation 2 (based on Table 3):

$$Y_{MACHIAVELLISM} = 12.484 - 2.033\,(X_{FEMALE}) + 0.337\,(X_{FACT2})^2 - 0.497\,(X_{FACT4})^3 + \varepsilon \quad (2)$$

This model can explain 11.7% of the variation of the Machiavellianism score. In our sample, male respondents, as well as ones with a higher 'physiological unethicality' (FACT2) value, tend to have a higher Machiavellianism level, while higher values of the 'overcharge' (FACT4) factor predict a lower level of Machiavellianism.

The second model in Table 3 shows the regression analysis results between the narcissism personality trait (explaining 10.9% of its variability) and the ethical attitude factors. The model is formalized in equation 3:

$$Y_{NARCISSISM} = 12.991 + 2.553(X_{MAJOR\_ML}) + 1.969(X_{MAJOR\_INT}) - 1.365\,(X_{FACT4}) + \varepsilon \quad (3)$$

Respondents of the sample tend to have more narcissistic personalities if they study management and leadership or international management. Higher values of the fourth ethics factor predict a less narcissistic personality.

The level of a psychopathic personality in the students' sample (Table 3) is formulated in Equation 4:

$$Y_{PSYCHOPATIC} = 10.807 - 1.973\,(X_{FEMALE}) - 2.186\,(X_{MAJOR\_HCM}) - 1.123\,(X_{FACT1}) - 0.176(X_{FACT1})^2 - 0.145(X_{FACT2})^3 - 0.230\,(X_{FACT4})^3 + \varepsilon \quad (4)$$

Psychopathic personality was lower in the sample for female and health management students, as well as if the values of the first, second, and fourth ethics factors had higher values. The model explained 18.3% of the studied personality trait.

DISCUSSION

Our findings (see Appendix 1) on ethical attitudes are consistent with the findings of Ludlum et al. (2013; 2015), according to which the most unethical behaviour is 'Divulging confidential information' (EB5), 'Passing blame for your errors to an innocent co-worker' (EB8) and 'Claiming credit for someone else's work.' (EB9). The least unethical behaviour is 'Eating snacks while at your work station' (EB19). Based on the above, we have failed to reject (on the 5% level of significance) both sub-hypotheses (H1.1, H1.2) of our first hypothesis (H1: 'the opinions of our respondents about the unethical nature of the examined behaviours are in line with the findings of Ludlum'). When analyzing the research outcomes, we must remember that from a moral viewpoint, misleading and lying have different meanings (Berstler, 2019). As our analysis was completed on a sample of business students, we also paid attention to the outcomes of Gwinner et al. (2019), who stated that business students are more likely to formulate an opinion based on the needs of the business life than the non-business students. This circumstance is very important because, as Holcomb et al. (2019) underlined, companies with Ethics and Compliance Committees are more successful than those that do not use this kind of company practice. The university students' opinion – who will once become leaders at these companies – is very important and has an outstanding impact on their future performance.

Exploratory factor analysis was carried out based on the ethical attitudes questionnaire items, and we identified six factors. Using linear regression analysis, we examined how these factors (and the background variables) reduce or increase the expected degree of the Dark Triad personality traits. We rejected our second hypothesis, 'H2: There is a significant positive linear correlation between unethical attitudes and Dark Triad personality traits' (on the 5% significance level) because our assumptions were only partially supported in the cases of certain factors in some models.

The investigations related to the ethical behaviour of the students and their moral beliefs have about a century-long history (Barnes, 1904; Carter, 1929; Dudycha, 1933). This topic is always actual as the universities have key roles in the employability of (former) students.

That circumstance means that universities are partly responsible for the students' employment (López-Miguens et al., 2021), and the students' success in the labor market can also depend on their ethical education. The role of ethical education in Eastern-Central-Europe became more important, as well as the ethics management elements used to spread in this region (Lašáková et al., 2021).

CONCLUSION

This paper aimed to examine the relationship between the ethical attitudes of university students and their Dark Triad personality traits. Ludlum's questionnaire (Ludlum, Moskalionov and Ramachandran, 2013) was used to measure ethical attitudes, and the Dirty Dozen (Jonason and Webster (2010) measurement tool was chosen to evaluate the Dark Triad traits. Besides descriptive statistics, linear correlation analysis, factor analysis, and regression analysis were applied to prove the relationship. Our findings are in line with previous research results. The most unethical behaviour was 'Divulging confidential information', 'Passing blame for your errors to an innocent co-worker', and 'Claiming credit for someone else's work'. The least unethical behaviour was 'Eating snacks while at your workstation'. The relationship between the Dark Triad personality traits and six ethical attitudes factors were tested using linear regression analysis. We have found connections only between a few ethical factors and each DT trait.

Our study has several limitations. One is that the data were collected only once from one university. Analysing only one sample raises the problem of common method variance, which is a possible source of methodological bias. For more generalizable conclusions, future studies should extend the area of investigation.

We see further research opportunities in exploring the correlations between specific ethical attitudes and Dark Triad personality traits. However, examining the correlation between other individual characteristics and ethical attitude/behaviour is also recommended. Among individual characteristics, future models should include personality types (e.g., MBTI) or traits (e.g., Big Five), as well as academic performance.

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APPENDIX

Ethical Behaviour (EB)	Mean	Std. Dev.	Median	Mean Rank
EB8. Passing blame for your errors to an innocent co-worker.	4.747	0.604	5.000	16.520
EB5. Divulging confidential information.	4.731	0.633	5.000	16.515
EB9. Claiming credit for someone else's work.	4.576	0.654	5.000	15.540
EB15. Pilfering (taking) organization materials and supplies.	4.444	0.761	5.000	14.763
EB10. Falsifying time/quality/quantity reports.	4.370	0.671	4.000	14.355
EB2. Padding (increasing) an expense account up more than 10%.	4.030	0.844	4.000	12.306
EB14. Authorizing a subordinate to violate organization rules.	3.997	0.832	4.000	11.939
EB16. Falling asleep at church.	3.684	1.053	4.000	10.285
EB11. Padding (increasing) an expense account less than 10%.	3.724	0.857	4.000	10.184
EB13. Falling asleep at work.	3.707	0.804	4.000	10.133
EB20. Not reporting others‟ violations of organization policies and rules.	3.515	0.826	4.000	8.975
EB4. Taking longer than necessary to do a job.	3.519	0.847	3.000	8.914
EB18. Taking extra personal time (arriving late for work, leaving early).	3.515	0.754	4.000	8.854
EB12. Call in sick to take a day off work.	3.485	0.745	4.000	8.803
EB17. Accepting gifts/favors in exchange for preferential treatment.	3.343	0.995	3.000	8.227
EB6. Doing personal business on organization time.	3.313	0.744	3.000	7.697
EB1. Using organization services for personal use (making long distance telephone calls).	3.226	0.775	3.000	7.337
EB3. Giving gifts/favors in exchange for preferential treatment.	3.131	1.026	3.000	7.079
EB7. Concealing ones errors.	3.121	0.846	3.000	6.705
EB19. Eating snacks while at your work station.	2.754	0.840	3.000	4.869

Note: N = 297, minimum and maximum values are 1 and 5 in every case

Table 1: Descriptives of ethical attitude-related responses, in order of their mean rank (source: own calculation)

Standardized EB values	Component					
	1	2	3	4	5	6
EB1	-0.045	-0.099	0.132	0.228	0.763	-0.147
EB2	0.146	0.001	0.821	0.157	0.201	-0.073
EB3	0.099	-0.018	0.038	0.868	0.089	0.030
EB4	0.204	0.227	0.046	0.019	0.518	0.239
EB5	0.510	0.120	0.127	0.011	0.157	0.020
EB6	0.150	0.357	0.075	-0.042	0.622	0.185
EB7	0.142	-0.041	0.099	0.046	0.185	0.768
EB8	0.741	0.055	-0.049	0.048	-0.085	0.133
EB9	0.744	-0.032	-0.057	0.128	0.242	0.030
EB10	0.666	0.137	0.183	0.077	0.010	0.197
EB11	0.113	0.051	0.881	0.029	0.021	0.101
EB12	0.236	0.593	0.063	0.080	0.229	0.161
EB13	0.263	0.684	-0.059	-0.112	-0.006	-0.050
EB15	0.547	0.261	0.211	-0.059	-0.006	0.079
EB17	0.061	0.245	0.145	0.827	0.089	0.114
EB18	0.079	0.541	0.128	0.077	0.229	0.302
EB19	-0.050	0.725	0.000	0.220	0.001	0.001
EB20	0.160	0.227	-0.077	0.077	-0.068	0.730

Note: Standardized EB values are the standardized values of the responses to ethical questions (see Table 1).

Table 2: Ethical factors – Rotated component matrix, 2017-2018 (source: own calculation) *N* = 307

	Machiavellianism		Narcissism		Psychopathy		Dark Triad Total	
Independent	*B*	*t*	*B*	*t*	*B*	*t*	*B*	*t*
CONSTANT	12.484	23.845***	12.991	43.031***	10.807	28.260***	37.525	36.557***
FEMALE	-2.033	-3.412***			-1.973	-4.239***	-3.447	-2.759**
BIRTHYEAR								
SIBLING_1								
SIBLING_2								
SIBLING_3								
SIBLING_4+								
PARTTIME								
2ND_YR								
3RD_YR								
MAJOR_FA								
MAJOR_CM							-6.581	-2.624**
MAJOR_ML			2.553	2.613 **				
MAJOR_INT			1.969	2.676**				
MAJOR_B								
MAJOR_G								
MAJOR_ HEA					-2.186	-2.123*		
ETHICS CLASS								
FACT1					-1.123	-3.566***	-3.402	-3.998***
FACT1²					-0.176	-2.280*	-0.668	-3.214**
FACT1³								
FACT2								
FACT2²	0.337	2.094*						
FACT2³					-0.145	-3.726***	-0.326	-3.116**
FACT3								
FACT3²								
FACT3³								
FACT4			-1.365	-4.975***				
FACT4²								
FACT4³	-0.497	-4.555***			-0.230	-2.732**	-1.271	-5.655***
FACT5								
FACT5²								
FACT5³								
FACT6								
FACT6²								
FACT6³								
F	13.563***		12.607***		11.612***		12.812***	
adj*R*²	0.117		0.109		0.183		0.200	
N	285		285		285		285	

*Notes: Listwise method. * 5% significant, ** 1% significant, ***0.1% significant*

Table 3: Linear regression model for the explanation of the Dark Triad personality traits, 2017-2018 (source: own calculation)

	birthyear	FAC1	FAC1²	FAC1³	FAC2	FAC2²	FAC2³	FAC3	FAC3²	FAC3³	FAC4	FAC4²	FAC4³	FAC5	FAC5²	FAC5³	FAC6	FAC6²	FAC6³
Machiavellianism	0.076	-0.102*	-0.017	0.029	-0.075	0.124*	-0.105*	-0.042	0.016	-0.046	-0.241***	-0.027	-0.271***	0.025	0.127*	-0.023	-0.037	0.012	-0.013
Narcissism	0.008	-0.059	-0.050	0.068	-0.068	0.038	-0.077	0.004	-0.013	0.007	-0.282***	0.093	-0.268***	-0.004	0.058	-0.021	0.054	0.070	0.086
Psychopathy	0.077	-0.194***	0.029	-0.014	-0.092	0.142**	-0.206***	-0.072	0.076	-0.071	-0.127*	-0.034	-0.175**	0.016	0.077	-0.046	0.053	-0.018	0.042
DT total	0.067	-0.144	-0.019	0.038	-0.098*	0.126*	-0.158**	-0.044	0.030	-0.044	-0.282***	0.015	-0.307***	0.016	0.112*	-0.037	0.026	0.029	0.047
birthyear		-0.080	0.083	-0.056	-0.047	0.011	-0.049	-0.184***	0.048	-0.112*	-0.108*	-0.043	-0.100*	-0.028	-0.011	0.028	0.046	0.049	0.035
FAC1			-0.729***	0.667***	-0.029	-0.016	0.009	0.002	0.061	-0.010	-0.007	0.108*	0.009	-0.010	-0.103*	0.066	-0.034	0.133*	-0.034
FAC1²				-0.967***	-0.017	-0.029	0.013	0.012	-0.026	-0.002	-0.011	-0.095	-0.020	-0.042	0.086	-0.055	-0.045	-0.041	-0.024
FAC1³					0.031	0.021	-0.003	-0.032	0.034	-0.010	-0.010	0.082	0.000	0.018	-0.049	0.013	0.035	0.048	0.002
FAC2						-0.145**	0.729***	-0.011	-0.045	0.018	-0.021	-0.045	0.007	-0.022	-0.145**	0.063	0.009	-0.024	0.044
FAC2²							-0.286***	-0.025	-0.055	0.030	-0.011	-0.028	0.025	-0.199***	0.318***	-0.304***	-0.038	0.025	-0.026
FAC2³								-0.006	-0.017	0.000	-0.082	-0.044	-0.037	0.058	-0.183***	0.190***	-0.002	-0.053	0.004
FAC3									-0.272***	0.696***	-0.072	0.069	-0.064	0.018	-0.110*	0.045	0.004	-0.038	0.012
FAC3²										-0.677***	0.001	0.033	-0.008	-0.034	0.068	0.026	0.043	0.149**	0.127*
FAC3³											-0.055	0.066	-0.039	-0.041	-0.114*	-0.047	-0.024	-0.137*	-0.073
FAC4												0.009	0.850***	0.008	-0.064	0.016	0.028	-0.041	-0.009
FAC4²													0.062	-0.082	-0.023	-0.051	0.106*	0.008	0.042
FAC4³														0.005	-0.035	-0.009	0.030	-0.040	0.002
FAC5															-0.050	0.750***	-0.043	0.012	-0.020
FAC5²																-0.288***	0.035	0.119*	-0.025
FAC5³																	-0.086	0.014	-0.042
FAC6																		0.057	0.783***
FAC6²																			0.235***

*Notes: N = 285. * 5% significant, ** 1% significant, ***0.1% significant*

Table 4: Correlation matrix for Dark Triad, 2017-2018 (source: own calculation)

Full research paper

HOW MUCH TO INVEST AND WHAT DEGREE TO GET?: EDUCATION AS A STRATEGY ON THE LABOUR MARKET SCALE

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ABSTRACT

When workers hear about a possible promotion, it is common for them to get training, and they can do so through education. However, there is the possibility that the worker needs to receive a salary according to the knowledge acquired in such training. In this study, considering a population of employed workers with incomplete secondary school, we apply game theory concepts to explore whether workers can train through study. If so, the model shows the percentage of the salary the worker is willing to invest in his education. Furthermore, the cost of studying implicitly involves an opportunity cost, deduced quantitatively in the model. In conclusion, our article defines specific thresholds to decide if the worker should study, the economic investment, and the time he would spend on it, depending on how strict the company is in auditing. The analysis does not define a Nash equilibrium since the company's reaction is not considered.

KEYWORDS

Asymmetric information, education, game theory, labour market, wages

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Highlights

- *The percentage of income the workers assign to finish their studies can exceed 50% as long as the company's audit is low.*
- *Workers can spend up to 75% of their income on education only if they achieve a master's degree and the company's audit is low.*
- *If the audit is intense, the worker will not exceed more than 30% of his income to continue his education.*
- *Workers are committed and responsible in their training when faced with companies that do not audit and distinguish significant wage increases.*
- *The opportunity cost of studying for a worker decreases as companies are more intense in auditing and distinguishing through wages.*

INTRODUCTION

Job training takes time, money, and effort. Fortunately, most of the time, such training brings rewardsin the short or medium term, either through a promotion or a wage increase. Such worker training is necessary for the company since companies' success relies on their workers' performance, mainly linked to their education and training (Flegl, Depoo, and Alcázar, 2022). Offering a promotion as a reward, a company could make two possible mistakes: ignore the talent acquired during the training and not value other skills based on cognitive abilities, such as experience and innate abilities (Armour, Button, and Hollands, 2018).

Concerning the first error, the fact that the company needs to consider the talent acquired in training could motivate a brain drain since there are always markets looking for new talent and qualified resources. In this sense, Fan and Yakita (2011) comment that skilled labour will emigrate if the foreign wage rate is higher than the local rate and if local companies do not recognize and value their workers. In this sense, Fischer and Lipovská (2015) comment on the brain drain specifically of Slovak students at an early age and with a high educational level in the Czech Republic. Noting that Slovak students not only finish their studies at Czech universities but also enter the Czech labour market.

Training involves a cost, usually covered by the company, which can be based on the salary paid to the worker. For example, Mehra et al. (2014) comment that training paid for by companies is desirable because it improves human capital and companies' income. In addition, they recommend that the investment in training be accompanied by a salary

increase, which would imply a more significant commitment from the workers and better productivity.

Although investing in staff training is essential for the company's success, there are always obstacles. Blatter et al. (2016) comment on the inverse relationship between hiring qualified workers and the costs of training personnel. Based on an analysis of Swiss companies, they comment that since hiring costs are constantly increasing, investing more in worker training is advisable. Now, if the training is through education, it also involves costs that are not monetarily observed. These expenses are called opportunity costs, which generally represent the public benefits lost when the worker is unemployed (Chodorow-Reich and Karabarbounis, 2016).

This study proposes training workers through education, whose costs are covered by themselves. Although our model does not consider a distribution of benefits for the talent acquired and applied in productivity, the model assumes the company will bring an incentive to the trained workers. However, the fact that the stimulus is not necessarily achieved generates uncertainty for the worker if the company recognizes this training or not.

We involve game theory concepts and subjective beliefs to model this scenario with uncertainty. In addition, the action of auditing or not of the company is considered as a sign that will distinguish between those who take the training and those who do not. Methodologically, this signal transforms subjective beliefs into objective ones. In general, the analysis shows the percentage of the salary the worker may invest to achieve a better level of education.

The paper has the following structure: the first section shows the literature review of the relationship between the labour market, education, and training. The second section analyses the game theory methodology, particularly concepts of best response and asymmetric information. The third part consists of the development of the model, and the fourth section corresponds to the applications of the model. The fifth section corresponds to the discussion of the results. Finally, we present the conclusion, limitations, and future work.

LITERATURE REVIEW

According to Borghans, Ter Weel, and Weinberg (2014), the skills learned by workers during training are crucial in occupational choice and wages; even more, those skills have helped to reduce the wage gap between men and women. Job training is recommendable to increase a worker's productivity, but due to internal or external crises, sometimes it is impossible to cover their costs. In a panel data analysis of 16,000 German firms, Bellmann, Gerner, and Leber (2014) studied the economic crisis's effect on workers' continuous upskilling. They found that the firms that were more affected by the crisis trained their personnel to a lesser extent and that the less affected firms focused their training on more experienced personnel rather than on their new employees.

Our study proposes training through education for employed workers; to achieve promotion and a possible increase in their income. Although sometimes, the training can have non-remunerated purposes, as Mendoza-Cota and Cabrera-Pereyra (2014) mentioned. Based on a panel data analysis applied to the labour market on the northern border of Mexico, the authors commented that the percentage of the population with secondary education increased by 5% because workers considered education as empowerment, regardless of the work incentive they could achieve.

One aspect that our model considers is the cost of training, which the company usually covers. In this sense, McCausland and Theodossiou (2004) state that the relationship between wage increases and unemployment is altered since the cost of training modifies the labour demand, and due to the incentives generated by the training and education of workers, the labour supply also changes. Meanwhile, using a programming model, Azizi and Liang (2013) recommend the rotation of workers' tasks to determine what type of training they require and, therefore, minimize the training costs and productivity loss.

On the other hand, it is recommended for the company to remunerate according to the talent acquired in training. Otherwise, in addition to causing brain drain, it could lead to higher unemployment. For example, Liu-Farrer (2009) comments on the migration of Chinese students to Japan, where the receiving country absorbs the graduates and delivers qualified labour to the Japanese labour market. It should be noted that the leave of workers is due to low benefits and contributions, such as insurance, bonuses, etc., and not just the low wages (Frazis and Loewenstein, 2013).

There are diverse ways of training. Yet, training through education always represents an extra benefit to the worker. In this sense, Naroş and Simionescu (2019) mention the experience of Romanian entrepreneurs recognized for having secondary and tertiary education. They emphasize that training through education is important to make the labour market more dynamic. This training through education always involves an *additional cost for the worker*, which is not perceived monetarily and is called *opportunity cost*. There are other ways to interpret the opportunity costs. Chodorow-Reich and Karabarbounis (2016), through a time series analysis of national accounts, modelled a job opportunity cost involving variables such as taxes, eligibility, benefits, and time, among others.

Our study assumes that the worker covers the training costs. This situation is acceptable, as long as the training is in line with the needs of the participants. For example, Pena-Shaff et al. (2020) comment on training based on a financial education program for low-income communities in Ithaca, New York, emphasizing that the educational program was successful, particularly in the confidence and financial planning of the communities. On the other hand, the fact that the worker covers the training costs reduces potential biases in the selection process, which could happen if the company covers the costs. In this regard, Cutuli and Guetto (2013), based on an econometric model applied to the European Social Survey, comment that the selection bias in training workers is due to the type of contracts, particularly fixed-term contracts.

The selective choice of workers could result from an asymmetry of information and subjectivity on the company's part. Armour, Button, and Hollands (2018) comment that hiring economically active personnel with disabilities is only 34%, compared to 74.2% of those without disabilities. Under this selective choice, companies could lose several benefits. Instead, a non-subjective selection would imply a more outstanding labour commitment of the workers and an advantage in their training. In addition, it could avoid possible shortsightedness of the company in assigning better salaries.

Companies generally have asymmetric information about their workers, but the opposite can happen. The workers need to recognize how the company will act. This scenario could explain why some people want to avoid accessing the labour market or education. For example, Loprest, Spaulding, and Nightingale (2019) comment that many young people need to be more connected to work and school. Therefore, these authors analyse policies for the inclusion of this population in the labour market based on training and education programs. In the same sense, Ruesga, da Silva-Bichara, and Monsueto (2014) mention that promotions are not egalitarian, and sometimes the firm does not observe workers' talent, education, and discipline, or it is indifferent to those qualities. In particular, it is possible that the company only attends if the worker has an advantage resulting from some training.

To reduce the asymmetry of information workers face, our model involves signals to know the firms with which they are dealing. These signals can mitigate any event involving wage inequality and economic stagnation. Naidu, Posner, and Weyl (2018) consider signals as policies and analytical methods to avoid the market power of firms and some mergers between them, which could cause imbalances in the labour market. Other indications to establish equilibrium in the labour market can be considered. For example, Popov and Bernhardt (2012) comment that companies consider the fraternity membership of students and fraternity admission options as signals to hiring students. This fraternity is regarded as having a high socialization value, but students must gain it to appear strong and not be hired.

Our analysis is based on Spence (1973). He considers that the agent with asymmetric information is firm since he does not know the quality of the potential worker to be hired, so it incorporates education as a signal. Hopkins (2012) shows a model of matching among workers who have confidential information regarding their capacity and develops another type of application of Spence. Such ability is used as a signal for the most qualified workers to be chosen by the best firms. Along the same path, Coles, Kushnir, and Niederle (2013) model a situation where workers send signals that interest employers, making job search and occupation matches easier. Finally, Andrade and Lomelí (2022) apply Spence to evaluate the efficiency and responsibility in education in the worker's training.

A similar analysis, where the company has confidential information, is shown in Andrade (2021). The author proposes a game to model the optimal decision of government support to help Mexican companies face the COVID-19 pandemic effects. Andrade concludes that the need for more information about the companies makes it impossible for the Government to provide efficient support.

MATERIALS AND METHODS

Game theory concepts

The decisions made by the company and the worker are strategies that can be analysed through game theory. Thus, we have the following definition,

Definition 1 (Nicholson and Snyder 2008). – A game is a strategic interaction between two economic agents, called players, represented as follows:

$$\Gamma = \left\{2, A_1, A_2, U_k(a_i, a_j)\right\},$$

Where A_1 and A_2 denote the strategy sets of players 1 and 2, respectively; $a_i \in A_1$ (with $I = 1, 2,\ldots, m$) denotes the possible strategy of player 1; $a_j \in A_2$ (with $j = 1, 2,\ldots, n$)[1] denotes the possible strategy for player 2 and $U_k(a_i, a_j)$ denotes the payoff function of player $k = 1, 2$.

To analyse if the performance of a player is the best according to the actions of his counterpart, it is necessary to define the following concept:

Definition 2 (Mas-Colell, Whinston, and Green, 1995). – Let $\Gamma = \left\{2, A_1, A_2, U_k(a_i, a_j)\right\}$ denote the simultaneous game, a strategy *ai* is the best response of player 1 to any strategy a_j of player 2, denoted as $a_i = BR_1(a_j)$, if[2]

$$U_1(a_i, a_j) \geq U_1(a_i', a_j), \ \forall \ a_i' \in A_1 \qquad (1)$$

One of the classic representations of a game, in particular for two players, is shown in Table 1, called a normal-form game. The rows determine the strategies of player 1 (i.e., *a* and *b*), and the columns represent the strategies of player 2 (i.e., *c* and *d*). The values within the matrix are the payoffs according to the strategies. For example, $U_1(a, c) = 3$ is the payoff for player 1 when he chooses strategy *a* and player 2 chooses strategy *c*.

Now suppose that in the game shown in Table 1, player 1 values his utility in two different ways under the strategy profile (*a*, *c*), that is,

$$U_1(a,c) = t, \text{ where } t = \begin{cases} 3 \ \textit{if Player } 1 \textit{ is type } 1 \\ 0, \ \textit{if Player } 1 \textit{ is type } 2 \end{cases}$$

That is, if player 1 values with $t = 3$, it is called type 1, and when it values with $t = 0$, it is called type 2. Both players know

		Player 2	
		c	*d*
Player 1	*a*	3, 2	-1, -1
	b	1, 1	2, 3

Table 1: Representation of a normal-form game for two players (source: own elaboration)

1 Players can have several strategies. In this case, m and n represent the number of strategies of player 1 and player 2, respectively, and can be equal.
2 Similarly, we can define the best response for player 2.

the values of t[3]; the difference in a game with complete information is that player 2 is still determining if Player 1 will act as type 1 or type 2. Hence, there needs to be more information or asymmetric from P2 towards the types of Player 1.

Player 2 can assign subjective beliefs, to reduce uncertainty about what type of player 1 he faces. These beliefs are based on statistics, reports, or experience and represent probabilities of behaviours (types) of player 1, i.e.,

$$P(P1 \text{ is type } 1) = p \text{ and } P(P1 \text{ is type } 2) = 1 - p, \qquad (2)$$

The above analysis is a game theory problem with asymmetric (incomplete) information, defined as follows,

Definition 3 (Riascos, 2016).- A game with incomplete information (asymmetric) is a strategic game under uncertainty, represented by,

$$\Gamma = \left\{2,\ A_1, A_2, T_k, P_2\left(t_{1h}\right), U_k\left(a_i, a_j, t_{1h}\right)\right\}$$

Where T_k denotes the set of types of each player $k = 1, 2$. P2(t_{1h}) is the belief assigned by player 2 to the person type $t_{1h} \in T_1$, which he does not know.[4] Finally, $U_k(a_i, a_j, t_{1h})$ is the payoff of player k for each of his types t_{kh}, for $h = 1, 2, \ldots, N$.

The beliefs or probabilities shown in (2) are subjective and assigned by the player with asymmetric information, in our case, P2. To make these beliefs more "reliable," player 1 sends signals to P2 so that the latter includes them, thereby updating them. To turn subjective beliefs into objective ones, we apply Bayes' theorem. In reality, these objective beliefs are conditional probabilities, where the condition is the signal, i.e.,

$$P(T1 \mid signal) = q \text{ and } P(T2 \mid signal) = 1 - q \qquad (3)$$

The game in definition 3, with the new probabilities shown in (3), is called the Bayesian game, and the equilibrium is called the Bayesian Nash equilibrium (Osborne, 2004).

THE MODEL

Population and training of workers

Training workers is a key element when the company decides to give a promotion and/or a salary increase. More specifically, the worker's training will be considered the investment the worker makes in his education. The objective of such investment is for the worker to complete his secondary education up to a possible postgraduate degree. Thus, the population under study involves company workers with incomplete secondary education. This vision of training through education involves years and costs that will be key in analysing this work.

The Story

The story of this analysis is as follows: the employed worker is willing and able to train through education, with the primary goal of obtaining a promotion and, thus, a salary increase. However, the worker needs to know if the company will consider this training sufficient for the promotion. Sometimes, companies need to think if the worker has more studies or better training than others. In this sense, Rodríguez (2004) comments that the fact that people are more or less trained does not guarantee to get a promotion to a new position or a better salary. That is, the assignment of jobs generally does not commensurate with the worker's skills.

Thus, the worker observes two types of firms: those indifferent toward the worker's training and those who appreciate it and make a distinction. This is,

Type 1) Firm is indifferent to training (*Ind*),

Type 2) Firm distinguishes the trained worker (*Dist*)[5]

The worker knows about these two types of firms, but they are not aware of which type of company he is facing, particularly whether it values his studies. Therefore, the worker faces a problem of asymmetric information, which we shall now analyse. In principle, the worker's strategies are[6],

1. Study (S)
2. Do not study (NS)

The objective is to analyse the worker's best response to face companies that value or not the additional years of study, from finishing their secondary education onwards. Such an optimal strategy will provide a threshold that defines whether investing in education is feasible. To do this, we need to represent the worker's benefits based on requirements and contracts between the worker and the two types of existing companies.

Beliefs and signals

Thus, let $P(Ind)$ and $P(Dist)$ the subjective beliefs the worker assigns when facing the two types of companies. Where $P(Ind) + P(Dist) = 1$, because the kinds of firms are disjoint events.

The uncertainty the worker faces, derived from the lack of information regarding the companies he meets, is incorporated in the expected payoff of the worker, $EU_{w.}$ Then, when the worker decides to study, we have that,

$$EU_W(S) = P(Ind)U_W(S, Ind) + P(Dist)U_W(S, Dist) \qquad (4)$$

Now, when he decides not to study, we have,

$$EU_W(NS) = P(Ind)U_W(NS, Ind) + P(Dist)U_W(NS, Dist) \qquad (5)$$

Where $U_w()$ is the worker's benefit function.

We must emphasize that subjective beliefs can lead to drastic errors, especially regarding investments. For example, if the worker invests his entire money in education, assuming that the firm will make distinctions based on quality and then fails to do so, the worker will be financially affected.

Another perception error would be that the worker did not want to continue his studies, hoping the company would be indifferent to his training. Still, in the end, it values and distinguishes trained workers.

Naturally, companies like to retain the best workers, either for their knowledge or their studies, because it is an advantage over their competitors in terms of quality and sales. However, there is uncertainty among workers about the decision to study since they still need to thoroughly identify whether the company will value such training in remuneration. Workers need companies to send signals about their kind to reduce this uncertainty about the type of companies they face.

In this work, we consider the action of auditing by the company to its workers as the signal. Figure 1 shows the extensive form of the model. At first, the firm knows whether it is type 1 (Ind) or type 2 (Dist). Then, the worker decides whether to study (*S*) or not to study (*NS*), but not before knowing that the firm audits (*A*) or does not audit (*NA*). Finally, at the end of the branches, the payments for the firm and the worker are shown, which are explained later.

The objective changes, that is, we are interested in knowing what happens with the worker's decision, knowing that the company audits (*A*) or does not audit (*NA*). Note, then, that the expected payoffs (4) and (5) change when the firm's signal is included, if the company audits,

$$EU_W(S) = P(Ind|A)U_W(S, Ind) + P(Dist|A)U_W(S, Dist) \qquad (6)$$

and also,

$$EU_W(NS) = P(Ind|A)U_W(NS, Ind) + P(Dist|A)U_W(NS, Dist) \qquad (7)$$

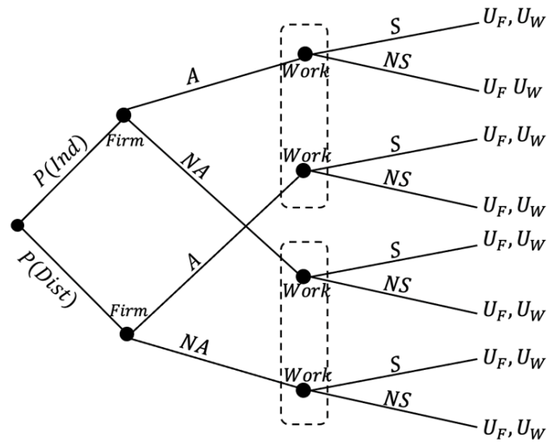

Figure 1: Asymmetric information game for the training of the worker, considering the audit of the company as a signal (source: own elaboration)

And in case the workers have information that the company does not audit (*NA*), we have the following:

$$EU_W(S) = P(Ind|NA)U_W(S, Ind) + P(Dist|NA)U_W(S, Dist) \qquad (6a)$$

$$EU_W(NS) = P(Ind|NA)U_W(NS, Ind) + P(Dist|NA)U_W(NS, Dist) \qquad (7b)$$

Construction of benefits

The payments will be based on the following criteria,

1. If the company is indifferent (Ind) about whether someone is training (studying), the payment is w,
2. When the company makes a distinction (Dist) between those who study and those who do not, it classifies the workers as low quality (They do not study) or high quality (They study).

Low-quality workers' wages are f_t, and high-quality workers receive an additional incentive on w of ε_t. Where $f_t < w < w + \varepsilon_t$, and the subindex t denotes the years studied.

3. Training through the study costs C and is covered by the worker.

Consequently, the benefit of a worker who studies and faces a company that is indifferent to this characteristic will be

$$U_W(S, Ind) = w - C, \qquad (8)$$

But when the worker deals with a company that distinguishes between skilled and unskilled workers, then,

$$U_W(S, \text{Dis}) = w + \varepsilon_t - C, \qquad (9)$$

Now, if the worker does not study, his payment when the company is indifferent is,

$$U_W(NS, \text{Ind}) = \text{w}$$

and

$$U_W(NS, Dist) = f_t,$$

when the firm makes a distinction.

Results

Considering the uncertainty of the worker due to the type of companies they may face. We will deduce a threshold to decide if studying (training) is a better option for the worker than not doing so. This is

$$EU_W(S) > EU_W(NS)$$

In principle, we will deduce the threshold knowing that the company audits (*A*); that is, replacing the expressions (6) and (7), we have

$$P(Ind|A)U_W(S, Ind) + P(Dist|A)U_W(S, Dist) >$$

$$P(Ind|A)U_W(NS, Ind) + P(Dist|A)U_W(NS, Dist)$$

of the payments of the worker when studying and not studying, and facing the diverse types of firms, we have

3 Although the analysis in this paper is through incomplete information games, the fact that all the elements are of common knowledge makes the asymmetric information problem manageable through an incomplete information problem (Riascos, 2016; Harsanyi, 1967). In this sense, the concepts are similar.

4 The value t_{1h} indicates the different types or behaviors of player 1, that is, $t_{11}, t_{12}, t_{13}, \ldots, t_{1N}$.

5 We must remember that training is equivalent to studying for 2, 3, 4, etc. years.

6 Although the company's strategies are not necessary in this scenario to formalize the game concept, the strategies could be promoted or not promoted.

$$P(Ind|A)(w-C)+P(Dist|A)(w+\varepsilon_t-C)>P(Ind|A)w+P(Dist|A)f_t \quad (10)$$

Given that $P(Ind|A)+P(Dist|A)=1$, then (10) results in

$$w-C+P(Dist|A)\varepsilon_t>P(Ind|A)w+P(Dist|A)f_t \quad (11)$$

If we group similar terms in (11), we have

$$w(1-P(Ind|A))+P(Dist|A)(\varepsilon_t-f_t)>C$$

And since, $P(Dist|A)=1-P(Ind|A)$,

$$P(Dist|A)(w+\varepsilon_t-f_t)>C$$

The above analysis leads to the following result:

Result 1. Assuming that the company audits, then the best strategy for the employee is to study if and only if,

$$P(Dist|A)>\frac{C}{w-f_t+\varepsilon_t} \quad (12)$$

A similar analysis, knowing that the company does not audit (*NA*) (second branch of Figure 1), gives us,

$$P(Dist|NA)>\frac{C}{w-f_t+\varepsilon_t} \quad (12a)$$

APPLICATIONS

Based on (12 or 12a), we derive specific values for the incentive ε_t and the payment that is received for not studying, f_t.

Thus, we can represent it as:

$\varepsilon_t=\theta w$, with, $0<\theta<1$ the additional share for studying.

To obtain a numerical value for ε_t, we consider the OECD report (2019), which states that young workers with higher education could earn up to 78% more than their peers with high school education. Therefore, and according to IIPE-UNESCO (2019), which states that on average, higher education begins after middle school and consists of three years of high school, four years of bachelor's degrees, two years of master's degrees, and three more years for doctoral degrees. That is, after middle school, which is the grade of our target population, it is necessary to invest nine years in education to obtain a master's degree (see Table 2).

Educational attainment	Years of study	Education incentive
	2	0.3279
High school graduate	3	0.4755
	4	0.5726
	5	0.6402
	6	0.6896
Bachelor's degree	7	0.7272
	8	0.7567
Master's degree	9	0.7805
	10	0.8001
	11	0.8165
Doctorate degree	12	0.8304

Table 2: Incentives for education after middle school [source: own elaboration based on information reported by OECD (2019) and IIPE-UNESCO (2019)]

Hence, Table 2 highlights the value of 78%, the additional income perceived by an individual with a master's degree (OECD, 2019). Based on the nine years required, from middle school, to obtain a master's degree, we can express the value of 78% as follows,

$$\varepsilon_t=e^{-2.23/9}w=0.78w \quad (13)$$

In general, the value of ε_t can be represented as,

$$\varepsilon_t=e^{-2.23/t}w \quad (13a)$$

Where t denotes the years of study, hence the values in column 3 in table 2.

To find the value of f_t, which refers to the payment when the company makes a distinction, and the workers did not study beyond secondary education, we rely on the reports by PRESTY (2019), which defines wages beyond middle school degrees (column 3, table 3).

Based on these salaries (column 3), the calculations in column 4 of Table 3 were made as follows:

Educational attainment	Years beyond high school education	Profit according to the study	Profit loss percentage	Approximate value
Just middle school		2191		
High school graduate	3	7200	0.6957	0.6271
	4			0.7047
	5			0.7558
	6			0.7919
Bachelor's degree	7	12200	0.8204	0.8187
	8			0.8395
Master's degree	9	14800	0.8520	0.8559
	10			0.8694
	11			0.8805
Doctorate degree	12			0.8899

Table 3: Profit loss percentages after middle school [source: own elaboration based on information reported by PRESTY (2019)]

$$\text{Percentages}=\frac{w_f-w_i}{w_f}$$

where w_f is the final study payment (high school, bachelor, or master) and w_i is the initial wage (middle school). The value of f_t can be expressed as,

$$f_t=e^{-1.4/t}w \quad (14)$$

Expression (14) was derived similarly to (13), that is, an exponential expression with an estimated exponent that will return a value close to 85% (row highlighted in grey). Such value corresponds to the percentage of income an employee with secondary education would not receive if he does not attain a master's degree.

Substituting the expressions (13a) for the incentives ε_t and (14) for the loss for not studying f_t, in (12), we have,

$$1>P(Dist|A)>\frac{C}{w-f_t+\varepsilon_t}=\frac{C}{w-e^{-1.4/t}w+e^{-2.23/t}w}=\frac{C}{w\left(1-e^{-\frac{1.4}{t}}+e^{-\frac{2.23}{t}}\right)} \quad (15)$$

Factoring the value of the wage w and since $P(Dist|A)<1$, we have,

$$\frac{C}{w}<1-e^{-\frac{1.4}{t}}+e^{-2.23/t} \quad (16)$$

which leads to the following result.

Result 2. Suppose that the worker knows that the company audits (or does not audit)[7], then studying is the worker's best strategy if and only if the percentage of income that he invests in studying is bounded by (16).

Since the threshold defined in (16) depends on the years of study the worker wants to achieve. We can construct the percentages that workers would spend on their salary (table 4) to accomplish these studies. In particular, it is observed in Table 4 that if a worker who currently has a high school degree wants to study and finish a degree, they would have to invest 90% of their income. Alternatively, if they intend to reach the master level, they must invest 92% of their income.

Although Table 4 shows a strategic scenario of how much to invest in wages, the threshold is constructed based on something other than the value of the subjective belief: $P(Dist|A)$. The reports in Table 4 only consider cases where the belief $P(Dist|A)$ in (16) is less than 1. Even the result loses meaning because it also applies when the company does not audit.

Educational attainment	Years of study	C/W: Percentage of income invested in education
	2	0.8313
High school graduate	3	0.8484
	4	0.8680
	5	0.8844
	6	0.8977
Bachelor's degree	7	0.9085
	8	0.9173
Master's degree	9	0.9246
	10	0.9308
	11	0.9360
Doctorate degree	12	0.9405

Table 4: Percentages of investment in education [source: own elaboration based on expression (16)]

To include the subjective belief in the application of (12), we rely on the reports of INEGI (2018), which supports that approximately 33.5% of SMEs monitor with key performance indicators, while 66.5% do not monitor. Therefore, $P(A)=0.335$ and $P(NA)=0.665$.

Now, Forbes (2022) comments that by 2023, 16.2% of the companies in Mexico could give an increase of 3 and 4%, while 41.7% could raise it between 5 and 6%. And considering that by law, every year, there is a 5% increase in workers' salary (INEGI, 2018), regardless of their performance, the previous reports do not imply any audit.

Thus, the percentage of companies that distinguish their workers with an increase of 3 to 4% and do not audit is $P(Dist\cap NA)=0.162$. While the percentage of companies that distinguish their workers with an increase between 5 and 6%, and do not audit, is: $P(Dist\cap NA)=0.417$. We will call case 1 companies that are not flexible in wages and case 2 companies that are flexible in wages.

Also, Forbes reports that 27.3% of employers will give a salary increase between 7 and 8%, and only 13.1% of companies will give their workers a raise of 9% or more. And considering that increases after 5% will require audits and performance indicators (INEGI, 2018). Then, the percentage of companies that distinguish their workers with an increase between 7% and 8% and audit is $P(Dist\cap A)=0.273$. In contrast, the percentage of companies that distinguish their workers with an increase

7 Since the threshold was obtained from $P(Dist|A)<1$, result 2 also applies when we know that the company does not audit since $P(Dist|NA)<1$. To or not to audit will become relevant when objective beliefs are built.

of 9% or more and audit is $P(Dist \cap A) = 0.131$. We identify the first case as a low audit and the second as an intense audit, considering that the increase is more significant.

Based on the above, we build the objective beliefs, $P(Dist|A)$ and $P(Dist|NA)$. The calculations are shown in Table 5.

Probability of auditing: $P(A)$=0.335	Probability of auditing and making a wage distinction: $P(Dist \cap A)$	Objective belief: $P(Dist\|A) = \frac{P(Dist \cap A)}{P(A)}$
0.335	Percentage of companies that assign increases between 7 and 8% and audit = 0.273	0.814
0.335	Percentage of companies that assign increases of more than 9% and audit = 0.131	0.391
Probability of not auditing: $P(NA)$=0.665	Probability of not auditing and making a wage distinction: $P(Dist \cap NA)$	Objective belief: $P(Dist\|A) = \frac{P(Dist \cap A)}{P(A)}$
0.665	Percentage of companies that assign an increase between 3 and 4 % without auditing = 0.162	0.243
0.665	Percentage of companies that assign an increase between 5 and 6 % without auditing = 0.418	0.628

Table 5: Modelling of the objective belief according to the expression (12) [source: own elaboration based on Forbes (2022) and INEGI (2018)]

Considering the values of the objective beliefs in Table 5, we can find thresholds for the percentage of income allocated to education and the number of schooling years that can be achieved more realistically.

In principle, column 3 of Table 6 shows the same values as Table 4, the additional observation in Table 6 is the application of subjective beliefs and the opportunity cost, which we explain later. By applying the subjective beliefs, we will obtain more specific thresholds for the percentage of income invested in education, applying the expression:

$$\frac{C}{w} < \left(1 - e^{-\frac{1.4}{t}} + e^{-\frac{2.23}{t}}\right) P(Dist|A) \qquad (17)$$

So, from the right-hand side of the inequality (17), table 6 shows more specific thresholds for how much to invest in education when the audit is low (column 4), and the percentage of income allocated to education when the audit is intense (column 6).

The exciting thing about Table 6 is that if the worker considers the auditing of the company (column 4 and column 6), he invests less than if he only considered that. The probability is less than one (column 3 in Table 6 and column 3 in Table 4). Thus, by considering how the firm acts, the worker is less risky at investing; and less risky when the audit is intense (column 6). The cost of studying in column 3 of Table 6 is a cost that does not consider what the company does. For example, the cost of obtaining a high school or bachelor's or master's degree is 84%, 90%, and 92%, respectively, which is relatively high. But, considering the company audits, the costs decrease (column 4 and column 6). Thus, we can deduct an opportunity cost (column 5 and column 7), defined as the difference between the cost of not considering what the company does and the cost of considering what the company does.

For example, if the firm's audit is low, the opportunity cost of having a bachelor's degree will be 16.9% of their income. In comparison, the opportunity cost of obtaining a master's degree will be 17.2%. But, if companies are harder to make a distinction when they audit, the percentage decreases to 35.5% and 36.1%, respectively. Therefore, the opportunity cost of the workers ranges from 55% to 56% (column 7, table 6, upper box).

In the same table, but in the lower part, we observe the cases when the company does not audit and its plan to distinguish through salaries, little flexible and very flexible (columns 4 and 6). It is noteworthy the low percentage that the worker allocates to education when the company is inflexible in granting significant salary increases and causing a remarkably high opportunity cost for education.

But the most notable in Table 6 are columns 5 and 7 at the bottom. If the company is flexible in granting significant salaries, the worker reacts by investing more in education, and therefore his opportunity cost is meagre (column 7). This aspect shows the commitment and loyalty of the worker for not feeling pressured (free of audit) and with a relatively significant increase in salary (about 6%).

Continuing the analysis, the worker will only study if expression (17) holds. Thus, if the percentage of income the worker spends on education is known, we can determine if it is convenient to study according to the objective beliefs the worker considers about the firm, which are reported in Table 7.

When the signal is: to audit

Educational attainment	Years of study	$1 - e^{-\frac{1.4}{t}} + e^{-\frac{2.23}{t}}$	$P(Dist\|A)$ =0.814 Low audit	Opportunity cost	$P(Dist\|A)$ =0.391 Intense audit	Opportunity cost
	2	0.8313	0.6767	0.1546	0.3251	0.5063
High school graduate	3	0.8484	0.6906	0.1578	0.3317	0.5167
	4	0.868	0.7065	0.1614	0.3394	0.5286
	5	0.8844	0.7199	0.1645	0.3458	0.5386
	6	0.8977	0.7307	0.167	0.351	0.5467
Bachelor's degree	7	0.9085	0.7395	0.169	0.3552	0.5532
	8	0.9173	0.7467	0.1706	0.3587	0.5586
Master's degree	9	0.9246	0.7526	0.172	0.3615	0.5631
	10	0.9308	0.7576	0.1731	0.3639	0.5668
	11	0.936	0.7619	0.1741	0.366	0.57
Doctorate degree	12	0.9405	0.7656	0.1749	0.3677	0.5728

When the signal is: do not audit

Educational attainment	Years of study	$1 - e^{-\frac{1.4}{t}} + e^{-\frac{2.23}{t}}$	$P(Dist\|A)$=0.243 Little flexible	Opportunity cost	$P(Dist\|NA)$ =0.628 Very flexible	Opportunity cost
	2	0.8313	0.202	0.6293	0.5221	0.3093
High school graduate	3	0.8484	0.2062	0.6423	0.5328	0.3156
	4	0.868	0.2109	0.657	0.5451	0.3229
	5	0.8844	0.2149	0.6695	0.5554	0.329
Bachelor's degree	6	0.8977	0.2181	0.6796	0.5638	0.3339
	7	0.9085	0.2208	0.6877	0.5705	0.3379
	8	0.9173	0.2229	0.6944	0.576	0.3412
Master's degree	9	0.9246	0.2247	0.6999	0.5806	0.3439
	10	0.9308	0.2262	0.7046	0.5845	0.3462
	11	0.936	0.2274	0.7086	0.5878	0.3482
Doctorate degree	12	0.9405	0.2285	0.712	0.5907	0.3499

Table 6: Thresholds regarding the percentage of income allocated to education and opportunity costs (source: own elaboration based on values shown in Table 5)

If C=0.5w and the signal is that the company audits

Years of study	$1 - e^{-\frac{1.4}{t}} + e^{-\frac{2.23}{t}}$	With low audit	Decision	With Moderate audit	Decision	Under intense audit	Decision
2	0.8313	0.6766782	Study	0.5004426	Do not study	0.3250383	Do not study
3	0.8484	0.6905976	Study	0.5107368	Study	0.3317244	Do not study
4	0.868	0.706552	Study	0.522536	Study	0.339388	Do not study
5	0.8844	0.7199016	Study	0.5324088	Study	0.3458004	Do not study
6	0.8977	0.7307278	Study	0.5404154	Study	0.3510007	Do not study
7	0.9085	0.739519	Study	0.546917	Study	0.3552235	Do not study
8	0.9173	0.7466822	Study	0.5522146	Study	0.3586643	Do not study
9	0.9246	0.7526244	Study	0.5566092	Study	0.3615186	Do not study
10	0.9308	0.7576712	Study	0.5603416	Study	0.3639428	Do not study
11	0.936	0.761904	Study	0.563472	Study	0.365976	Do not study
12	0.9405	0.765567	Study	0.566181	Study	0.3677355	Do not study

If C=0.75w and the signal is that the company audits

Years of study	$1-e^{-\frac{1.4}{t}}+e^{-\frac{2.23}{t}}$	With low audit	Decision	With Moderate audit	Decision	Under intense audit	Decision
2	0.831	0.6766782	do not Study	0.5004426	do not study	0.3250383	do not study
3	0.848	0.6905976	do not Study	0.5107368	do not study	0.3317244	do not study
4	0.868	0.706552	do not Study	0.522536	do not study	0.339388	do not study
5	0.884	0.7199016	do not Study	0.5324088	do not study	0.3458004	do not study
6	0.8977	0.7307278	do not Study	0.5404154	do not study	0.3510007	do not study
7	0.9085	0.739519	do not Study	0.546917	do not study	0.3552235	do not study
8	0.9173	0.7466822	do not Study	0.5522146	do not study	0.3586643	do not study
9	0.9246	0.7526244	Study	0.5566092	do not study	0.3615186	do not study
10	0.9308	0.7576712	Study	0.5603416	do not study	0.3639428	do not study
11	0.936	0.761904	Study	0.563472	do not study	0.365976	do not study
12	0.9405	0.765567	Study	0.566181	do not study	0.3677355	do not study

If C=0.5w and the signal is that the company does not audits

Years of study	$1-e^{-\frac{1.4}{t}}+e^{-\frac{2.23}{t}}$	Little flexible	Decision	Moderately flexible	Decision	Very flexible	Decision
2	0.8313	0.2020059	do not study	0.3624468	do not study	0.5220564	Study
3	0.8484	0.2061612	do not study	0.3699024	do not study	0.5327952	Study
4	0.868	0.210924	do not study	0.378448	do not study	0.545104	Study
5	0.8844	0.2149092	do not study	0.3855984	do not study	0.5554032	Study
6	0.8977	0.2181411	do not study	0.3913972	do not study	0.5637556	Study
7	0.9085	0.2207655	do not study	0.396106	do not study	0.570538	Study
8	0.9173	0.2229039	do not study	0.3999428	do not study	0.5760644	Study
9	0.9246	0.2246778	do not study	0.4031256	do not study	0.5806488	Study
10	0.9308	0.2261844	do not study	0.4058288	do not study	0.5845424	Study
11	0.936	0.227448	do not study	0.408096	do not study	0.587808	Study
12	0.9405	0.2285415	do not study	0.410058	do not study	0.590634	Study

Table 7: Final decisions comparing the investment threshold to the beliefs about the firms [source: own elaboration based on the expression (17)]

For example, suppose that the worker spends half of his income on training, that is, $\frac{C}{w}=\frac{0.25w}{w}=0.5$, and he believes that he is facing a company that he audits, then the worker will study if and only if,

$$0.5<\left(1-e^{-\frac{1.4}{t}}+e^{-\frac{2.23}{t}}\right)*P(Dist \mid A), \qquad (17.1)$$

The calculations of (17.1) are shown in columns 3, 5, and 7 at the top of Table 7. In particular, it is observed that the worker will always want to study (column 3) if the company audit is low. On the other hand, when the company is intense in the audit (column 7), the worker will decide not to study. In conclusion, the worker will consider the company's pressure through the audit, which is crucial to opt for the training.

Under the same beliefs, but considering that the worker spends 75% of his income on education, then he will study if the following is true,

$$0.75<\left(1-e^{-\frac{1.4}{t}}+e^{-\frac{2.23}{t}}\right)*P(Dist \mid A) \qquad (17.2)$$

The calculations are shown in the middle box of Table 7. Note now that under this required percentage of income to study, the worker will study only if he gets beyond a master's degree, if the audit is low.

Finally, the lower part of Table 7 shows when the company does not audit, and the worker allocates 50% of his income to study. That is, the worker will study if and only if,

$$0.5<\left(1-e^{-\frac{1.4}{t}}+e^{-\frac{2.23}{t}}\right)*P(Dist \mid NA) \qquad (17.3)$$

In this case, the worker will always decide to study when the company is very flexible in the distinction of salaries due to the worker's achievements. This situation reiterates the worker's commitment to the trust and credibility that the company shows toward him.

DISCUSSION

Our initial proposal is that training of the workers should be through education, in the sense that the workers will take a position of greater responsibility. For example, Atibuni (2019) comments that the training of teachers in an educational system must be efficient and responsible because trained teachers would opt for positions of higher hierarchy. In the same sense, Adejare et al. (2020), through an analysis of structural equations applied to non-academic employees of Nigerian universities, conclude that training affects the managerial efficiency and quality of services of non-academic workers if external experts conduct the training.

Another assumption of our work is that the worker covers the cost of the training to avoid a bias on who takes the training or who does not, the bias that occurs when the company covers the cost (Cutuli and Guetto, 2013). In addition to what Folz and Shults (2018) point out, although professional training is essential for the management and organizational performance of the company, these programs are the first to disappear when the company goes bankrupt.

On the other hand, note in Table 4 that completing high school involves 84% of the worker's wage, a bachelor's degree 90%, and a master's degree 92%, which, could be very high. However, it is important to emphasize that in addition to the economic cost, we are considering the time required for this aim, known as opportunity cost. In this regard, Curtis, Moriarty, and Netten (2012) state that when adding up all the possible training costs, including the opportunity cost, this sum could be almost three times the visible monetary costs.

Another way of looking at opportunity costs is the cost of efficiency and responsibility that workers learn during their education, allowing them to enter the labour market early. In this sense, Zając, Jasiński, and Bożykowski (2018), analysing the educational system in Poland, comment that private school students tend to have better opportunities in the labour market because they are involved from their final stage of education. Showing a strategy, in terms of efficiency in education towards the labour market, that some schools have. In addition, the value of training through education is related to economic performance and institutional responsibility (Tomlinson, 2018).

In addition to the opportunity cost and considering that in our article, the workers themselves assume the training costs, it could be considered a tax credit paid in some countries. For example, Leuven and Oosterbeek (2004) state that Dutch companies can claim a tax refund when they train their workers over 40. Related to the above, our analysis involves an incentive that would be granted by the firm, linked to the audit of the company and the training. Leuven and Oosterbeek (2004) comment that if a tax rebate is obtained for the training firms provide, they can increase wages to encourage such training.

For the results, we build subjective beliefs because the company makes a distinction in wages, which generates uncertainty for workers. To reduce this uncertainty, we transform the beliefs into objectives, considering the audit (evaluation) of the company as a sign that the workers are trained and that they can improve productivity. Although many workers might be uncomfortable with such audits, these could have benefits at some point. For example, Chung et al. (2021), through an analysis between Korean companies and suppliers, commented that the audit of the companies helped the suppliers to improve their efficiency in human resources and that the companies did not impose sanctions. In addition, the audit implied that the contracts between both parties were not interrupted.

In the final decision of workers regarding education, our results show that the worker decides to train (study) by predicting a low audit by the company and that in addition to the incentive granted by the company (additional 7-8%) in the long term could suit the worker. In this sense, Juravich (2017) analyses what happened with the closure and restart of a furniture factory. When it was sold, the new owners valued the skills learned for years by the workers of the old factory and not only re-hired them but used them as trainers for new workers.

Our analysis shows the preparation of the worker in terms of more years of education. Also, we consider a signal that the firm audits so that the worker qualifies for better pay. Contrasting our analysis, Assaad, Krafft, and Salehi-Isfahani (2018) discuss the mismatches in the labour market and its relationship with the higher education system for the labour market in Egypt and Jordan. They emphasize that hiring decisions are not based solely on whether the worker studied in a public or private school; other issues, such as the family nucleus, are considered.

That is, the uncertainty about the possibility that the company does not value the worker's training is due to the lack of knowledge of the company towards its workers. In this sense, Bol et al. (2019), based on a relationship between the educational sector and the labour market in France, Germany, and the United States, comment that the knowledge of the companies towards the workers, through a match between the occupations and the educational level of the workers, implies an increase in the productivity and salary of the worker.

In addition, income could increase if workers' educational credentials were better appreciated in the labour market. Then, it is recommended that employers make a difference between their skilled and unskilled workers since it would increase workers' educational levels (Fan and Yakita, 2011).

Table 7 shows the main findings of our work, highlighting that workers consider education (training) more efficiently and responsibly when companies trust them and lighten their audit probability. Based on a sample of Portuguese universities, Bruckmann and Carvalho (2018) conclude that university institutions have a greater effect on the labour market, considering a mix of teaching between the traditional school and a managerial approach. They end up calling this hybrid-teaching archetype: efficient-collegiality.

Therefore, a low and reliable audit implies efficient training, coupled with the cost and time in the years invested (see Table 7). Furthermore, it can motivate employees. For example, Budiyanti et al. (2020) comment on leadership education and training programs carried out for 500 HR employees in Indonesia, with low cost and without restrictions, which had a positive effect mainly on the confidence and motivation of the participants.

Finally, our work defines specific thresholds to decide if the worker should study, depending on the company's approach to auditing and the years of education invested. The work is related to Andrade and Lomelí (2022) results, in which the authors consider that companies invest in training and decide to promote the trained worker when the benefit obtained by the promotion substantially exceeds the training cost.

CONCLUSION

This model was designed to show the best response from workers when facing the uncertainty of whether the firms value training. Among the results, we showed the percentage of income workers who invest in education when training is the best option.

Since training costs are high, the model considers the existence of other immersed costs, which we approximate and define as opportunity costs. Such opportunity costs are inferred when workers consider signs about the companies' behaviours if they value training, signs that workers use to build subjective beliefs.

Another result of our work is the percentage of income that the worker assigns to his training. We show that when the firm sends signals, through a low audit, that it will consider the training to grant an incentive, the worker could invest 75% of their income in training. With such an investment, the worker would prefer to study only if he achieves a master's degree or higher.

The analysis recommends that workers consider factors such as uncertainty, time, costs, and when they will be trained, mainly when they absorb the cost of training. Also, it is helpful for the company to know the approximate costs of training its workers and the approximate times if it was to bear the costs.

However, the analysis reveals some limitations, ranging from considering the basic levels of education for a certain sector, such as the Mexican society; since starting from secondary school, three years are considered to reach high school, seven to obtain a bachelor's degree and nine years to obtain a postgraduate degree. In addition, since there is no specific percentage of firms who audit their workers, we considered percentages of evaluations that firms make in general to their workers, along with the fact that wage increases were set considering that firms evaluated their workers simultaneously. In other words, the information was approximate according to the data found. We could have modelled more precise situations by programming or generating random numbers. Furthermore, we do not find a Nash equilibrium. We only show the decision under uncertainty of a single player: the worker. The solutions to the limitations are pending for future work.

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Full research paper

EXPLORING STUDENTS' MATHEMATICAL BELIEFS: GENDER, GRADE, AND CULTURE DIFFERENCES

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ABSTRACT

The investigation of students' conceptions of knowledge of mathematics and the process of knowing mathematics is important to provide an understanding of the phenomena behind students' performance. However, there is a scarcity of empirical investigation of students' beliefs about mathematics knowledge in the Indonesian context. This study aims to assess students' beliefs about mathematics education. The relation of these beliefs with gender, grade, and culture was also examined. Fifteen classes were selected by stratified random sampling methods. 536 students (boys = 217, girls = 319) from 8-9 grades participated in the present study. The result of this study revealed that students tend to perceive their mathematics teachers as having tried to make mathematics lessons interesting and perceived that mathematics knowledge continues to expand. Boys' students hold stronger beliefs that they can understand the most difficult tasks in mathematics than girls' students. Grade eight students have higher beliefs than ninth-grade students. Javanese students hold stronger beliefs in mathematics performance than Madurese students. The finding of this study provided information on how to design teaching and learning mathematics in the Indonesian context.

KEYWORDS

Culture, gender, grade, mathematics, students' beliefs

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Highlights

- *Students' conceptions of the teacher role, the nature of mathematics, mathematics performance, and mathematics learning are explored.*
- *Indonesian students believe that mathematics knowledge is dynamics.*
- *Students' beliefs in mathematics learning are different based on their ethnicity.*
- *Boys' and girls' students are different in certain mathematics beliefs.*

INTRODUCTION

Individual conceptions about mathematics knowledge and how they come to know mathematics are essential factors, containing fruitful information about the individual mental process, which have been addressed in the literature review. The ways students conceptualize mathematics or epistemological beliefs in mathematics are important for research and may provide a wealth of understanding to explain the important phenomena behind students' performance in mathematics learning. Beliefs drive students' behavior toward mathematics and their tendency to solve mathematical tasks (Voica et al., 2020). Beliefs are the engine that navigates students to use certain strategies when solving mathematical tasks (Öztürk, Akkan and Kaplan, 2020). Existing studies have shown epistemological beliefs about mathematics was linked with various aspect such as performance, motivation, and attitudes toward mathematics (Heyder et al, 2020; Perera and John, 2020; Silver et al., 2021). Hidayatullah and Csíkos (2023) reported that epistemological beliefs significantly correlate with attitudes and motivation. The stronger individual beliefs, the higher their motivation and perception about objects. Students with strong beliefs about themselves, like believing that they can solve or understand the most difficult topic in mathematics, may drive to put more effort in order to achieve the best performance in mathematics. Gijsbers et al. (2020) reported that students might have fewer beliefs in the relevance of mathematics unless they get an intervention to strengthen their beliefs. Since the prior research (Öztürk, Akkan and Kaplan, 2020; Voica, Singer and Stan, 2020) suggested that there was a relationship between personal mathematical beliefs and performance in math, there may be a possibility that poor performance in math is affected by individual beliefs. Accordingly, the cognitive test result is not enough to explain the phenomena behind poor performance in mathematics, like the students' mathematics scores in Indonesia (Hidayatullah and Csíkos, 2023). The investigation of individual epistemological beliefs about mathematics education provided fruitful information on how to increase the quality of mathematics education.

In the Indonesian context, research beliefs about mathematics have been conducted by several researchers. Zulkarnain et al. (2021) investigated students' self-efficacy beliefs and problem-solving ability in mathematics learning. The focus of that study describes the differences in students' beliefs about their capability in mathematics learning and their ability to solve mathematical tasks. However, researchers did not explain students' conceptions of nature mathematics and problem-solving in mathematics. Other research by Elizar (2021) investigated the influence of mathematics beliefs on students' achievements. Although this study has proved the influence of beliefs about mathematics on achievements, the theoretical framework of the belief system was not mentioned clearly. The latest study was conducted by Hidayatullah et al. (2022), which investigated students' epistemological beliefs in mathematics using the theoretical framework as suggested by Op 't Eynde et al. (2006). In this study, the researcher emphasizes o the adaptation of these mathematics-related belief system questionnaires and their relationship with the ability to solve word problems. However, the researcher failed to provide an explanation of the level of students' mathematical beliefs. Also, whether their personal background (e.g., gender, grade, and culture) contributed to these beliefs or not was unexplored. Therefore, investigating personal conceptions in mathematics with a more comprehensive understanding, as suggested by Op 't Eynde et al. (2006), is necessary. For that reason, our cross-sectional study attempts to identify students' mathematical beliefs in the Indonesian context. Moreover, relevant factors such as gender, age, and cultural differences were examined in the present study. Because in the previous, education equality in the Indonesian context has always been questioned.

1. How do students believe in mathematics in the Indonesian context?
2. Does gender inequality exist in terms of students' beliefs about mathematics education?
3. How do students believe in mathematics education across levels?
4. Are there significant differences that can be identified through the investigation of epistemological beliefs in mathematics based on culture?

THEORETICAL FRAMEWORK

Mathematical beliefs in the education context

Beliefs in mathematics are defined as implicit or explicit students' beliefs held to be true about mathematics education, the self as a mathematics learner, and mathematics in the class context (De Corte, 2015). Accordingly, the beliefs consisted of three dimensions: beliefs about mathematics education, self-efficacy beliefs in mathematics, and personal beliefs about lesson mathematics in the class. These dimensions determine close interaction with each other and students' prior knowledge of their mathematics learning and problem-solving activities in the class context. However, these beliefs may change alongside the growth of students' interaction and their experience in mathematics lessons. For instance, the research by Gijsbers et al. (2020) showed how mathematical beliefs changed through certain interventions. Students showed stronger beliefs about mathematics's relevance after an intervention. Therefore, mathematical beliefs may be stronger or less after they have many experiences during mathematics lessons, like the teaching style and interaction with students.

Concerning the role of beliefs in mathematics learning, some empirical evidence describes the critical role of beliefs about mathematics in the context of mathematics schools. Csíkos et al. (2011) have reported that students' beliefs about word problems determine the way students solve word problems in mathematics. The researchers found in the context of Hungary, students failed to involve real-world knowledge because students held mistaken beliefs about word problems in mathematics. Öztürk et al. (2020) suggested that when the level of students' mathematical beliefs predicted their skill in mathematic problem-solving. Students with higher beliefs in solving mathematics problems tend to have better skills in problem-solving. Through their investigation, Voica et al. (2020) found that when students believe in their capability to solve mathematics problems, they have stronger motivation, affecting their performance while solving mathematical tasks. The latest research by Hidayatullah and Csíkos (2022) also found the role of beliefs about mathematics on the word problem-solving in mathematics. However, most previous studies emphasise the relation between beliefs and mathematics outcome. At the same time, students' beliefs about mathematics education differences based on their personal is still unexplored.

Gender and mathematics beliefs

Several researchers have recorded the connections between beliefs and gender. However, no single result mentioned consistently boys are overachieved than girls students or vice versa. For example, Vuletich et al. (2020) found that females hold stronger beliefs about mathematics than male students. These findings affirmed that mathematics is boys' domain. While Dustan et al. (2022) reported that boys tend to believe they are overscored than girls, girls also believe that boys overscored than girls. Liou et al. (2021) reported that boys hold stronger beliefs than girls. The latest study by Seo et al. (2019) showed that girls have more negative beliefs than boys among Latina and White adolescents in the united states. In the Indonesian context, the association between mathematics-related beliefs with gender differences has not been studied. At the same time, gender equality questions arise since the segregation of boys' and girls' seats in the field has still been conducted by most schools, particularly in Islamic schools (Srimulyani, 2007). The segregation of boys and girls in several Indonesian schools is based on the assumption unify them in the same place would generate a negative impact. Therefore, the investigation of gender differences in terms of epistemological belief systems in mathematics is important. Through this investigation, students' beliefs and performance were explored.

Beliefs and students' grade

In the historical development of cognition research, Piaget in his work explained that individual cognition develops gradually from sensory motoric to formal operational (Zhan et al., 2022). He also explained that the way individual cognition develops through the spontaneous process is tied to the whole process of embryogenesis. At the same time, embryogenesis is not only about body matter but also about mental process development matter. Since cognition has developed over the years, individual beliefs also develop because it contains cognition aspect. Perry's investigation has noted how individual beliefs developed over the years (Taylor, 2016). A longitudinal study by Caprara et al. (2011) in Rome reported that the level of students' grades contributed to students' beliefs about themselves. However, in this research, authors did not explain whether the differences in the level of study also generated differences in beliefs or not. Mozahem et al. (2021) reported that individual beliefs about their capability decreased after becoming older because they received a negative experience like a repeated failure that affected the level of the judgment of their capability. A study by Liou et al. (2021) investigated the students' motivational beliefs across grade levels and gender differences have found that students' conception of their capability decreased significantly from 4 grade to 8 grade. Passolunghi et al (2014), through their investigation, found that pupils in elementary education have higher levels of beliefs than pupils in middle schools. Therefore, we assumed that in the educational context, students in different grades differ because they have different experiences in mathematics learning. For instance, ninth-grade students have more experience regarding mathematics learning in the classroom than eight grade students. Grade ninth students may hold stronger beliefs in mathematics learning since they have experience with problem-solving much more than eighth-grade students. In the present study, the differences in grade study are examined to explain whether the level of study generated different beliefs about mathematics education.

Beliefs differences and students' culture

According to the social cognitive theory proposed by Bandura (2001), individual social life, including social interaction, contribute to students' cognition. Culture also plays a key role in determining students' cognition as well as their perception of mathematics (Kang and Leung, 2022). However, there was an inconsistency among the previous research concerning students' beliefs and their relation to cultural differences. For example, Kang and Leung (2022), during their comparison study between Dai and Han students in China, did not find any significant differences in the context value of beliefs in mathematics. In contrast, Seo et al. (2019) have proved differences in students' beliefs based on ethnicity, where the researcher found that Latina, Asian, and Black girls hold higher beliefs (e.g., growth mindset) than white girls. In the Indonesian context, there is a diversity of cultures. According to the Bureau of Statistics, there are 1331 ethnics that generated multiculturism. According to the Ministry of Education and Culture data, there are 652 local languages. As we discussed earlier, the social environment may generate differences in students' beliefs about knowledge (Kang and Leung, 2022; Seo et al., 2019). In the present study, our participants can pertain to two regions: Sumenep and Surabaya. The two regions, even if in the same province, they have different cultures. For instance, students in Surabaya are Javanese ethnic and use the Javanese language. In the classroom, students use the Indonesian language as the official language. However, for informal interaction and daily life activities, they use the Javanese language. In comparison, students in Sumenep are Madurese ethnic and use the Madurese language for communicating in daily life. In the classroom, they use the Indonesian language as an official language for interaction. Surabaya is an urban city, the center of business in east java province. Contrary, in the Sumenep, most people are farmers. So, the people in both city has a different culture, which may imply the extent they perceive mathematics knowledge. Therefore, in the present study, the student's beliefs about mathematics education based on cultural differences are examined.

METHOD

Participants

The present study took place in Surabaya and Sumenep, east-java province, Indonesia. In Surabaya, most students are Javanese ethnic, while in Sumenep, the students are mostly Madurese ethnic. Fifteen classes were selected using stratified random sampling from sixth of public and private schools. 536 seventh and eighth-grade (boys = 217, girls = 319) students participated in the present study and completed the questionnaire. Most classes in the present research segregated the groups of boys and girls. All participants were asked to complete the questionnaire in the present study.

Instruments

To measure students' mathematical beliefs, we adapted 28 items from a mathematics-related beliefs system questionnaire (Op 't Eynde, De Corte and Verschaffel, 2006). This questionnaire consisted of four factors. We selected ten items of *beliefs about the role and functioning of the teacher*, for instance: "My teacher wants me to understand the concepts, not only memorize the mathematics formula." Seventh item of *belief about the significance of and competence of mathematics*. For instance: "I am very interested in mathematics learning" and "I can understand even the most difficult material. "Seventh items of *beliefs about mathematics as a social activity*, for example: "Mathematical knowledge continues to expand, & new things are found all the time" and "Anyone can learn mathematics. " Four items of *beliefs about mathematics as a domain excellent*, for example: "I am only satisfied when I got good grades in mathematics" and "I want to do well in mathematics to show the teacher and my friends how good I am at it."

Procedure

The procedure of this study is through three steps. In the first steps, we started communicating with principals and mathematics educators. We described the purposes of this study. We send our proposal research to several teachers as well as our instruments. The instruments in the present study have been reviewed by the mathematics educators in the schools. In the second step, after we got permission from the principals, we administered our instruments to the schools. Mathematics educators helped with the collecting data process. MRBQ and mathematics tests were administrated to students using online systems. For the MRBQ, we used the Likert scale rate from 1 to 5; 1 = Strongly disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly agree. The data collection process has taken place at the end of the semester. The collecting data process took place for two weeks. This means the teachers gave enough time to the students to complete our instruments. In the third step, we analyze our data.

Characteristic	Full sample	Percentage
Gender		
Boys	217	40.5%
Girls	319	59.5%
Grade		
seventh	410	76.5%
eight	126	23.5%
Ethnic		
Javanese	400	74.6%
Madurese	135	25.4%
Age		
12years	6	1.1%
13 years	206	38.4%
14 years	256	47.8%
15 years	63	11.8%
16 years	5	0.9%

Table 1: The demography of the participants

Data analysis

This research used a quantitative approach which performed several statistical data analyses to answer the research questions. Several data analysis was used during the data analysis process. In the first step, we confirmed the validity and reliability of the questionnaire. Confirmatory factor analysis (CFA) was used to examine the construct validity of the questionnaire. The combination of CFI, TLI above 0.9, and RMSEA below 0.05 indicated the model of the construct validity fit (Hu and Bentler, 1999). Descriptive statistics were performed to answer the first questions. Finally, an independent sample *t*-test was performed to examine the beliefs about mathematics differences based on students' gender, level of study, and culture. According to Cohen (1992) the effect size is low if the value of *r* varies around 0.1, medium if *r* varies around 0.3, and large if *r* varies more than 0.5.

RESULTS

Confirming the validity and reliability

In this study, we performed exploratory factor analyses (EFA) to confirm the variance of students' mathematics beliefs. The coefficient of KMO and Barlet test sphericity = 0.95, Chi-square ($df = 272$) = 648.26, $p < .001$, indicated that the sample in the present study is adequate. Maximum likelihood was used as a parameter estimate, with varimax rotation and an absolute value of 0.3. Four factors have been identified: beliefs about the teacher, the nature of mathematics, mathematics learning, and mathematics performance.

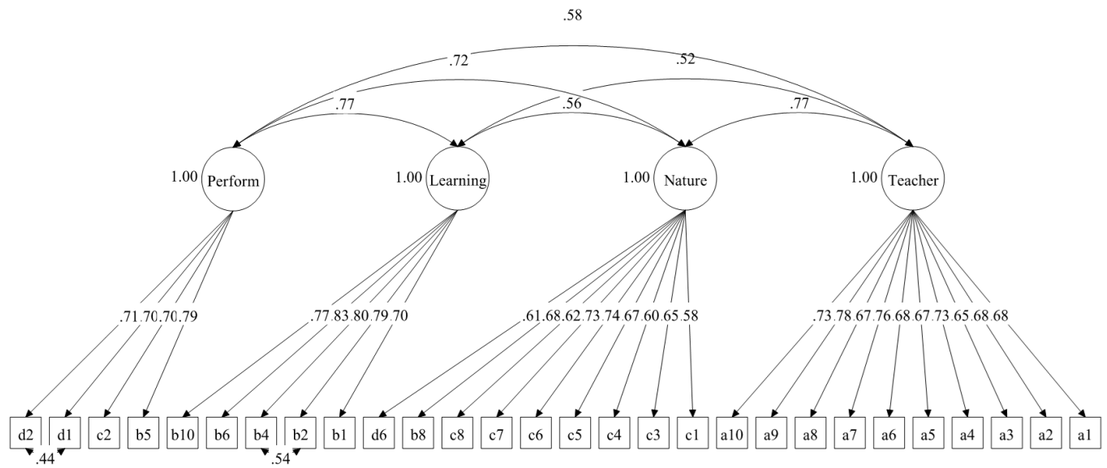

Figure 1: Confirmatory factor analysis of students' mathematical beliefs

We found the fit model of this questionnaire (See figure 1), Chi-square = 808.70, *df* = 342, CFI = 0.94, TLI = 0.94, RMSEA = .05, SRMR = 0.04, $p < .001$ (Hu and Bentler, 1999; van de Schoot et al, 2012). All items have good factor loading, ranging from 0.58–0.82 (Appendix 1). We confirmed the reliability of the questionnaire by performing Cronbach alpha. The result showed that all of the factors have good reliability, beliefs of the teacher consisted of 10 items (alpha = .90), the nature of mathematics consisted of 9 items (alpha = .87), mathematics learning consisted of 5 items (alpha = .89), and mathematics performance consisted of 4 items (alpha = .89). Beliefs in the teacher consisted of the item which related to the statement of students' beliefs about the role of their mathematics teacher in the classroom context. Beliefs in the nature of mathematics entailed students' judgment about the nature of mathematics, such as the statement "mathematical knowledge continues to expand." Beliefs in mathematics learning related to students' intrinsic and extrinsic orientation beliefs in mathematics learning. In comparison, beliefs in mathematics performance deal with students' judgment about their capability in mathematics learning.

Preliminary analysis

Table 2 describes the descriptive statistics and the correlation beliefs about mathematics education factors. The result showed that beliefs about nature strongly correlated with beliefs about the teacher and moderately correlated with mathematics learning and performance. It means that those who believed in the role of their mathematics teachers tended to be more confident and more interested in mathematics.

Variables	Mean	SD	1	2	3	4	5	6
Beliefs about teacher	4.23	0.75						
Nature mathematics	4.38	0.68	.68**					
Mathematics learning	3.33	1.05	.47**	.48**				
Mathematics performance	3.76	0.95	.47**	.60**	.64**			
Gender	-	-	-.01	-.08	.10*	.00		
Grade	-	-	-.11*	-.08	.01	-.06	-.06	
Ethnic	-	-	-.09	-.03	.14*	-.06	.19**	.30**

*Note: * significant p < .05, ** significant p < .001*

Table 2: Correlation between each belief about mathematics factors and the achievement of mathematic

Beliefs about mathematics learning were moderately correlated with the conception of nature mathematics. Students who viewed mathematics as dynamic knowledge tended to be more interested in mathematics learning. Beliefs about mathematics learning were strongly correlated with beliefs in mathematics performance.

RQ1: How do students believe in mathematics in the Indonesian context?

In the first factor (See Appendix), students expressed strong beliefs in the role of mathematics teachers as indicated by the highly mean result of the "beliefs in the role of the teacher" factor (3.40-4.40, on a 5-point Likert scale). Students viewed that their teacher was really friendly in mathematics learning (M = 4.16, SD = .99). Students strongly expressed that their mathematics teacher listens to them carefully if they have any questions (M= 4.38, SD = 0.91) and understand their students if the students face some difficulties in mathematics learning (M = 4.02, SD = 1.10). Students believe that their teachers have tried to make mathematics lesson to be not bored learning (M= 4.24, SD = 1.04) and give students time to explore new things (M = 4.23, SD = 1.04)

Second, beliefs in nature mathematics. Students hold strong beliefs about nature mathematics as indicated by the mean result of the items in this factor (4.11-4.68, on a 5-point Likert scale). For further analysis, we found that students perceived that mathematics evolved, dynamics, and the new this still can be discovered (M = 4.28, SD = 0.93). Students viewed problem-solving in mathematics requires smart thinking (M = 4.44, SD = 1.01), and there are many ways to find the right solution in mathematics problems (M = 4.37, SD = 0.91). Students also expressed that all people could study mathematics (M = 4.40, SD = 0.93), and mathematics has been used by many people in daily life (M = 4.41, SD = 0.93).

The third is the belief in mathematics learning. Generally, students expressed moderate beliefs in mathematics learning according to the mean result of the corresponding items in this factor (3.20–3.44 on a 5-point Likert scale). In mathematics learning, students expressed the belief that they could understand mathematics content, even if it was very difficult (M = 3.30, SD = 1.24). Students expressed that they like mathematics (M = 3.20, SD = 1.32) and are interested in mathematics learning (M = 3.25, SD = 1.32). However, the mean result for neutral in these beliefs was also high, as indicated by the median results (median = 3.00) of the items.

The fourth is beliefs about mathematics performance. Students showed moderate beliefs, as indicated by the mean result of the items (M = 3.64 to 3.94). Students expressed that they were quite confident about getting good grades in mathematics learning (M = 3.94, SD = 1.09), and they wanted to show other people that they are good at mathematics (M = 3.76, SD = 1.25). Students want to show others that they are better than other students in mathematics learning (M = 3.69, SD = 1.25). Students also viewed that with mathematics, someone can use their skills to understand more comprehensive problems in daily life (M = 3.64, SD = 1.07).

RQ2: Do gender inequality exist in term of mathematical beliefs?

Table 3 compares boys' and girls' beliefs about mathematics education factors. An independent sample *t*-test was used to examine whether the gender differences generated different beliefs and performance in mathematics learning.

Independent Variables	Boys (217)		Girls (319)		*F*	*t*(534)	*p*	Cohen's *d*
	M	SD	M	SD				
Beliefs in the teacher	4.24	0.79	4.23	0.72	2.43	0.11	.92	0.01
Nature of mathematics	4.32	0.69	4.42	0.61	3.87	-1.76	.08	-0.16
Mathematics learning	3.46	1.05	3.24	1.05	0.33	2.35	.01*	0.21
Mathematics performance	3.76	0.95	3.76	0.95	0.41	-.03	.97	-.00

*Note: * significant p < .05, ** significant p < .001*

Table 3: Boys' and Girls' mathematical beliefs differences

The independent sample *t*-test result indicated no significant differences between boys' and girls' students' beliefs about the teacher, the nature of mathematics, and mathematics performance. Boys and girls were different in their beliefs about mathematics learning ($p < 0.01$), where the boys (M = 3.46, SD = 1.05) gained higher beliefs than the girls (M = 3.24, SD = 1.05). However, the differences between them were small ($d = 0.21$).

RQ3: How do students believe in mathematics education across levels?

Table 4 describes the result of the *t*-test to identify whether there are differences in students' beliefs about mathematics education across the level. According to the result of the *t*-test, there were no differences in students' beliefs in the nature, learning, and performance of mathematics. Students in grade eight are different from students in grade ninth in their beliefs about the teachers with a small effect size ($d = 0.26$). Students in grade eight hold stronger beliefs about the role of a teacher than students in grade nine; (M = 4.24, SD = 0.73 vs. M = 4.09, SD = 0.79, respectively).

RQ4: Are there significant differences that can be identified through the investigation of beliefs about mathematics education based on ethnicity?

Table 5 describes the result of the *t*-test for the differences in mathematical beliefs based on ethnicity. The result showed that Javanese students and Madurese were equal in believing mathematics teachers, nature, and performance in mathematics. However, the differences between the two were significant in the beliefs in mathematics learning. The differences between the two was medium based on the value of Cohen's *d* ($d = 0.33$). Javanese students have higher beliefs about mathematics learning (M = 3.42, SD = 1.04) than Madurese students (M = 3.07, SD = 1.06).

Independent Variables	Eight (410)		Ninth (126)		*F*	*t*(534)	*p*	Cohen's *d*
	M	SD	M	SD				
Beliefs about the teacher	4.24	0.73	4.09	0.79	3.82	2.44	.01*	0.26
Nature of mathematics	4.41	0.63	4.29	0.68	3.87	2.22	.07	0.19
Mathematics learning	3.32	1.06	3.34	1.05	0.02	-.24	.81	-0.03
Mathematics performance	3.79	0.92	3.66	1.02	2.91	1.37	.17	0.14

*Note: * significant p < .05, ** significant p < .001*

Table 4: The differences in epistemological beliefs about math based on a level of study

Independent Variables	Javanese (400)		Madurese (136)		*F*	*t*(534)	*p*	Cohen's *d*
	M	SD	M	SD				
Beliefs about the teachers	4.28	0.72	4.13	0.80	3.43	1.96	.05	0.19
Nature of mathematics	4.39	0.63	4.35	0.68	0.03	0.69	.49	0.07
Mathematics learning	3.42	1.04	3.07	1.06	0.60	3.35	.001**	0.33
Mathematics performance	3.79	0.94	3.66	0.97	0.41	0.51	.16	0.14

*Note: * significant p < .05, ** significant p < .001*

Table 5: The differences in epistemological beliefs about math based on ethnicity

DISCUSSIONS

This study explores students' beliefs about mathematics in the Indonesian context. We also investigated relevant factors (e.g., gender and region) and their relation to these beliefs. We found explored the students' tendencies toward mathematics. Also, we found differences in students' conceptions of mathematical knowledge based on gender and ethnicity preferences in the Indonesian context. The findings of this study contributed to improving the quality of mathematics education in the Indonesian context.

Firstly, we found that students expressed strong beliefs in the role of the teacher in mathematics learning. Students showed that their mathematics teacher is friendly, cares about students' problems, and try to create an interesting lesson about mathematics. Students also showed that their math teachers had taught them to understand the process of mathematics rather than memorizing. How teachers interact with students may contribute to students' beliefs in the role of teachers, like the appreciation of the students by the mathematics teachers (Li et al., 2021). Therefore, in the mathematics context, mathematics educators

emphasize the process rather than memorizing. Also, since this study took place in East Java, all of the schools taught students to highly appreciate the role of teachers because, in this region, the teaching profession is highly valued. The norm guide students were unthinkable for a student to address a teacher by "talking down" or "talking intimately" to the teacher (Quinn, 2011). Consequently, students highly believe that their mathematics educators know everything, as well as students' problems.

We found students expressed a strongly believe in the nature of mathematics. Rather than perceiving mathematics as a statics knowledge, students viewed mathematics is always evolving and that new things still can be discovered. Also, the finding of this study revealed that they believe that there are many ways to solve mathematics problems. Students also highly believe that everyone can learn mathematics. Our interpretation of this stage, the student's daily life activities, such as interaction with digital technology to access mathematics information, may be why students believe in many ways to solve problems in mathematics. Interestingly students also believe that everyone can understand mathematics rather than believing that mathematics competence is genetics matters. Most students believe that hard work can reach the best grade in mathematics.

However, the data on students' beliefs about mathematics learning showed that the number of students who expressed disagreement or strongly agreed with the item "I like mathematics" was very high. Also, students 32% strongly disagree or disagree with the item "I am very interested in mathematics." This data indicated that, in reality, many students don't interest in mathematics. This finding was in contrast with previous beliefs, such as beliefs in the nature of mathematics and mathematics teachers. The possible explanations, the way teachers transform mathematics learning, and the nature of mathematics are not the single factors behind students' motivation to study mathematics. The experience failed repeated also contributed to students' beliefs about mathematics (Usher and Pajares, 2009; Özcan and Kültür, 2021). With respect to students' beliefs in mathematics performance, the finding of this study revealed that students expressed a strong belief they would get a good score in mathematics. They have external orientation beliefs such as the inner desire to show that they have good capability in mathematics to their peers or their mathematics teachers. This finding is in line with the finding by (Wang et al., 2022), which revealed that Asian students tend to have high confidence that they are capable in mathematics. Students also expressed beliefs to show that they are better than other students. This finding is quite surprising since many students expressed did not agree with the previous beliefs. Although they were not like mathematics, they wanted to show they had the capability in mathematics. Indeed, further analysis is necessary to explain more comprehensively the contradiction of these beliefs, they believe that everyone can study mathematics and believe in gaining high scores in mathematics on the one hand, and they don't like mathematics on the other.

Second, we found that boys and girls were equal in the conception of mathematical knowledge except for beliefs in mathematics learning. The finding of this study told us boys had higher beliefs in mathematics learning. For instance, boys hold stronger beliefs that they like mathematics, are interested in mathematics learning, and understand the course material in mathematics even if it was difficult for them than girls. For these beliefs, the data is contrary to Vuletich et al. (2020), but it is in line with Dustan et al. (2022), Liou et al. (2021), and Seo et al. (2019) that found boys hold stronger beliefs in mathematics than girls. Seo et al. (2019) mentioned that girls students tend to perceive mathematics as more difficult for them than boys students. However, further investigation is necessary to confirm the differences between the two in the context of beliefs in mathematics learning.

Third, we found that students in eighth grade hold stronger beliefs about the teacher than in ninth grade. For example, students hold stronger beliefs that their mathematics teachers have tried to make mathematics learning interesting, their teachers care about students' problems, and their teachers really understand students' problems in mathematics learning. This finding is in line with the prior research (Liou et al., 2021; Mozahem et al., 2021; Passolunghi et al., 2014), which mentioned the differences in beliefs about mathematics in different grades, where students in the lower grade level study tend to have stronger beliefs than students in the higher level study. Pupils' experience and interaction with the teachers over the years may contribute to these beliefs. Mozahem et al. (2021) in their study argue that the source of personal beliefs like mastery experience, vicarious experience, social persuasion, and physiological state is the factor behind the decreasing or lower beliefs in different grades. According to the cognitive development theory, the change of beliefs in the form of the development of mental cognition is a process that concerns the totality of the knowledge structure (Zhan et al, 2022).

Fourth, this study's finding revealed differences between students based on their ethnicity in their beliefs about mathematics learning. Javanese students hold stronger beliefs in mathematics learning than Madurese students. Javanese students are much more interested in mathematics learning than Madurese students. Also, they expressed more confidence in understanding the most difficult topic in math than Madurese students. This finding reveals the same result as the previous research (Seo et al., 2019), which reported the differences in beliefs based on cultural differences. Social cognitive theory (Bandura, 2001) suggests that sociocultural factors influence individual behavior through their psychological mechanism. Cultural embeddedness contributed to shaping the ways individual beliefs are developed.

Although the present study provided a wealth of information regarding beliefs about mathematics education, several limitations should be noted. The present study focused on explaining students' beliefs about mathematics education. We did not investigate the extent to which these beliefs influence students' performance in mathematics. Future research and the investigation of these beliefs in the Indonesian context should identify the relation of this belief to other aspects such as performance and motivation achievements. This research examined students' beliefs based on the self-report that failed to explain a deep understanding of students' beliefs personally. Future research should be considered to do a deep interview with students to investigate their beliefs about mathematics education. This study used a small sample and compared the beliefs of students based on two regions. However, the small sample in the present study did not represent all Indonesian contexts. Therefore, future research should consider the generalizability of the sample.

IMPLICATION

This study found that students hold strong beliefs about the teacher, the nature of mathematics, and the performance of mathematics. We found significant differences in students' beliefs in mathematics learning based on gender and grade preferences. Also, we found differences in beliefs in mathematics performance based on cultural differences. The finding of this study has some implications for teaching practices. Since the findings tell us that students hold strong beliefs about the teacher, mathematics educators can increase students' performance by providing a good example of mathematics. Because students will follow the ways teachers deal with mathematics. Mathematics educators should put some effort into increasing girls' beliefs in mathematics learning. Mathematics educators are necessary to maintain students' beliefs in mathematics learning since our data found that students' beliefs in grade ninth lower than students in grade eight, for example, by involving gamification strategy in mathematics learning. For the policy maker, this data can be used how to ensure the equity of education based on the differences in culture and region.

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DECLARATION OF COMPETING INTEREST

No conflict of interest exists.

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APPENDIX

STUDENTS' MATHEMATICS-RELATED BELIEFS SYSTEMS

Variables	Mean	Med	SD	SE
Beliefs about teacher				
My teacher is very friendly	4.16	4.00	0.99	0.04
My teacher listens carefully	4.38	5.00	0.91	0.39
My teacher understands my difficulties	4.02	4.00	1.11	0.04
My teacher cares about me when I have difficulties	3.40	4.00	1.10	0.05
My teacher appreciates me even if my result is not good	4.40	5.00	0.94	0.04
My teacher really wants me to learn new things	4.27	5.00	0.96	0.04
My teacher tries to make mathematics lessons interesting	4.24	5.00	1.04	0.04
My teacher wants me to understand the content, not just memorize it	4.38	5.00	0.96	0.04
My teacher gives me time to find new problems and to try out possible solutions	4.23	5.00	1.04	0.05
My teacher provided me with a thorough step-by-step explanation before handing me an assignment	4.30	5.00	1.03	0.04
Beliefs about nature mathematics				
I think I can use what I learn in mathematics in other courses	4.11	4.00	1.02	0.04
Solving mathematics problems is demanding and requires thinking, even for smart students	4.44	5.00	1.01	0.04
Mathematics is used by many people in their daily life	4.41	5.00	0.93	0.04
Mathematical knowledge continues to expand, & new things are found all the time	4.28	5.00	0.93	0.04
There are several ways to find the correct solution to a mathematics problem	4.37	5.00	0.91	0.04
Anyone can learn mathematics	4.40	5.00	0.93	0.05
I choose mathematical assignments that I can learn from even if I am not at all sure of getting a good grade	4.19	5.00	1.08	0.05
If I try really hard, I will understand very well in math	4.52	5.00	0.84	0.04
I am only satisfied when I get a good grade	4.68	5.00	0.75	0.03
Beliefs about mathematics learning				
I can understand even the most difficult material	3.30	3.00	1.24	0.05
I like to learn mathematics every time	3.20	3.00	1.32	0.06
I am very interested in mathematics learning	3.25	3.00	1.32	0.06
I can understand course materials in mathematics	3.47	4.00	1.15	0.05
I prefer mathematics tasks for which I have to exert myself to find the solution	3.44	4.00	1.27	0.05
Beliefs about mathematics performance				
I am confident that I will get a good grade in mathematics.	3.94	4.00	1.09	0.47
Mathematics enables students to better understand the world he live in	3.64	4.00	1.07	0.05
I want to show the teacher that I am better than most other students	3.69	4.00	1.25	0.05
I want to do well in mathematics to show the teacher and my friends how good I am at it	3.76	4.00	1.19	0.05

Full research paper

IDENTIFYING THE FACTORS INFLUENCING MATHEMATICS TEACHERS' GRADING PRACTICES REGARDING STUDENTS' IN-CLASS PERFORMANCE: A RELIABILITY AND VALIDITY STUDY

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ABSTRACT

This study aims to develop a scale to identify the factors influencing mathematics teachers' grading practices regarding students' in-class performance. The study was carried out with 180 secondary and 140 high school mathematics teachers from the southwestern region of Türkiye. The scale's construct validity was determined using item analysis, exploratory factor analysis (EFA), and confirmatory factor analysis (CFA). The EFA results showed that the scale consisted of a 5-point Likert-type scale with 36 items under eight factors (mathematical knowledge and skills, social behaviors, affective skills, effort, homework performance, follow-up test results, academic exam results, and external benchmarks). The scale explained 70.02% of the total variance, with factor loadings ranging from 0.50 to 0.92. The item-total correlations ranged from 0.36 to 0.64, and *t*-test results for the item discrimination index were significant. The Cronbach's alpha coefficient for the overall scale was calculated to be 0.92. The CFA results indicated that the scale model had a good fit (Chi-square/*df* = 1.39; RMSEA = 0.051; IFI = 0.98; NNFI = 0.97; CFI= 0.98; and SRMR = 0.062). Based on the findings, the scale is a valid and reliable instrument that may be used in determining the factors influencing mathematics teachers' grading practices.

KEYWORDS

Grading, mathematics, participation in classroom activities, performance assessment, scale development

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Highlights

- *This study aimed to develop a scale to identify the factors influencing the grading of students' in-class math performance.*
- *The study was carried out with 180 secondary and 140 high school mathematics teachers from Türkiye.*
- *The EFA and CFA results confirmed the construct validity of the scale.*
- *A valid and reliable scale with 36 items and eight subfactors (mathematical knowledge and skills, social behaviors, affective skills, effort, homework performance, follow-up test results, academic exam results, and external benchmarks) was created.*

INTRODUCTION

One of the primary functions of education is to prepare students to account for changing individual and societal demands over time. In today's information and technology era of rapid changes and developments, high-level thinking skills such as conceptual learning, making assumptions, problem-solving, criticizing, critical thinking, analyzing, and producing have increased in importance (Birgin, 2011). Many student-centered education approaches, such as cooperative learning, project-based learning, and social constructivist learning, have been proposed in response to these demands as alternatives to the traditional teacher-centered education approach (Shepard, 2000). Connecting concepts to everyday life, actively participating in the teaching process, and allowing students to construct their knowledge in a social learning environment are all critical components of a student-centered education approach (National Council of Teachers of Mathematics [NCTM], 2000). Assessment is an integral and formative part of the teaching process in the student-centered education approach, focusing on both the learning product and the learning process (Stiggins, 1997; Wiliam, 2011). As a result, the student-centered education approach necessitates the use of alternative assessment tools and methods that allow students to determine their learning performance, reveal their strengths and weaknesses, and measure high-level knowledge and skills (Birgin and Baki, 2009).

Assessment in education serves several purposes, including determining student success and deficiencies in the learning-teaching process; determining the effectiveness of teaching methods; revealing the weak and strong aspects of the applied curriculum; and monitoring student development (Ministry of National Education [MoNE], 2018). For effective and efficient assessment, both formative and summative purposes must be considered (Black and Wiliam, 1998; Stiggins, 1997). A summative assessment is performed at the end of the process to evaluate the teaching. Instead of at the end of instruction, formative assessment necessitates process-oriented assessment. Rather than grading, formative assessment seeks to identify instructional deficiencies (Birgin, 2011). As a result, formative assessment focuses on student performance and helps to eliminate deficiencies and organize students' knowledge.

Multiple-choice, matching, true-false, and fill-in-the-blank questions are frequently used in traditional assessment methods. Traditional assessment methods, however, fall short of ensuring students' growth throughout the process and addressing their learning deficits (Bennett, 2011; Guskey, 2011). On the other hand, student-centered assessment strategies provide teachers and students with new responsibilities. In this regard, the student is given the responsibility of actively engaging in the process and assessing both himself and his peers, while the teacher is responsible for planning and organizing the learning environment and assessing both the learning product and the learning processes (Shepard, 2000; Wiliam, 2011). As a result, the student-centered assessment approach requires the use of alternative assessment tools such as performance assessments, projects, portfolios, self- and peer-assessments, observations, interviews, structured grids, and concept maps in addition to traditional assessment tools to track a student's progress during the learning process and provide the necessary feedback.

When reviewing the literature, it is notable that some studies have focused on determining the factors that influence teachers' classroom assessment practices and grading behaviors (e.g., Bursuck et al., 1996; Cizek et al., 1995; Duncan and Noonan, 2007; Frary et al., 1992; Mc Millan et al., 2002; Sun and Cheng, 2014). The results of studies conducted in different countries have shown that many non-academic factors as well as academic achievement are effective in determining student grades. These factors include exam success, attendance, effort, attitude, homework habits, attendance, classroom behaviors, responsibility, bringing textbooks and materials, personal care behaviors, grade distribution in the classroom, grade distribution of other teachers, and school success policy (e.g., Cizek et al., 1995; Cheng and Sun, 2015; Frary et al., 1993; McMillan, 2001; McMillan et al., 2002; Randall and Engelhard, 2010). Furthermore, research has shown that teachers' grading practices differ depending on the curricula in the countries (e.g., Cheng and Sun, 2015; Duncan and Noonan, 2007; Demir et al., 2018; Suurtamm et al., 2010), the school type and grade level (Adams and Hsu, 1998; Cizek et al., 1995; Mc Millan, 2001), the in-service training support that teachers receive (Acar-Erdol and Yıldızlı, 2018; Zhang and Burry-Stock, 2003), school policies (Brookhart, 1994; Veldhuis et al., 2013), and the teachers' beliefs about assessment methods (e.g., Adams and Hsu, 1998; Sun and Cheng, 2014).

The mathematics curriculum in Turkey, which was updated in 2018 based on a student-centered education approach, focuses on the student's performance in the classroom and learning process as well as exam success. Previous studies have revealed that Turkish teachers lack the knowledge to use alternative assessment tools and methods recommended by the curriculum (e.g., Acar-Erdol and Yıldızlı, 2018; Serin, 2015) and prefer traditional assessment methods over alternative assessment methods (e.g., Birgin and Baki, 2009; Demir et al., 2019). Furthermore, teachers' alternative assessment practices were found to be negatively impacted by insufficient in-service training and material support (e.g., Akcadag, 2010; Özenç and Çakir, 2015; Yıldızlı, 2020), a heavy course load, crowded classrooms, resistance to change, and pressure from central exams (e.g., Birgin and Baki, 2012; Demir et al., 2018).

Although studies on teachers' grading practices in some countries have been conducted (e.g., Cross and Frary, 1999; Cheng and Wang, 2007; McMillan, 2001; Randall and Engelhard, 2010; Sun and Cheng, 2014; Zhao et al., 2016), it has been noticed that there is no scale to identify the factors influencing the grading practices of mathematics teachers in Türkiye. Therefore, this current study aims to develop a scale to identify the factors affecting Turkish mathematics teachers' grading practices.

Teachers' Grading Practices and Affecting Factors

Classroom assessment has been a complex process. There are several stages to this process, including the development and use of assessment tools, sharing and assessing results, and deciding on instructional strategies (Bennett, 2011). The choice of instructional activities, the observation of the student's growth during the teaching process, and the evaluation of his participation in the course activities are additional requirements for this procedure (Zhang and Burry-Stock, 2003). At this point, teachers' knowledge, abilities, and application strategies for classroom assessment are critical. In this context, some research has concentrated on the factors that influence grading and how teachers grade students in the classroom.

According to research findings (e.g., Adams and Hsu, 1998; Duncan and Noonan, 2007; Zhang and Burry-Stock, 2003), teachers' lack of knowledge and inadequacies about assessment methods raise concerns about the quality of classroom assessment practices. Furthermore, previous research (e.g., Acar-Erdol and Yıldızlı, 2018; Brookhart, 1993; 1994; Cizek et al., 1995; Cheng and Sun, 2015; Cross and Frary, 1999; Frary et al., 1992; Guskey, 2011; McMillan, Myran, and Workman, 2002; McMillan, 2001; Sun and Cheng, 2014) has

shown that when determining a student's end-of-term grade, teachers generally do not consider the assessment experts' recommendations but partially do consider non-academic success factors such as homework, class participation, effort, ability, and attitude. Furthermore, it was revealed that teachers' grading practices differ according to the grade level (e.g., Bursuck et al., 1996; Duncan and Noonan, 2007; Gullickson, 1985; McMillan et al., 2002; Randall and Engelhard, 2010), field or course type (e.g., Duncan and Noonan, 2007; Frary et al., 1993; McMillan, 2001; Zhang and Burry-Stock, 2003), and county education systems and cultures (e.g., Cheng and Wang, 2007; Suurtamm et al., 2010; Zhao et al., 2016).

Bursuck et al. (1996) found that when grading students, primary and secondary school teachers consider factors such as effort, bookkeeping, class attendance, class participation, and preparation, with primary school teachers emphasizing student ability more than secondary and high school teachers. Duncan and Noonan (2007) determined in their study of 513 high school teachers that teachers value behaviors that promote success in grading practices (e.g., ability level, student effort, participation in the lesson, development, study habits, and negative behavior in the classroom) more than out-of-class benchmarks (e.g., the school's informal success policy, grade distribution of other teachers, and student success in previous years). Furthermore, mathematics teachers are less concerned with these factors than other branch teachers (social sciences, English, and visual arts).

McMillan et al. (2002) investigated classroom teachers' grading and assessment practices, as well as the factors they consider when grading students and the types of assessments they use. Six factors have been identified as influencing teachers' assessments of student success. Teachers were found to place a higher value on academic achievement and achievement-enhancing behaviors such as effort and development in grading while placing a lower value on factors such as doing homework, comparing with other students, the grade distribution of other teachers, and being on the borderline. Randall and Engelhard (2010) conducted a study with 516 elementary, secondary, and high school teachers in America, and found that teachers primarily follow the school district's official academic success policy and give grades based on success. However, they revealed that for borderline students, some teachers consider non-academic factors such as motivation, effort, and behavior. Similarly, Cizek et al. (1995) found that 61% of teachers use non-academic criteria in grading, such as behavior and effort. Cross and Frary (1999) revealed that 37% of secondary school teachers consider behavior and attitude, and Frary et al. (1992) determined that 31% of teachers agree that student behavior should be considered in grading. Based on previous research, it can be stated that it is necessary to take caution when deciding the grading, as non-academic factors and arbitrary grading practices will have a negative impact on the validity and reliability of students' grades.

Determination of Primary and Secondary School Students' Math Grades in Türkiye

In Turkey, the Ministry of National Education (MoNE) updated the mathematics curriculum after 2005 to reflect student-centered education approaches. The mathematics curriculum (MoNE, 2018) emphasized the importance of monitoring the development of students' cognitive, affective, and psychomotor knowledge and skills, valuing assessment practices for recognition and shaping, and considering both the learning process and the learning product in determining student success. It is encouraged to use alternative assessment tools and methods (project, performance, portfolio, group work, self-assessment, rubrics, etc.) in addition to traditional assessment tools to identify student progress and achievement in the learning process.

The Preschool Education and Primary Education Institutions Regulation (MoNE, 2014: 7) of the Ministry of National Education emphasizes the following factors in determining student success: Exam scores and participation in class activities are used to assess student success in the fourth grade of primary school. Exam scores, participation in course activities, and, if applicable, project work are used to assess the success of middle school students. The regulation defines participation in classroom activities as 'work that students do in the classroom or at school, activities that enable them to use and develop their cognitive, affective, and psychomotor skills such as critical thinking, problem-solving, reading comprehension, and research, as well as to evaluate their performance' (MoNE, 2014: 1). Furthermore, participation in class activities will be awarded three times for the mathematics course that exceeds two hours per week. Students are required to complete at least one performance study per semester and a project for at least one course per academic year. It is suggested that, in addition to academic success, student participation in class activities, as well as cognitive, affective, and psychomotor development, be taken into account when determining student achievement grades.

Following curriculum updates, some studies on teachers' assessment practices have been conducted in Türkiye over the last two decades. Only a few studies have examined the mathematics teachers' decision-making and grading practices in Türkiye (Yıldızlı, 2020). There is a need for a scale to assess the factors that influence students' participation in in-class mathematical activities in deciding their grades, considering that the Turkish mathematics curriculum was revised in 2018 and that in-class activities place a focus on participation. As a result, this study contributes to the development of a scale to identify the factors influencing students' decision-making performance in math class.

METHOD

In scale development studies, it is suggested that participation is based on volunteerism and sampling of the attribute being assessed (DeVellis and Thorne, 2021). The convenient sampling method enables the selection of people who are easily available and eager to volunteer for the research. As a result, participants were informed about this study and provided with an informed consent form.

Participants

The participants in this study are divided into two groups. The exploratory factor analysis of the scale was performed with Study Group I, and the confirmatory factor analysis of the scale was performed with Study Group II. Details of the participants in the study were summarized in Table 1. Data were obtained from a total of 320 mathematics teachers in a province in the southwestern region of Türkiye, 180 in middle schools (5th–8th grade) and 140 in high schools (9th–12th grade). In this study, 49.7% (n = 159) of the participants were female, and 50.3% (n = 161) were male teachers. 50% (n = 160) of the participants work in the city center, 31.6% (n = 101) of whom work in the provincial center, and 18.4% (n = 59) of whom work in rural areas. In terms of professional seniority, 15.3% of participants have a seniority of 1–5 years; 20.6% of them have a seniority of 6–10 years; 15.6% of them have a seniority of 11–15 years; 16.6% of them have a seniority of 16–20 years; and 31.9% of them have a seniority of over 20 years.

Gender	Study Group I (n = 170)		Study Group II (n = 150)		Total (n = 320)	
	Middle School	High School	Middle School	High School	n	%
Female	48	35	44	32	159	49.7
Male	45	34	43	39	161	50.3
Seniority						
1–5 years	12	11	14	12	49	15.3
6–10 years	20	14	17	15	66	20.6
11–15 years	16	10	14	10	50	15.6
16–20 years	17	12	15	9	53	16.6
+ 20 years	28	22	27	25	102	31.9

Table 1: Participants

The Development Process of the Scale

Table 2 summarizes the development processes of the scale to determine the factors that mathematics teachers consider when grading students' in-class math performance.

To begin the process of developing scale items, the literature on teachers' grading practices was reviewed (e.g., Brookhart, 1993; 1994; Cheng and Sun, 2015; Cizek et al., 1995; Duncan and Noonan, 2007; Frary et al., 1993; McMillan, 2001; McMillan et al., 2002; Sun and Cheng, 2014; Suurtamm et al., 2013). Furthermore, the assessment practices recommended in the Turkish primary and secondary school mathematics curricula were investigated. Moreover, the grading procedures and principles stated in the regulation of the primary and secondary education institutions in Türkiye (MoNE, 2014) were reviewed. Following the literature review, a pool of 45 items was created by taking into account the characteristics and factors used to grade the student's participation in classroom activities and performance.

Stage	Procedure
Making an item pool:	• Reviewing national and international studies and creating a draft item pool
Assuring the face and content validity:	• Obtaining comments from subject matter experts and math teachers on the draft items' content, language, and expression suitability • Making changes to the scale items based on the suggestions
Implementation of the draft scale:	• Applying the draft scale to the mathematics teacher to ensure the scale's validity and reliability
Item analysis:	• Calculating item-total correlation and item discrimination
Analysis construct validity:	• Kaiser-Meyer-Olkin (KMO) and Bartlett's sphericity tests were used to assess construct validity. • Performing exploratory factor analysis (EFA) and confirmatory factor analysis (CFA)
Reliability:	• Calculating Cronbach's alpha coefficient

Table 2: Development stages of the scale

The draft scale was reviewed by two mathematics education experts, a measurement and assessment expert, and two educational sciences experts to ensure its content and face validity. Five items were removed, three new items were added, and some items were corrected in response to expert opinions and suggestions. Furthermore, the opinions of eight experienced mathematics teachers were solicited in terms of content, language, and expression, and corrections were made to the three items following their suggestions. There are 43 items in total in the final draft scale to determine the features and factors that are taken into account in the grading of the student's in-class mathematics performance. A 5-point Likert scale was used to respond to the scale item (1 = not at all, 5 = completely).

The validity and reliability of the scale were carried out in two stages. In the first stage, the scale was administered to 170 mathematics teachers for item analysis of the draft scale. Both the item discrimination index and the item-total correlation were computed. The item discrimination index was determined using 27% lower and 27% upper group methods. To assess the scale's conformance with the construct validity, the Kaiser-Meyer-Olkin (KMO) sample fit test and Bartlett's sphericity test were first performed (Field, 2005). To examine the factor structure of the scale, exploratory factor analysis (EFA) was performed using principal component analysis and oblique rotation method (direct oblimin), which allow correlations between the factors. The Cronbach's alpha coefficient was used

to assess the reliability of the scale as well as that of its sub-dimensions. In the second stage, confirmatory factor analysis (CFA) was carried out on 150 mathematics teachers using LISREL 8.8 to assess the model's fit for the scale's factors.

Data Analysis

The scale was applied to the participants, and their responses to each item were scored from 1 (not at all) to 5 (completely). The statistical software programs LISREL 8.5 and SPSS 17.0 were used to conduct the data analysis. For the convenience of the analysis and the assumptions, the evaluation of the blank data, the normality test, the linearity, and the determination of extreme values (excluding the -3 and +3 values of the standard deviation) were evaluated before the data analysis. Outlier data scores were removed from the analysis. The answers provided by 140 high school math teachers and 180 middle school math teachers were evaluated as a result of the data analysis. It was found that the kurtosis (-0.724) and skewness (-0.294) values for the scale, which ranged from +1 to -1, indicated a normal distribution. The discrimination indices of the items were examined for the 27% lower and 27% upper groups, as well as the item-total correlation values. Also, EFA and CFA were performed to confirm the construct validity of the scale. Cronbach's alpha coefficient was calculated to determine the reliability of the scale.

RESULTS

This section presents the item analysis test results for the construct validity and reliability of the scale, the EFA and CFA, and reliability test findings.

Findings Relating to the Scale's Item Analysis

Item-total correlation and *t*-test scores for 27% of the upper and lower groups were calculated for the scale's item analysis. A positive and high item-total correlation indicates that the test's internal consistency is good and that the items exhibit similar behaviors. The degree to which items identify individuals in terms of the measured feature can also be determined using item-total correlation. According to the literature, highly discriminating items have an item-total correlation of 0.30 or higher; items between 0.20 and 0.30 can be included in the scale or modified if they are judged essential; and items less than 0.20 should be eliminated from the scale (DeVellis and Thorne, 2021). For this reason, when selecting the items for the scale, it was assumed that the item-item correlation was not extremely high ($r > 0.90$) and that the item-total correlation was above 0.30. One item with an item-total correlation between 0.20 and 0.30 ($r = 0.237$ for B13) and two items with item-total correlations below 0.20 ($r = 0.108$ for B36 and $r = 0.194$ for B37) were excluded from the scale. The item-item correlation values calculated for the remaining 40 items in the scale were found to be not very high ($r < 0.90$), and the significant item-total correlation values ranged from 0.36 to 0.64 (Table 3).

To assess the distinctiveness of the items on the scale, the item mean scores of the 27% upper and lower groups were compared using the *t*-test. The significant difference is considered evidence of the internal consistency of the scale (DeVellis and Thorne, 2021). As shown in Table 3, the *t*-test results for the 40 items on the scale were determined to be significant ($p < 0.01$). Based on these findings, it was accepted that the items on the scale were distinctive.

Item No	Item-Total Correlation	*t*–value	Item No	Item-Total Correlation	*t*–value
B1	0.508**	5.464**	B22	0.640**	9.249**
B2	0.570**	6.690**	B23	0.509**	6.477**
B3	0.417**	6.883**	B24	0.529**	7.852**
B4	0.438**	7.635**	B25	0.537**	6.758**
B5	0.493**	7.829**	B26	0.493**	7.283**
B6	0.485**	7.241**	B27	0.557**	6.628**
B7	0.493**	7.805**	B28	0.592**	7.332**
B8	0.511**	7.075**	B29	0.552**	8.419**
B9	0.496**	4.740**	B30	0.596**	8.557**
B10	0.501**	5.608**	B31	0.494**	8.617**
B11	0.544**	5.706**	B32	0.602**	8.290**
B12	0.512**	5.245**	B33	0.597**	8.247**
B14	0.542**	7.823**	B34	0.599**	7.816**
B15	0.519**	7.078**	B35	0.570**	7.017**
B16	0.509**	7.470**	B38	0.479**	7.046**
B17	0.524**	7.154**	B39	0.354**	5.008**
B18	0.561**	6.578**	B40	0.455**	6.562**
B19	0.588**	7.358**	B41	0.544**	8.314**
B20	0.507**	6.951**	B42	0.510**	7.937**
B21	0.519**	6.946**	B43	0.367*	5.022**

*$p < 0.05$ **$p < 0.01$

Table 3: Item analysis results for the scale

Findings Relating to the Exploratory Factor Analysis (EFA)

Factor analysis is a statistical technique for combining variables that assess the same structure (Field, 2005). To determine the scale's factor structure, EFA was performed. Bartlett's sphericity test and Kaiser-Meyer-Olkin (KMO) proficiency test results were examined to determine whether the data were adequate for factor analysis. It is emphasized that for the data to be suitable for factor analysis, the result of the KMO test should be greater than 0.60 and the result of the Bartlett's sphericity test should be significant (Field, 2005). In this study, the KMO test result was found to be 0.867, and the Bartlett's sphericity test result was significant ($\chi^2 = 4899.104$, $p < 0.001$). These findings indicated that the data were suitable for factor analysis.

Principal component analysis and the oblique rotation method (direct oblimin) were used to conduct EFA. The oblique rotation method allows the factors to correlate (Tabachnick and Fidell, 2007). In the process of factor analysis, it was required that the factor loadings of the items be at least 0.40 and that, when the items were collected under different factors, the difference between the factor loadings be at least 0.10. According to the first EFA results, the scale was categorized into nine factors with an eigenvalue above 1.00, which could account for 71.63% of the total variance. Four items (B14, B15, B35, and B40) were found to have high values in several factors, with the difference between factor loadings being smaller than 0.10. Due to this, it was decided to remove four items from the scale and repeat factor analysis on the remaining 36 items. The results of repeated factor analysis indicated eight factors with eigenvalues greater than one, accounting for 70.02% of the total variance, with factor loadings ranging from 0.50 to 0.92. The factor analysis results are shown in Figure 1 as a line graph of the eigenvalues, and the sub-factor loadings are shown in Table 4.

According to the results of the principal component analysis, the common factor variances of the items varied from 0.545 to 0.854, and the total variances explained by each factor after oblique rotation were 29.35%, 8.82%, 8.60%, 6.67%, 5.41%, 4.19%, 3.62%, and 3.32%, respectively. As seen in Table 3, the first-factor loadings ranged from 0.509 to 0.733, the second-factor loadings ranged from 0.626 to 0.808, the third-factor loadings ranged from 0.800 to 0.923, the fourth-factor loadings ranged from 0.789 to 0.852, the fifth-factor loadings ranged from 0.709 to 0.836, the sixth-factor loadings ranged from 0.575 to 0.830, the seventh-factor loadings ranged from 0.839 to 0.893, and the eighth-factor loadings ranged from 0.501 to 0.873.

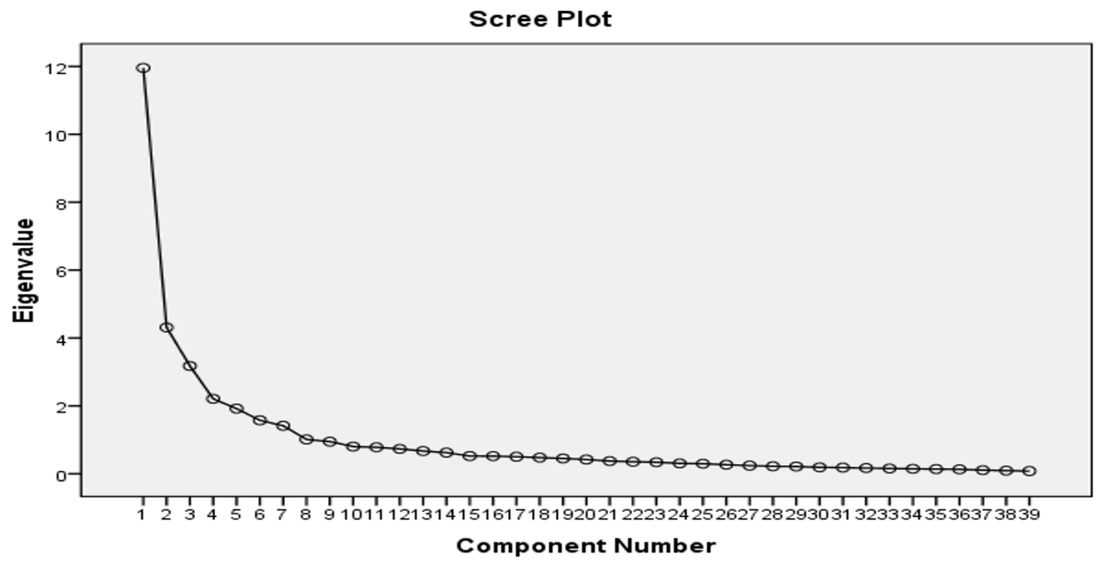

Figure 1: Eigenvalue screen plot graph of the scale

The sub-factors that resulted from the EFA were given names by considering the properties of the items they include. The sub-factor items of the scale were given in Appendix. The first factor, which contains seven items, was given the name 'mathematical knowledge and skills'. Due to external benchmark factors influencing the student's academic performance, the second factor, which contains five items, was given the name 'external benchmarks'. Because they reflect the student's social attitudes and behaviors in the classroom and at school, the third factor, which contains six items, was given the name 'social behaviors'. The fourth factor, which contains three items, was given the name 'homework performance'. The fifth factor, which contains four items, was given the name 'effort'. The sixth factor, which contains six items, was given the name 'affective skills'. The seventh factor, which contains two items, was given the name 'academic exam results'. The eighth factor, which contains three items, was given the name 'follow-up test results'.

The Pearson correlations between the scale's overall scores and its sub-factors were calculated as another construct validity

Item	Factor Common Variance	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8
B17	0.643	0.733							
B18	0.728	0.728							
B16	0.557	0.713							
B21	0.573	0.689							
B19	0.715	0.577							
B20	0.661	0.529							
B22	0.597	0.509							
B43	0.668		0.808						
B41	0.668		0.764						
B38	0.585		0.757						
B39	0.583		0.742						
B42	0.545		0.626						
B31	0.806			-0.923					
B34	0.775			-0.863					
B32	0.854			-0.861					
B30	0.813			-0.856					
B33	0.688			-0.804					
B29	0.694			-0.800					
B4	0.817				0.852				
B3	0.796				0.852				
B5	0.770				0.789				
B9	0.746					0.836			
B12	0.725					0.826			
B11	0.759					0.744			
B10	0.611					0.709			
B24	0.668						-0.830		
B26	0.706						-0.740		
B27	0.749						-0.734		
B28	0.630						-0.616		
B23	0.646						-0.589		
B25	0.679						-0.575		
B2	0.834							0.893	
B1	0.735							0.839	
B7	0.777								-0.873
B8	0.816								-0.843
B6	0.591								-0.501
Eigenvalue:		10.56	3.17	3.09	2.40	1.95	1.51	1.31	1.20
Explained Variance:		29.35%	8.82%	8.61%	6.68%	5.42%	4.19%	3.63%	3.32%
Cronbach's alpha (α):		0.90	0.85	0.93	0.83	0.90	0.86	0.83	0.80

Table 4: Pattern matrix of scale and factor loadings

Variables	1	2	3	4	5	6	7	8
Total Scale Score	0.708**	0.335**	0.642**	0.557**	0.585**	0.621**	0.643**	0.565**
1. Math Knowledge and Skills	-	0.216**	0.334**	0.351**	0.393**	0.547**	0.454**	0.405**
2. External benchmarks		-	0.284**	0.072	0.011	0.243**	0.008	0.228**
3. Social Behaviors			-	0.341**	0.329**	0.521**	0.193*	0.256**
4. Homework performance				-	0.410**	0.365**	0.127	0.438**
5. Effort					-	0.438**	0.200**	0.279**
6. Affective skills						-	0.371**	0.279**
7. Academic exam results							-	0.208**
8. Follow-up test results								-

$*p < 0.05$ $**p < 0.01$

Table 5: Pearson correlation coefficient for scale sub-factors (n = 170)

indicator (Table 5). Table 5 revealed a moderately positive and significant relationship between the overall scale and the sub-factors ($p < 0.01$), ranging from 0.335 to 0.708. Additionally, it was found that the scale sub-factors did not have a high correlation.

Findings Relating to the Confirmatory Factor Analysis (CFA)

CFA is another way to test the scale's construct validity (Field, 2005). The most common goodness-of-fit indices of the model in the CFA were used to decide whether a model should be accepted or not. Fit indices used in this current study include Chi-square (χ^2), Chi-square/degrees-of-freedom ratio (χ^2/df), Standardized Root of Squared Residual (SRMR), Goodness of Fit Index (GFI), Non-Normed Fit Index (NNFI), Incremental Fit Index (IFI), Comparative Fit Index (CFI), Root Mean Square Error of Approximation (RMSEA), and Adjusted Goodness-of-Fit Index (AGFI). For model fit, the ratio of χ^2/df should be less than 3, but less than 5 is also acceptable. When CFI, NNFI, IFI, and GFI are higher than 0.85, AGFI is higher than 0.80, and SRMR and RMSEA are less than 0.08, the model is a good fit (DeVellis and Thorne, 2021; Kline, 2016).

The items on the scale in this study were loaded under eight factors based on EFA analysis. The 36-item scale was administered to 150 math teachers, and 1st-order CFA was performed with the LISREL 8.8. The Chi-square test for goodness-of-fit in the CFA was first calculated to be $\chi^2 = 908.46$ ($df = 566$, $p < 0.001$), and the ratio of χ^2/df was found as 1.60, which was less than 3. There were correlations found between the measurement errors of items B16 and B17, B18 and B19, B20 and B21, B30 and B31, and B33 and B34. Following the necessary modifications based on the analysis results, a path diagram with 36 items consisting of this eight-factor structure was created (Figure 2). The standardized factor loadings of the model items ranged from 0.49 to 0.94, and the t-test results for items were significant ($p < 0.01$).

According to Table 6, the fit indices for the 1st-order CFA after structure modifications were found to be $\chi^2/df = 1.39$ ($\chi^2 = 782.01$, $df = 561$, $p < 0.001$), which was less than 3. This result showed the model had a good fit (Kline, 2016). Other fit indices for the final model were determined to be RMSEA = 0.051, NNFI = 0.97, IFI = 0.98, GFI = 0.77, CFI = 0.98, AGFI = 0.73, and SRMR = 0.062, respectively. Some fit indices (RMSEA, NNFI, IFI, and SRMR) indicated that the scale model had a good fit, whereas AGFI and GFI fit indices indicated that the model had an acceptable fit (DeVellis and Thorne, 2021; Kline, 2016). These findings confirm the scale's factor structure.

CFA	χ^2	df	χ^2/df	RMSEA	NNFI	IFI	GFI	CFI	AGFI	SRMR
1st-order after structure modification	782.01	561	1.39	0.051	0.97	0.98	0.77	0.98	0.73	0.062
2nd-order after structure modification	816.71	581	1.41	0.052	0.97	0.98	0.77	0.98	0.73	0.070

Table 6: Fit indices of the 1st- and 2nd- order CFA of the scale

A second-order CFA was also performed to determine the structural relationship between the scale and the sub-factors. The results in Table 7 indicated that the standardized factor loadings of the 1st-order latent variables in the model ranged from 0.21 to 0.86, and the t-test results were significant ($p < 0.01$). All of the fit indices for the 2nd-order after structure modification in Table 6 ($\chi^2 = 816.71$, $df = 581$, $\chi^2/df = 1.41$, RMSEA = 0.052, NNFI = 0.97, IFI = 0.98, GFI = 0.77, CFI = 0.98, AGFI = 0.73, and SRMR = 0.070) confirmed that the model had a good and acceptable fit (DeVellis and Thorne, 2021; Kline, 2016).

2nd-order Variable	1st-Order Variable	Factor loading	Error Variance	t-value	R^2
Grading	1. Social Behaviors	0.70	0.50	7.67	0.50
	2. Math Knowledge and Skills	0.86	0.25	9.16	0.74
	3. Effort	0.73	0.47	8.79	0.53
	4. Affective skills	0.80	0.36	7.64	0.64
	5. External benchmarks	0.21	1.02	2.13	0.04
	6. Homework performance	0.74	0.46	9.34	0.54
	7. Follow-up test results	0.58	0.47	5.34	0.53
	8. Academic exam results	0.62	0.60	6.76	0.39

Table 7: Factor loadings in the 2nd-order CFA for the scale model

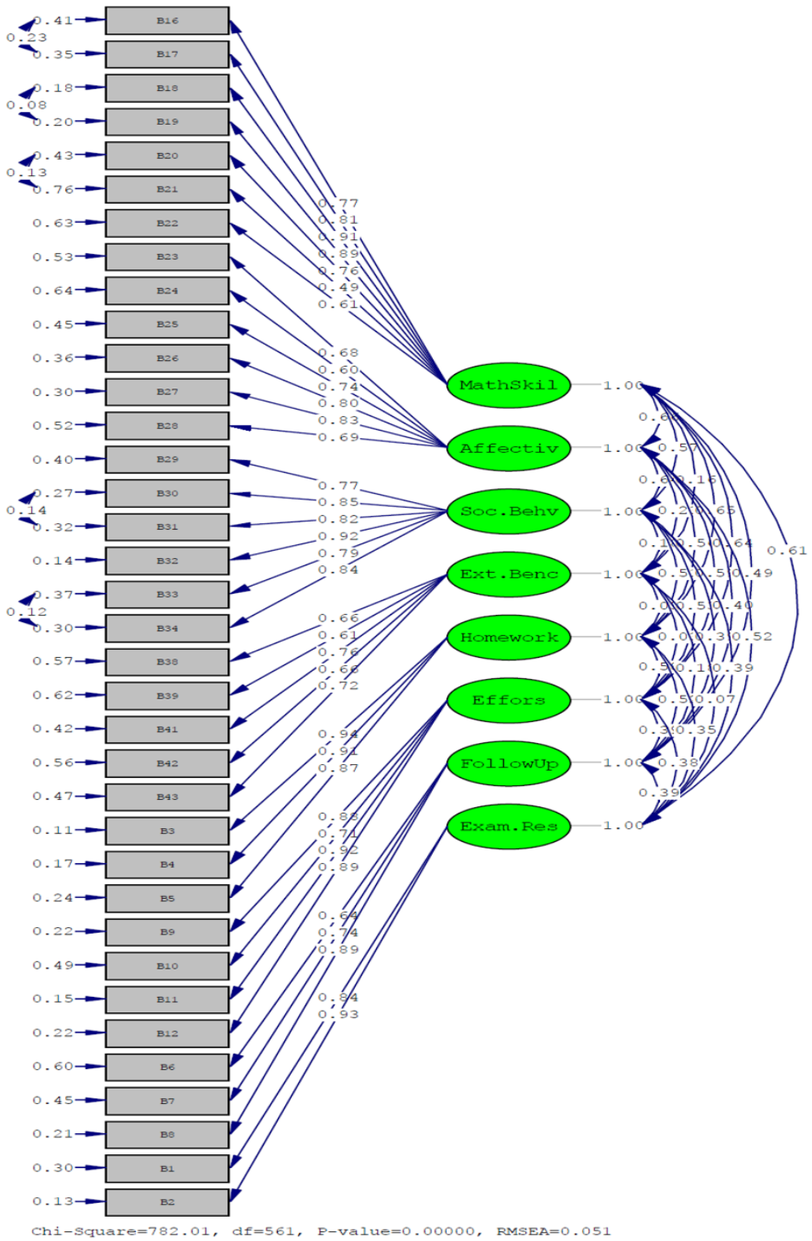

Figure 2: Factor loadings in the 1st-order CFA (standardized factor loadings)

Findings Relating to the Reliability Test

The reliability coefficient for scales measuring affective characteristics is recommended to be higher than 0.70 (Field, 2005). The overall Cronbach's alpha (α) coefficient of the scale was calculated as $\alpha = 0.92$ in this study. The Cronbach's alpha (α) coefficients for sub-factors were found to be 0.93 (Social behaviors), 0.89 (Math knowledge and skills), 0.90 (Effort), 0.86 (Affective skills), 0.85 (External benchmarks), 0.83 (Homework), 0.80 (Follow-up test results), and 0.83 (Academic exam results), respectively (Table 4).

DISCUSSION AND CONCLUSION

The study aimed to develop a scale to determine the factors that mathematics teachers consider when grading their students' in-class math performance. Item-total correlation and a *t*-test for 27% of the upper and lower groups were calculated for item analysis. It is suggested that the item-total correlation was greater than 0.30, and any items with a score between 0.20 and 0.30 were modified and improved (DeVellis and Thorne, 2021). In this study, three items were excluded because the item-total correlation of one item was less than 0.20, and two items were between 0.20 and 0.30. The item-total correlation for the remaining items ranged from 0.36 to 0.64, and the *t*-test results for the upper and lower groups were significant ($p < 0.01$). These findings indicated that the item discrimination of the scale was within an acceptable level (Field, 2005).

In the first stage of this study, EFA was performed on the scale's construct validity using principal component analysis and oblique rotation method (Oblimin), where factors are allowed to correlate. In this study, the Kaiser-Meyer-Olkin (KMO) value was 0.867, and Bartlett's sphericity test chi-square value was 4899.104 ($p < 0.001$). These findings demonstrated the feasibility of EFA (Tabachnick and Fidel, 2007). The first-factor analysis results revealed a nine-factor scale with eigenvalues greater than one. Four items were removed from the analysis since their factor loadings were less than.40 or had cross-loading. After performing the factor analysis for the remaining items, it was found that the scale composed of eight factors with 36 items, with factor loadings ranging from 0.50 to 0.92, accounting for 70.02% of the total variance. In social sciences, total variances ranging from 40% to 60% are considered sufficient on multi-factorial scales (Tabachnick and Fidell, 2007). These findings demonstrated that the scale's sub-factors and related items were sufficient to explain the factors influencing math teachers' grading practices. The correlation between the sub-factors and the overall scale was moderately significant, ranging from 0.34 to 0.71.

In this study, the items in the sub-factors were examined, and the sub-factors were labeled as 'mathematical knowledge and skills', 'external benchmarks', 'social behaviors', 'homework performance', 'effort', 'affective skills', 'academic exam success', and 'follow-up test results', respectively. Some of the grading factors that emerged in this study are consistent with previous studies (e.g., Cheng and Sun, 2015; Cizek et al., 1995; Duncan and Noonan, 2007; Frary et al., 1993; McMillan, 2001; McMillan et al., 2002). McMillan (2001) identified six factors for grading practice (i.e., academic enabling behaviors, use of external benchmarks, academic achievement, use of extra credit and borderline cases, use of graded homework, and use of homework not graded). Duncan and Noonan (2007) determined two factors for grading practices: 'academic enabling behaviors' (e.g., ability level, student effort, participation in the lesson, development, study habits, and negative behavior in the classroom) and 'use of external benchmarks' (e.g., the school's informal success policy, grade distribution of other teachers, and student success in previous years). Chen and Sun (2015) revealed three factors for grading practice: the 'norm/objective-references factor' (e.g., learning goal, other students' grades), the 'efforts factor' (e.g., homework, effort, improvement, work habit), and the 'performance factor' (e.g., academic, non-academic performance, academic ability). Previous research has shown that certain non-academic factors are effective in determining students' grades, and these factors differ depending on grade level and country. In contrast to previous research, the academic success factor for grading in this study emerged as two different sub-factors (follow-up test results and academic exam results). This finding could be explained by the fact that academic exams are an official requirement in the Turkish education system, whereas the follow-up test results are optional.

CFA is another method for determining scale construct validity (Field, 2005). First- and second-order CFA was performed on 150 math teachers who were not part of the EFA group in this study. The results of the 1st-order CFA after structure modifications indicated that the standardized factor loadings for each item ranged from 0.51 to 0.94, and the *t*-test results were significant. The model fit indices were found to be at a good and acceptable level (Kline, 2016; Tabachnick and Fidell, 2007). Moreover, the results of second-order CFA showed that the model had good fit indices. These findings confirmed the scale's sub-factors structure. The reliability coefficient for the scales should be greater than 0.70 (DeVellis and Thorne, 2021). In this study, Cronbach's alpha coefficient for the overall scale was calculated to be 0.92, and Cronbach's alpha coefficients for the sub-factors ranged from 0.80 to 0.93. The reliability analysis revealed that the overall reliability of the scale and its sub-factors was satisfactory.

The findings of this study revealed that the scale, which consists of 36 items and eight sub-factors, was a valid and reliable instrument for identifying the factors influencing mathematics teachers' grading practices regarding students' in-class performance. As a result, it can be stated that the scale will contribute to future research in this field.

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CONFLICT OF INTERESTS

The authors declare no conflict of interest.

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APPENDIX

SCALE ITEMS

To what extent do you consider the following characteristics or factors in determining a student's participation and performance in math course activities? (1 = not at all, 5 = completely)

Factor 1: *Mathematics Knowledge and Skills* *(7 items, Cronbach's alpha = 0.89)*
Item 7 (B20). Matematiksel dil ve sembolleri kullanma becerisini (Ability to use mathematical language and symbols)
Item 8 (B18). Problem çözmede öğrendiği bilgileri kullanmasını (Using the learned knowledge to solve problems
Item 9 (B17). Matematiksel bilgileri kavramasını (Understand mathematical knowledge)
Item 10 (B21). Sahip olduğu matematik yetenek düzeyini (Mathematics ability)
Item 11 (B19). Muhakeme etme ve akıl yürütme becerisini (Reasoning skills)
Item 12 (B16). Matematiksel kural, formül ve bilgileri hatırlamasını (Recall mathematical rules, formulas and information)
Item 13 (B22). Derslerde gösterilen pratik zeka göstergeleri (Practical intelligence indicators shown in the lessons)

Factor 2: *External Benchmarks* *(5 items, Cronbach's alpha = 0.85)*
Item 24 (B38). Diğer derslerdeki başarısını (Achievement level in other courses)
Item 25 (B43). Diğer okulların not/başarı politikasını (Other school' grade/achievement policy)
Item 26 (B39). Diğer öğrencilere göre başarı durumunu (Achievement status compared to other students)
Item 27 (B41). Okul idaresinin başarı politikasını (The achievement policy of the school administration)
Item 28 (B42). Sınıfın matematik başarı düzeyini (Mathematics achievement level of the class)

Factor 3: *Social Behaviors* *(6 items, Cronbach's alpha = 0.93)*
Item 1 (B32). Sınıf içindeki sosyal ve ahlaki davranışları (Social and moral behavior in the classroom)
Item 2 (B31). Diğer öğretmenler yönelik saygısı ve iletişimini (Respect and communication with other teachers)
Item 3 (B34). Sınıf içi ve okul kurallarına uyma (To comply with classroom and school rules)
Item 4 (B30). Ders öğretmenine yönelik saygısı ve iletişimi (Respect and communication towards the course teacher)
Item 5 (B29). Sınıf arkadaşlarına yönelik saygısı ve iletişimi (Respect and communication towards classmates)
Item 6 (B33). Sınıf dışındaki sosyal ve ahlaki davranışları (Social and moral behavior outside the classroom)

Factor 4: *Homework Performance* *(3 items, Cronbach's alpha = 0.83)*
Item 29 (B4). Ev ödevlerinin niteliği ve kalitesini (The quality of homework)
Item 30 (B3). Ev ödevlerinin zamanında yapılmasını (Timely completion of homework)
Item 31 (B5). Ekstra yapılan araştırma ödevlerini (Extra research assignments)

Factor 5: *Effort* *(4 items, Cronbach's alpha = 0.90)*
Item 14 (B9). Derste göstermiş olduğu gayret ve çabasını (Effort in the lesson)
Item 15 (B12). Derslere katılım düzeyi ve sıklığını (Level and frequency of participation in classes)
Item 16 (B11). Süreç içinde gösterilen gelişim performansını (The improvement performance shown in the process)
Item 17 (B10). Sınıf içinde sorulara doğru cevap verme sıklığını (Frequency of answering questions correctly in class)

Factor 6: *Affective Skills* *(6 items, Cronbach's alpha = 0.86)*
Item 18 (B24). Dersi sevme (Loving the lesson)
Item 19 (B26). Matematik çalışmalarına gönüllü olmasını (Volunteering in mathematics studies)
Item 20 (B27). Derse yönelik tutum (Attitude towards the lesson)
Item 21 (B23). Derse karşı ilgisi ve önem verme düzeyi (Interest and giving importance to the lesson)
Item 22 (B25). Öğrenme istekliliği (Willingness to lesson)
Item 23 (B28). Derse yönelik öz-güvenini (Confidence in the lesson)

Factor 7: *Academic Exam Results* *(2 items, Cronbach's alpha = 0.83)*
Item 35 (B1). Yazılı sınavlardaki performansını (Performance in written exams)
Item 36 (B2). Derse ilişkin proje görev performansını (Project task performance related to the course)

Factor 8: *Follow-up Test Results* *(3 items, Cronbach's alpha = 0.80)*
Item 32 (B8). Ünite/İzleme test sonuçlarını (Unit test results)
Item 33 (B7). Deneme sınav sonuçlarını (Trial exam results)
Item 34 (B6). Yapılan ara sınav (quiz) sonuçlarını (The results of the pop quizzes)

Items removed from the scale:
B13. Derse devam-devamsızlık durumunu (Course attendance-absence status)
B14. Ders araç-gereçlerini düzenli olarak getirmesini (Bring the course equipment regularly)
B15. Verilen görev ve sorumluluklarını yerine getirmesini (To fulfill the assigned duties and responsibilities)
B35. Kişisel bakım, giyim ve temizliğini (Personal care, clothing and cleaning)
B36. Velinin statüsünü (Parent's status)
B37. Diğer öğretmenlerin not dağılımını (Distribution of grades of other teachers)
B40. Velinin öğretmen ile iletişim düzeyi (Parent's level of communication with the teacher)

Full research paper

DIGITAL STORYTELLING IN ECONOMICS SUBJECTS AND ITS EFFECTIVENESS ON STUDENT LEARNING OUTCOMES BY GENDER AND DIFFERENT ECONOMIC KNOWLEDGE

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ABSTRACT

Digital storytelling (DST) is one of the alternative teaching methods and previous research shows its positive impact on students' motivation and learning outcomes, especially in humanities subjects. In vocational subjects such as economics, the effectiveness of this method is questionable. 856 respondents aged 15 to 19 from six business academies in the Czech Republic took part in the testing, which focused on the effectiveness of digital storytelling in economics. This paper presents other possible factors that may have influenced students' performance in the post-test. A comparison of the results from the pre-tests and post-tests of the experimental and control groups showed that the students from the experimental group reached higher mean values in the post-test than the students from the control group. It was also found that in the group that used digital storytelling, the year of study and the initial knowledge of the students assessed in the pre-test influenced the mean post-test scores. On the other hand, the factor of students' gender was not demonstrated. At the end of the testing, a questionnaire survey was conducted to investigate students' views on digital storytelling and their preferences for teaching methods.

KEYWORDS

Business academy, digital storytelling, economics, education, standard teaching, student achievement

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Highlights

- *The use of the alternative teaching method DST does not differentially affect learning outcomes by gender.*
- *The use of the alternative teaching method DST differentially affects learning outcomes by year of study in high school.*
- *The use DST method and standard teaching in economics does not have a differential effect on the learning outcomes of students with lower pre-test scores.*
- *The use of DST method and standard teaching in economics has a differential effect on the learning outcomes of students with higher pre-test scores.*
- *DST method has a higher effect on students' learning outcomes with higher pre-test scores than standard teaching.*

INTRODUCTION

Digital storytelling, abbreviated as DST, is one of the tools that can be used to draw the attention of the audience and convey information and knowledge. In earlier times, storytelling was one of the few ways people passed on their experiences, advice, and traditions. With the proliferation of printing, computers, databases, and electronic communication, information has become freely available in endless quantities and people are now overwhelmed by information. It is becoming increasingly difficult to engage the viewer and the story is once again proving to be a powerful tool in business communication (Dolan, 2017), marketing (Mengu et al., 2017; Phillips, 2012), personal life (Ramsden and Hollingsworth, 2013) and education (Miller, 2014). As Frazel (2010) wrote in his book, digital storytelling is a modern expression of old art. Digital stories are created using audiovisual technology and with the development of information technology and other tools, there are new ways to use this 'old art'. People share their experiences through social networks (YouTube, Instagram, tik-tok, etc.) and present them as personal stories (Sanchez-Lopez et al., 2020). Storytelling creators use photos, videos, text, music, the narrator's voice, and sound effects to create multimedia presentations on a given topic. Stories can connect theoretical knowledge with real life and attract, inspire and evoke positive and negative emotions. Linking listening and visual perception with the experience of certain emotions can help to better understand and remember the information presented. For example, better memorization through the elicitation of emotions was confirmed by a survey conducted in 2014 in Greece (Papadopoulou and Vlachos, 2014). The main aim of the research was to find out whether the repetition of already known concepts using the DST method and inducing emotions would help in better memorization. The research results show an improvement in language skills, higher motivation, and engagement of students in the learning process. All the mentioned attributes of this tool predispose digital storytelling to be used in the process of education.

Ongoing research around the world verifies the benefits of multimedia and digital storytelling in education. In their article, the authors (Wu and Chen, 2020) reviewed research on the use of digital storytelling conducted between 1993 and December 2018. The studies cited in the article and many others show the overwhelmingly positive impact of this alternative teaching method on student motivation, critical thinking, and academic achievement. Pupils in primary schools (Hung et al., 2012; Liu, Huang and Xu, 2018; Tsou et al., 2006; Yang and Wu, 2012), secondary schools (Lestari et al., 2019; Lin et al., 2013) and universities (Goldingay et al., 2018; Hafner and Miller, 2011) perceive digital stories in teaching as diversification of teaching and linking theoretical knowledge with real life. The results of studies show that especially in foreign language teaching (Afrilyasanti and Basthomy, 2011; Anderson and Macleroy, 2016; Heathfield, 2014; Yang and Wu, 2012), literature (Balaman, 2018; Yuksel, Robin and McNeil, 2021), psychology (Belland, 2017) and other humanities and social sciences, digital storytelling has positive results on students' learning outcomes and motivation. This teaching method has also been tested in mathematics (Niemi et al., 2018), technology, and natural sciences (Belland, 2017), and also here a positive effect was confirmed mainly on the cognitive results of the students. In contrast, Stocchetti (2016) together with other authors of the articles, points out that the role of digital storytelling is often overestimated and highlights the benefits and risks of using information technology in education. Some research shows contradictory results. Research conducted in a junior elementary school in Taiwan in 2014 during English language and literature classes evaluated the DST method as unsatisfactory. Students were not shown to have a better understanding of the selected concepts, nor was there evidence of a positive effect on students' motivation (Liu et al., 2014). The authors reached similar results in a survey that was also conducted in a primary school in Taiwan in 2017. Some students were more motivated after using the method, while others were demotivated (Belland, 2017; Huang et al., 2017). Belland (2017) investigated the effectiveness of digital stories in STEM subjects, i.e., science, technology, engineering, and mathematics, and points out that the high effectiveness of this method may not be true in all subjects.

In economics subjects, according to available sources, a survey was conducted in 2001 at a university in Bratislava (Andrasik, 2023). Using digital stories, students were introduced to several possible causes of economic behaviour that affect the business cycle and then explained the mathematical methods that solved the given problem. However, this study did not investigate the impact of using different teaching methods. Another survey focused on the use of digital storytelling in economics courses was conducted by the authors (Lestari et al., 2019). The authors focused on the influence of alternative teaching methods on students' motivation and the atmosphere during the teaching. The results, which were obtained by means of a questionnaire survey, show that students rated the effectiveness of the media used and digital storytelling very positively. However, this research also did not investigate the impact of digital storytelling on student learning outcomes in an economics subject.

Many factors influence the effectiveness of the digital storytelling teaching method, such as the subject taught, the topic, the chosen story, and its processing. Each person is an individual, perceives the world around him/her differently, and is focused on different stimuli. As Minhova (2012) states, a large number of images can increase the cognitive load of students and can be distracting. Interpretation can become confusing and complex. It is important to include lesson-specific visual material and to select it with the age and mental level of the learners in mind. In the author's opinion, the verbal presentation should remain the basic teaching method and pictorial material should serve as a supplement to facilitate understanding of the material (Minhova, 2012). As Pratten (2015) states, the key to the success of digital storytelling in education is to create a story that appeals to as many audiences as possible. An important prerequisite is the author's understanding of the audience. The author must be able to put himself/herself in the shoes of the listener and create a story based on age, gender, education, or social status (Pratten, 2015). In schools, students are usually divided into classes according to age, which is optimal for creating a digital story for a given class. However, there may be differences in knowledge of the subject. Another variable that can affect the effectiveness of the story being told is the gender of the student. Teaching in schools is done together in most subjects, and digital stories may affect males and females differently.

The aim of this research is to discover whether the effect of digital storytelling on students' learning outcomes in an economics subject is related to the year of study of the students, their prior knowledge of the economics, and the gender of the student. First, the methodology of the pedagogical experiment and the method of data collection are described. The results are presented in four subsections. The first subchapter focuses on differences in post-test scores by year of study. The second subchapter reports whether there are significant differences in post-test score based on the student's gender, and the third subchapter examines the effect of DST as a function of pre-test performance. The questionnaire

survey focusing on students' motivation and critical thinking is evaluated in the fourth subsection. The results obtained are summarized in the discussion chapter, the limitations of this pedagogical experiment and suggestions for further research are given in the conclusion.

MATERIALS AND METHODS

Based on the given objective, mixed research was carried out, where quantitative research is predominant, complemented by qualitative research. First, pilot research was conducted with a small number of respondents in which the test instruments were validated on a different economic topic. A total of 82 business academy students in the Czech Republic were randomly divided into two groups and taught using two different methods on the topic "Total and Marginal Utility". The students in the experimental group (n = 41) watched the digital storytelling and the students in the control group (n = 41) listened to the teacher's explanation with the support of the presentation. Several changes in methodology were made after the pilot phase. The total number of six questions in the pre-test and post-test was increased to 16 due to the higher reliability of testing, and the total number of six questions in the questionnaire survey was increased to 10. Unlike the pedagogical experiment, the pilot phase was conducted in person (Nunvarova et al., 2023).

A total of six business academies from the Czech Republic participated in the pedagogical experiment, which was conducted during online learning from February to June 2021 via MS Teams. A total of 856 respondents from all four grades of business-oriented secondary schools, i.e., aged 15 to 19, were tested. Students were randomly divided into two independent groups in each grade. There was a total of 430 students in the experimental group and 426 students in the control group. The economic topic "Demand, Supply and Price Elasticity" was selected for testing based on the Framework Curriculum, which is mandatory for all business academies, and the School Curriculum of all participating schools. Testing was carried out only in those classes in which this topic had not yet been covered. Jana Nunvarova, one of the authors of this article, who is also an economics teacher at the business academy, created a digital storytelling (DST) called "How Vojta sold shoes". DST has been validated by experts and was used in the teaching of an experimental group. The video lasts a total of 7 minutes and tells the story of a boy who has just graduated from a business academy and has been offered to take over his family's shoe shop. Through his mistakes, the young inexperienced salesman gradually tests his knowledge from the business academy, the basic principles of the market mechanism and the theoretical knowledge of price elasticity of demand. In the control group, the concepts of demand, supply and price elasticity were explained using the standard method, i.e., teacher explanation supported by a presentation. The effectiveness of both methods on students' learning outcomes was verified by the same tests for both groups. The pre-test and post-test contained a total of 16 identical closed questions on the given economic topic. The reliability of the test was verified using the Kuder-Richardson formulas20 (Mares et al., 2015). The observed value of 0.714 satisfies the lower limit for a test with good reliability.

Students in the experimental and control groups were tested separately for one class period, i.e., for 45 minutes. As shown in the flowchart in Figure 1, both groups were first introduced to the testing procedure via MS Teams and completed the pre-tests using MS Forms. Then, the experimental group students watched the digital storytelling and the control group students listened to the teacher's explanation with the support of the presentation. After introducing the given economic topic using different teaching methods, students of both groups completed the post-tests. In order to evaluate which method suited them better for the topic, a second teaching method was applied to both groups after completing the post-tests. The students in the experimental group listened to the teacher's explanation supported by the presentation and the control group watched DST. At the end of the lesson, both groups completed a questionnaire focusing on students' motivation and critical thinking. In it, students could give their opinions on both teaching methods and answer the questions using a Likert scale.

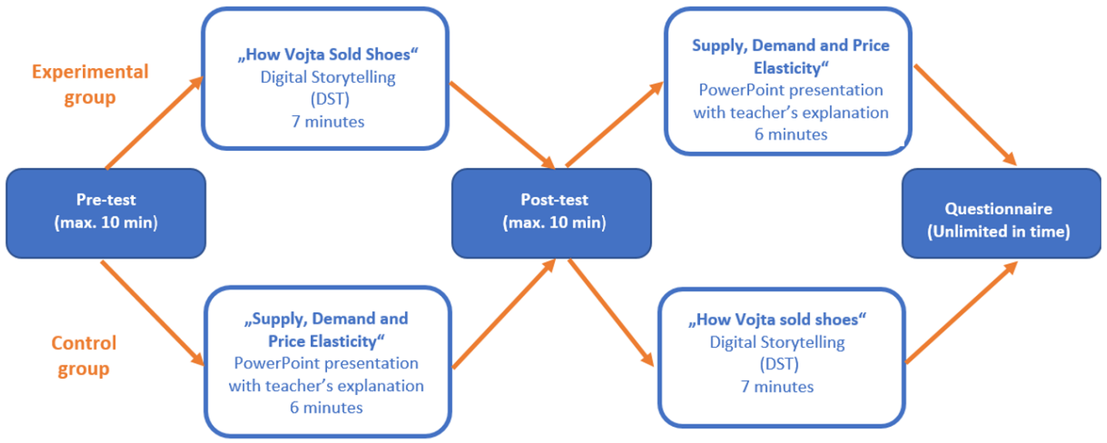

Figure 1: Diagram of testing schedule, (source: own processing)

The data obtained from the pre-tests, post-tests, and questionnaire survey were processed using MS Excel and the calculations were performed using IBM SPSS Statistics 26 software. A significance level of 5% was considered when performing the tests. The students' academic performance was compared not only between the experimental and control groups, but also depending on the duration of study, gender of the students or their initial knowledge. The gender of the students was determined by the binary categorization of male and female, as usually indicated at birth. The length of study was determined by the year the student attended at the time of testing. It was not considered if a student repeated a year for any reason. For example, although he/she would have studied one year longer, he/she would have lacked the knowledge of the next year. Initial knowledge of a given economic topic was assessed through a pre-test which students complete before using the standard or alternative teaching method. Specifically, students' performance was compared according to their group affiliation, determining the pre-test's 1st and 4th quartiles. Students were divided into a group of those who performed worse in the pre-test and a group of those who performed well in the pre-test. For these two groups, it was assessed whether storytelling was a better way of teaching for them.

In this paper, we would like to deal with the following hypotheses:

H1: In the group that used the DST method, gender has an impact on the mean score of the post-test.

H2: In the group that used the DST method, the year of study has an impact on the mean score of the post-test.

H3: The use of DST methods in economics has a different effect on the post-test scores of students who are in the first quartile (Q1) according to the pre-test results.

H4: The use of DST methods in economics has a different effect on the post-test scores of students who fall into the fourth quartile (Q4) according to the pre-test results.

RESULTS

The students' initial knowledge of supply, demand and price elasticity was tested using a pre-test containing 16 closed questions. After using the DST method in the experimental group and the teacher's explanation supported by the presentation in the control group, a post-test was used to determine the differences in the students' results. The results of the paper (Nunvarova, Poulova, Prazak & Klimova, 2023) were that students in the experimental group had slightly worse results in the pre-test than students in the control group and that students in the experimental group achieved the same results in the post-test as students in the control group. This means that the DST method is not worse than standard teaching methods. Furthermore, repeated measures ANOVA showed that students in the experimental group had a higher individual mean success rate in the post-test than students in the control group. The similar result can be verified by the t-test performed on the difference between the individual score of the post-test and the pre-test. The mean difference score of the experimental group (n_1 = 430) is 1.754 ($s.d.$ 2.677) and the mean difference score of the control group (n_2 = 426) is 1.228 ($s.d.$ 2.667). Using the t-test for two independent samples with equal variances (Levene's test, $F(1, 854) = 0.108$, p-value = .743), we can see that the difference score of the experimental group is significantly higher than the difference score of the control group ($t(854) = 2.879$, p-value = 0.002). This means that the students in the experimental group who were taught with the help of storytelling achieved higher scores in the post-test individually.

Here we present other possible factors that were recorded and that might influence the students' results in the post-test. In particular, we consider the following factors: *group* (experimental/control, 430/426), *gender* (male/female, 304/552) and *class* (4 classes of high schools - the class 1 includes students in their first year of study etc., 140/301/258/157).

Data were analyzed using ANOVA with three factors given. The results showed that the factor *group* ($F(1, 850) = 0.225$, p-value 0.636) and the factor *gender* ($F(1, 850) = 0.378$, p-value 0.539) were not significant in the post-test. On the other hand, the factor *class* was found to be significant ($F(3, 850) = 3.309$, p-value 0.020) and, therefore, a more detailed analysis was conducted focusing on this factor. None of the interactions between the factors are significant. Based on these results, we do not have sufficient evidence for hypothesis H1 that gender has an impact on the mean score of the post-test. We have also found evidence for hypothesis H2 that the year of study influences the mean score of the post-test, but we will discuss this issue in more detail in the next section.

Differences in post-test scores based on the year of study

The analysis focusing on the factor *class*, which turned out to be significant in the previous test, is divided into two steps, one for the experimental group and one for the control group, see Figure 2 and Table 1.

First, the one-way ANOVA test was conducted for the experimental group with the factor *class*, which proved to be significant ($F(3, 426)=3.723$, p-value 0.012, $eta2$=0.026), which means that the factor *class* influences the mean score of the post-test in the experimental group, although the effect size is relatively small. The Tukey's post-hoc test for multiple comparisons shows significant differences between class 1 and class 4 (p-value 0.038, 95% CI of the difference [-2.45, -0.05]) and between class 2 and class 4 (p-value 0.011, 95% CI of the difference [-2.24, -0.23]). On the other hand, the results of the one-way ANOVA test for the control group with factor *class* indicate that there were no significant differences among them ($F(3, 422) = 0.565$, p-value 0.638). This means that we do not have enough evidence that the factor *class* influences the mean score of the post-test in the control group. Based on the given results, we have sufficient evidence for hypothesis H2 that the year of study has an impact on the mean score of the post-test in the experimental group.

Assessment of the effectiveness of alternative learning (digital storytelling) and depending on the results in the pre-test

Further data analysis focused on assessing the post-test results of the experimental and control groups in relation to their placement in the pre-test. Specifically, students'

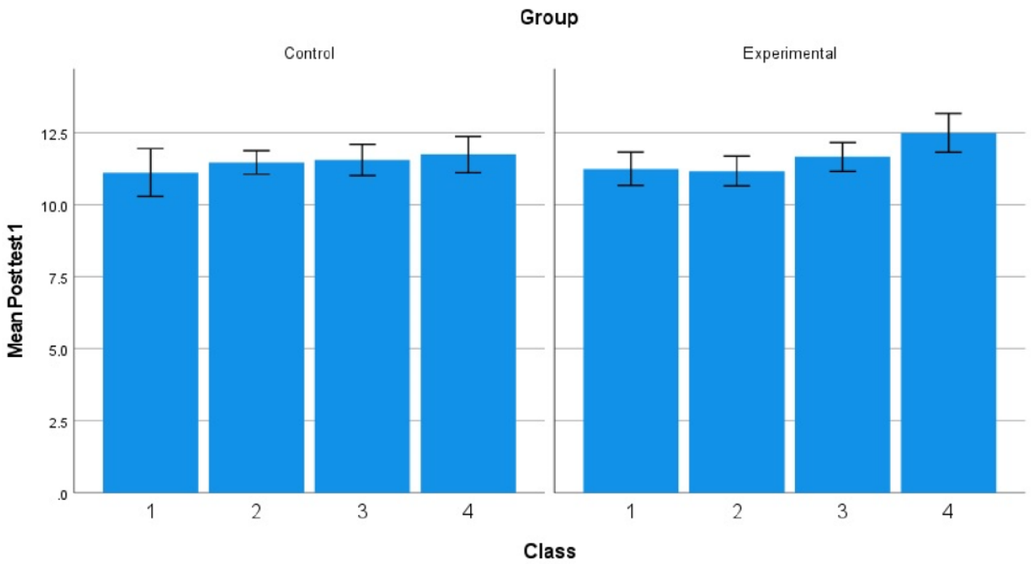

Figure 2: Mean post-test scores in the experimental and control groups. Error bars means 95% CI (source: own arrangements in IBM SPSS Statistics)

Group	Class	*N*	Mean	Std. Deviation	Grouped Median	Maximum	Minimum
Experimental	1	79	11.25	2.569	11.42	16	5
	2	118	11.18	2.821	11.28	16	5
	3	153	11.67	3.122	12.00	16	2
	4	80	12.50	3.052	13.39	16	3
	Total	430	11.61	2.960	12.02	16	2
Control	1	61	11.13	3.227	11.50	16	3
	2	183	11.48	2.757	11.66	16	3
	3	105	11.56	2.835	11.90	16	2
	4	77	11.75	2.754	12.00	16	6
	Total	426	11.50	2.843	11.78	16	2

Table 1: Descriptive statistics of the post-test in the experimental and control groups (source: own computations in IBM SPSS Statistics)

performance was compared according to their group membership, determining the pre-test's 1st and 4th quartiles. That is, students were divided into a group of those who performed worse in the pre-test and a group of those who performed well in the pre-test. For these two groups, it was assessed whether storytelling was a better way of teaching for them or not.

The descriptive statistics of the pre-test is presented in Table 2 and the corresponding quartiles of the pre-test scores are presented in Table 3.

	N	mean	standard deviation	95% confidence interval		minimum	maximum
				lower limit	upper limit		
Pre-test	856	10.06	2.356	9.91	10.22	2	16
Pre-test, experimental group	430	9.86	2.303	9.64	10.08	3	16
Pre-test, control group	426	10.27	2.393	10.04	10.50	2	16

Table 2: Descriptive statistics of the pre-test (source: source: own calculations in SPSS Statistics)

Based on these scores, the respondents (students) were divided into 2 groups. The first group, which we will label S, included all students who received a pre-test score less than the first quartile of Q1, i.e., 9 points. This group contains 212 students, of which 118 are in the experimental group and 94 are in the control group. The second group, which we mark by D, includes those students who received scores greater than or equal to the third quartile of Q3, i.e., 12 points, in the pre-test. This group contains 230 students, of which 98 are in the experimental group and 132 in the control group.

The results of the post-test in groups S are summarized in Table 4.

	Q1	Q2	Q3
Pre-test	9	10	12

Table 3: Quartiles of the pre-test, (source: own calculations in SPSS Statistics)

	N	mean	standard deviation	95% confidence interval		minimum	maximum
				lower limit	upper limit		
Post-test for students S	212	9.83	3.049	9.42	10.25	2	16
Post-test, experimental group S	118	9.94	3.081	9.38	10.50	2	16
Post-test, control group S	94	9.70	3.019	9.08	10.32	2	16

Table 4: Descriptive statistics of the post-test for students with low scores in the pre-test (source: own calculations in SPSS Statistics)

Based on a *t*-test for the means of two independent samples with identical variances (Levene's test, $F(1, 210) = 0.028$, *p*-value = 0.866) it cannot be shown at the 0.05 level of significance that students with low scores on the pre-test (Q1) from the experimental group perform differently than students with low scores on the pre-test (Q1) from the control group (t (210) = 0.565, *p*-value = 0.573). The difference between teaching methods is statistically insignificant and, therefore, we reject hypothesis H3, that the use of DST methods in economics has a different effect on the post-test scores of students who are in the first quartile (Q1) according to the pre-test results. This means that the observations made for the group of students labelled S who were in the first quartile of Q1 show no difference in teaching style, and teaching using storytelling does not result in different outcomes for this group of students than standard teaching.

The results of the post-test in group D are summarized in Table 5.

	N	mean	standard deviation	95% confidence interval		minimum	maximum
				lower limit	upper limit		
Post-test for students D	230	13.44	2.037	13.17	13.70	7	16
Post-test, experimental group D	98	13.53	1.914	13.53	14.30	8	16
Post-test, control group D	132	12.73	2.060	12.73	13.44	7	16

Table 5: Descriptive statistics of the post-test for students with high scores in the pre-test (source: source: own calculations in SPSS Statistics)

Table 5 shows the values obtained in group D. The students of the experimental group, i.e., those who were taught using the digital storytelling method, achieved an average score of 13.53, while the students of the control group achieved an average score of 12.73. Based on a *t*-test for the means of two samples with equal variance (Levene's test, $F(1, 228) = 1.854$, *p*-value = 0.175), it can be shown at the 0.05 significance level that students in the experimental group, perform significantly better than students in the control group (t (228) = 3.132, *p*-value < 0.001). Based on these obtained results, we fail to reject the hypothesis H4 that the use of DST methods in economics has a different effect on the post-test scores of students who fall into the fourth quartile (Q4) according to the pre-test results. This means that the observations made for the group of students (D) demonstrate a difference in teaching style and teaching using digital storytelling shows better results for this group of students than standard teaching.

Evaluation of a questionnaire survey focused on student motivation and critical thinking

At the end of the testing, students in both the experimental and control groups completed a questionnaire survey. The questionnaire consisted of 10 closed-ended questions, which were answered using a 4-point Likert scale (definitely no - rather no - probably yes - definitely yes) or by selecting from the teaching methods. Students were also given the opportunity to write additional comments on the methods used in teaching economics. The graphical representation of the answers to the selected questions shows the students' attitude towards the alternative method of digital storytelling.

Figure 3shows the intensity of students' agreement with the statement that they remembered the selected economic concepts better after watching digital storytelling than after standard teaching, i.e., teacher explanation supported by a presentation. As the graph shows, 62.8% of the students in the experimental group and 69.2% of the students in the control group agree or strongly agree with this statement.

The next question focused on students' preferences when choosing between two teaching methods. Again, students answered using a Likert scale whether they preferred digital storytelling to standard teaching (teacher explanation supported by a presentation) in teaching economics. As shown in the Figure 4, 55.5% of students in the control group preferred the alternative teaching method - digital storytelling. In the experimental group, 45.41% of students answered "rather yes" or "definitely yes" to this statement.

In question 9, students already directly select the teaching method from four options. The options offered were the alternative method of digital storytelling, standard teaching (teacher interpretation supported by a presentation), a combination of both options and self-study. The self-study option was offered because the students may have already encountered the concepts being explained, even though this economic topic had not been discussed in the year's

economics course so far. As shown in Figure 5, the majority of the students chose a combination of both options, regardless of their inclusion in the experimental group (61.35%) or control group (63.33%).

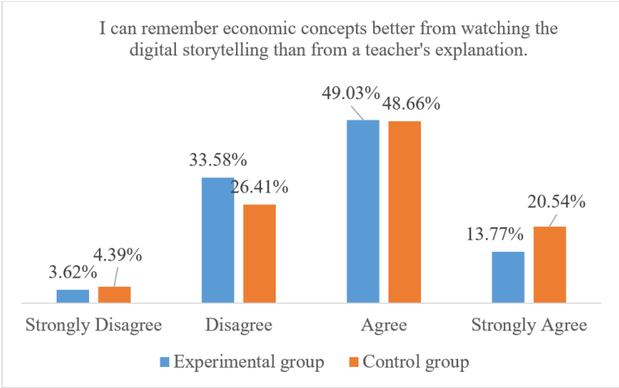

Figure 3: Graphical processing of question 4 from the questionnaire survey (source: own processing)

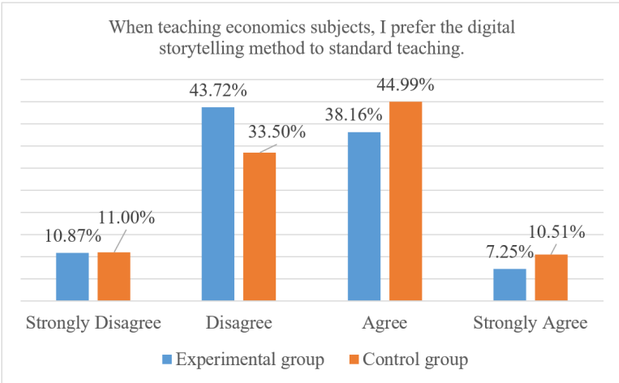

Figure 4: Graphical processing of question 8 from the questionnaire survey (source: own processing)

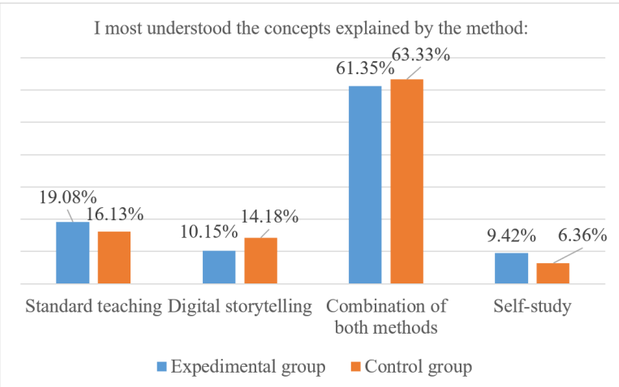

Figure 5: Graphical processing of question 9 from the questionnaire survey (source: own processing)

This result is also confirmed by the students' opinions written in the questionnaire survey. For example, a student (17 years old) of the third year of business academy from the control group wrote: *"I think the teacher's explanation is necessary. At the same time, thanks to DST, I can better visualize the information and connect it with the theory from the explanation. That's why I find the combination the best."* The opinion of another fourth-year student (19 years old) from the experimental group was, *"Definitely, the combination of interpretation and storytelling is good. But it depends on the topic being discussed and also the fact that something different suits everyone."* Another opinion was written by a student (19 years old) studying year 4: *"I liked storytelling and I think it is a good way to learn. I remembered the story more. Anyway, concepts are better remembered when you see them in front of you with the definition - as it was in the presentation. The combination of both seems perfect to me. But first the interpretation and then the storytelling. One learns something about the theory and then sees it in practice."* The students (19.08% of the experimental group and 16.03% of the control group) who chose the standard teaching option in question 9 explained their choice with greater clarity and the possibility to read or note the information. As one of the students (18 years old) of the fourth year stated, *"I often get lost in storytelling, unlike in presentations where everything is clear."* The opposite view was shared by a student (17 years) from the third-year control group. *"Storytelling is much more interesting and grabs a lot more attention than a teacher's explanation. It's more memorable in an entertaining way than just an explanation."* As shown in Figure 5, 10.15% of the students in the experimental group and 14.18% of the students in the control group agreed with her opinion.

One of the questions in the questionnaire survey focused on the order of teaching methods when they are combined. In Figure 6, we can see that a higher percentage of students from both the experimental (50.97%) and the control group (57.95%) preferred to first listen to the teacher's explanation with the support of a presentation and then watch the digital storytelling when combining the two options.

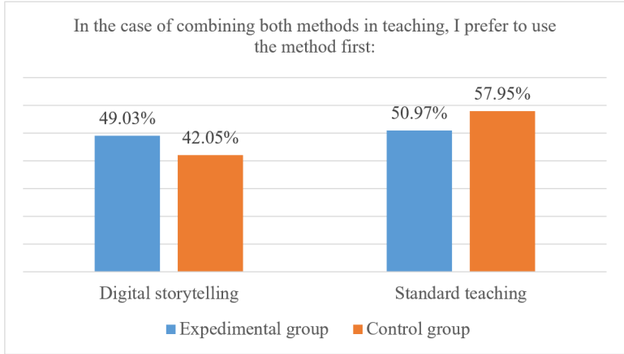

Figure 6: Graphical processing of question 10 from the questionnaire survey (source: own processing)

A 17-year-old student in Year 3 from the experimental group wrote: *"Definitely the teacher's explanation first with the support of the presentation and then storytelling, I personally find it better this way. Although it is true that after the storytelling, I already understood some of the concepts in the presentation better."* However, the percentage difference in the number of students who would prefer the opposite order is not very large. For example, a student aged 16 from the second year of the experimental group stated, *"I would prefer the DST first and then the classical interpretation. The story was able to keep my attention more, but I understood some things better from the presentation. That's why the combination of both methods suits me probably the most."*

As can be seen from the results, the students' opinions on the order of teaching methods differ, but the majority of students prefer a combination of both methods. They perceive digital storytelling as a pleasant diversification of teaching, stories keep their attention. Students appreciate the DST method for linking theoretical concepts with practice and for better memorization of selected economic concepts. A fourth-year pupil from the experimental group wrote *"Digital storytelling is a great method to really understand the material. It doesn't provide the students with meaningless concepts but puts them into practice and therefore forces them to de facto construct the definitions of the concepts and derive them from the information in the story. Although some of the definitions need to be said independently afterwards, storytelling is a great method not only to teach students the concepts but also to show them how they work in real life. I enjoyed it tremendously, and the difference between the attention I personally gave to the DST and the presentation was also a difference - without meaning to, I caught myself distracted, not paying attention, at the beginning of the presentation. That didn't happen to me with DST."*

DISCUSSION

This research aimed to discover whether the effect of digital storytelling on students' learning outcomes in an economics subject is related to the year of study of the students, their prior knowledge of economics, and the gender of the student. At the same time, a questionnaire survey was conducted to find out students' opinions about the digital storytelling method in teaching economics subjects. The research was conducted from February to June 2021 as part of online distance learning and involved a total of 856 students aged 15 to 19 at six business academies in the Czech Republic. The students were randomly divided into two independent groups. The 430 respondents in the experimental group viewed digital storytelling on the topic of supply, demand and price elasticity, while 426 respondents in the control group were taught by standard teaching method (teacher's explanation supported by a PowerPoint presentation). The students' initial knowledge was tested using a pre-test containing a total of 16 closed questions, and after the application of the DST method and standard teaching, a post-test with

the same questions was used to determine differences in the student's results. The data were analysed according to three factors that may have influenced the students' performance on the post-test. These include factor *group* (experimental/control), *gender* (male/female) and *class* (4 high school classes - class 1 includes first-year students etc.). A multi-way ANOVA test was conducted with three given factors, in which the factor *group* and the factor *gender* were found to be not significant. Based on these results, we do not have sufficient evidence for hypothesis H1 that gender has an impact on the mean score of the post-test. This result is supported by previous research (Gerstner and Bogner, 2009; Oludipe, 2012) that tested the effect of different teaching methods by gender and found no significant difference in student achievement.

The factor *class*, on the other hand, was evaluated as statistically significant, and therefore a more detailed analysis was performed.

First, a one-way ANOVA test was performed for the experimental group, which was again found to be statistically significant. However, the one-way ANOVA test for the control group with the factor *class* showed the opposite results, i.e. that the different years of study did not show significant differences in the mean post-test scores after using both methods. This means that we do not have enough evidence that the factor class influences the mean score of the post-test in the control group. Based on the given results, we have sufficient evidence for hypothesis H2 that the year of study has an impact on the mean score of the post-test in the experimental group. No other research was found in the available sources that focused on the effect of DST on learning outcomes as a function of students' age. According to previous research, the DST method is suitable for all levels of education and yields positive learning outcomes in elementary schools (Liu, Yang and Chao, 2019), middle schools (Lin et al., 2013), and universities (Sheafer, 2017).Usually, respondents of the same age are tested together.

Another factor that could affect digital storytelling's effectiveness in teaching economics is initial knowledge of the topic. Therefore, the results of the students of the experimental group and control group in the post-test were assessed in relation to their ranking in the pre-test. Students were ranked according to their pre-test scores and divided into four groups, according to quartiles. Based on these results, two groups were formed. The first group (S) included all students who received a pre-test score less than the first quartile of Q1, i.e., 9 points. This group contained 212 students (118 in the experimental group and 94 in the control group). These students scored lower than the others in the pre-test and, therefore, less initial knowledge of the economic topic can be assumed. Students with low pre-test scores in the experimental group were not shown to perform differently on the post-test than students with low pre-test scores in the control group. The difference between teaching methods is statistically insignificant, and therefore we reject hypothesis H3 that the use of DST methods in economics has a different effect on post-test results for students who are in the first quartile (Q1) according to the pre-test results.

The second group (D) included students who scored greater than or equal to the third quartile of Q3, i.e., 12 points, on the pre-test. Thus, the initial knowledge of these students was better than that of the other respondents in this area. This group contained 230 students (98 in the experimental group and 132 in the control group). For this group (D), at the 0.05 level of significance, it was shown that students in the experimental group, performed significantly better than students in the control group. Based on these obtained results we fail to reject the hypothesis H4 that the use of DST methods in economics has a different effect on the post-test scores of students who fall into the fourth quartile (Q4) according to the pre-test results. This means that the observations made for the group of students (D), demonstrate a difference in teaching style and teaching using digital storytelling shows better results for this group of students than standard teaching. For students with an average better result in the pre-test, digital storytelling helped them understand the subject better by linking theory with practice. The alternative method was more effective in teaching the economic topic. In the case of students with a lower average score on the pre-tests, their learning outcomes on the post-test were not affected by the teaching method. Thus, it can be said that for students with worse results, it does not matter which teaching method is chosen. On the contrary, for students with better learning outcomes, the choice of teaching method will significantly affect students' future knowledge. The results can be compared with a study (Nwagbo, 2006) that investigated the relative efficacy of the guided inquiry and the expository teaching methods on the achievement in and attitude to biology of students of different levels of scientific literacy in four secondary schools in Nsukka, Enugu State, Nigeria. The study found no statistically significant difference between teaching methods and the level of scientific literacy on achievement in biology. The study's conclusions are inconsistent with the results of the pedagogical experiment in terms of the effectiveness of different teaching methods depending on the results in the pre-test. In the pedagogical experiment, the DST method had different effects on the post-test scores of students with higher initial knowledge and students with lower initial knowledge. The reason may be the difference in the subjects and teaching methods used in testing, and the requirements for initial knowledge (basic economic concepts and the level of science literacy). In economics, a similar study was conducted in four different high schools in Northern California (Mergendoller et al., 2006). This study compared the effectiveness of problem-based learning (PBL) and traditional instructional approaches in teaching macroeconomics while also examining whether PBL method had the same effect on students who demonstrated different levels of four skills: verbal ability, interest in economics, preference for group work, and problem-solving efficacy. Overall, PBL was found to be a more effective approach to teaching macroeconomics than traditional lecture. Thus, there was no confirmed difference in effectiveness of the teaching methods used with respect to the level of the four chosen skills, which again represents different results with the pedagogical experiment. In the pedagogical experiment, the greater effectiveness of the DST method in economics was demonstrated only for students with higher initial knowledge, not for students with lower initial knowledge. This may again be due to differences in teaching methods and the way students are divided into groups. The effectiveness of teaching methods in economics has also been investigated in studies (Kirchherr and Piscicelli, 2019; Wetzel et al., 1982), but none of the mentioned studies investigated the effect of DST method.

Another issue is the motivation and interest of students in their studies. The questionnaire survey confirmed the results of previous research both in different subjects (Belland, 2017; Chan et al., 2017; Jonassen, 2003; Lin et al., 2013; Miller, 2014; Schiro, 2004; Wu and Chen, 2020) and in the field of economics (Andrasik, 2023; Lestari et al., 2019) evolutionary animation and programmed learning. System dynamics approach using storytelling helps understanding a multitude of complex behaviours arisen in contemporary economy. Method is advantageous first of all in situations where explanation of complex phenomena is required too sophisticated mathematical tools. Using those simulation (numerical. Students perceive the DST method as more enjoyable than standard teaching, in which they maintain more attention and remember more from watching a digital story. As shown in Figure 3, more than half of the students in the experimental and control groups agree with the statement that they remember selected economic concepts better after watching digital storytelling than after standard teaching. In the next question, given a choice of two applied teaching methods, 55.5% of the students from the control group who first listened to the teacher's explanation with the support of a presentation and then watched the DST preferred digital storytelling.

On the contrary, more than half of the students from the experimental group (54.59%), who first applied the DST method and then listened to the teacher's explanation with the support of the presentation, prefer standard teaching. "Rather yes" or "definitely yes" to use digital storytelling to teach economic concepts was answered by 45.41% of the students from the experimental group; see Figure 4. The results show that students in the control group, who already had some knowledge of the topic from the teacher's explanation, perceived the digital story as a more beneficial method for understanding the selected economic concepts. More than half of the students in the experimental group who heard new economic concepts for the first time in a digital story would have preferred standard teaching. In the next question, when students could choose not only the teaching methods used but also the combination of both methods and self-study, the option of combining both methods received the highest percentage. According to the pupils' opinions, the methods complement each other, link economic concepts and definitions with real life, and together they help to understand and better remember the learning material. The results obtained are consistent with the results of Robin's (2009) research. The DST shows the interconnections within the wider curriculum and facilitates discussion of the themes presented in the story. However, the teacher's interpretation is irreplaceable in some subjects and topics. These views support the theory in the book focusing on interpersonal communication as a means of personal and social development (Minhova, 2012). If the two methods were combined in teaching economics, more than half of the pupils would first integrate the teacher's explanation with the support of a presentation, and then complement it with a digital story on the topic.

The advantage of this pedagogical experiment is the large number of respondents and the maintenance of a level playing field for all respondents during testing due to online distance learning. Students completed the same pre-tests and post-tests using MS Forms. Through MS Teams, they were provided with the same educational digital storytelling and explanation by the same teacher with the support of the presentation. All research participants attended a business academy at the time of the research. The selected topic was not taught before the pedagogical experiment. Thus, it can be assumed that the students had an initial knowledge of the topic at the same level. However, their knowledge of basic concepts and general overview may have varied due to individual interest in economics.

This study has some limitations. Although the sample consisted of 856 students, the conclusions of the pedagogical experiment relate only to the selected sample, and the results cannot be generalized. The educational digital storytelling took approximately 7 minutes so that the entire test could be carried out within the duration of one class. Therefore, it would be advisable to verify the results by further investigation, for example, implementing a longer DST or with different economic topics. The choice of the economic topic, the design of the DST and presentation, the teacher's interpretation and the classroom atmosphere are other factors that could have influenced the results of the study. Another limitation is that the students in the experimental group performed slightly worse in the pre-test than the students in the control group, although the assignment of respondents to the groups was random and the topic was not discussed in school (Nunvarova et al., 2023). The entire testing was conducted online as part of a distance education for Covid-19, which brought with it a number of advantages and disadvantages. The advantage of online instruction was the maintenance of the same testing conditions for all 856 respondents, the disadvantage was the lack of direct communication between teacher and student. Some authors confirmed the importance of face-to-face instruction and the possibility of direct communication with the teacher (Belland, 2017; Goldingay et al., 2018). Further research could focus on establishing the effectiveness of DST in economics, for example, supplemented by discussion with students in face-to-face teaching. The data obtained were further analysed in terms of the year of study, student's gender, and the results in the pre-test. Other factors that could be analysed from the data collected are the field of study or the location of the business academy. Comparing the success rates of different test questions could also provide interesting results, as some questions were based on definitions and others focused on practical examples and understanding of theory.

CONCLUSION

Digital storytelling is one of the alternative teaching methods that has been shown to have a positive impact on student motivation (Lestari et al., 2019), critical thinking (Yang and Wu, 2012) and the atmosphere in teaching (Wu and Chen, 2020). The results of the pedagogical experiment conducted in the teaching of economics in business academies support this claim. The use of the DST method led to a higher mean

success rate in the post-test for students in the experimental group than for students in the control group (Nunvarova et al., 2023). However, this improvement was very small, in contrast to the results published in, for example, foreign language research (Anderson and Macleroy, 2016; Heathfield, 2014) or literature (Balaman, 2018; Yuksel et al., 2021). The data were analysed using multi-way ANOVA test with three factors that might influence the students' results in the post-test. The results showed that in the group that used the DST method, the gender of the students did not affect the average post-test score. On the contrary, the factor *class* was shown to be statistically significant and in the group that used the DST method, the year of study influenced the average post-test score. The third factor was the results from the pre-test, i.e., the students' initial knowledge. The differential effect of the DST method and standard teaching in economics on learning outcomes was not proven for students who had lower pre-test score. On the other hand, the differential effect of the DST method and standard teaching in economics on learning outcomes was demonstrated for students who had higher pre-test scores. For this group of students, it was found that the effect of the DST method is greater than that of standard teaching methods. In the final questionnaire, students appreciated the linking of theory and practical examples and better memorization of economic concepts when using the DST method. Nevertheless, most of them consider the teacher's explanation in the economics subject as irreplaceable. They perceive the digital storytelling as a motivational tool and a method to support their learning.

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TECHNOSTRESS AND CONTINUANCE INTENTION OF ONLINE LEARNING IN HIGHER EDUCATION: EVIDENCE FROM INDONESIA

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ABSTRACT

As a developing country, Indonesia faces many obstacles in implementing online learning due to the lack of infrastructure and technical skills. The mandated online learning policy during the spread of the covid-19 virus became a turning point and made massive use. However, the online learning policy raised unforeseen issues such as stress, especially among students. This study focuses on the continuance intention of online learning among college students in Indonesia. The person-environment fit theory serves as a theoretical anchor, with technostress being examined as a predictor. This research uses an online questionnaire to reach 466 college students as research participants. We used partial least square structural equation modeling (PLS-SEM) to examine the research model. The result shows that three types of technostress (techno-overload, techno-invasion, and techno-uncertainty) are confirmed to have a significant negative effect on the continuance intention of online learning. Meanwhile, the other two (techno-complexity and techno-insecurity) do not affect online learning continuance intention. The current study contributes to the literature regarding the technostress and continuance intention of online learning topics, especially in developing countries such as Indonesia. Furthermore, the research provides valuable insight for policymakers and university administrators, enabling them to formulate effective policies for mandated online learning.

KEYWORDS

College student, continuance intention, online learning, technostress

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Highlights

- *The continuance intention of online learning in developing countries has become questioned due to raised stress among students.*
- *Technostress consists of five types (techno-overload, techno-invasion, techno-complexity, techno-insecurity, techno-uncertainty).*
- *Technostress plays a role in reducing the continuance intention of online learning among college students.*
- *Due to the many advantages of online learning, the stakeholders (e.g., government and university) should consider taking the right policies to reduce the negative effect of online learning implementation.*

INTRODUCTION

Online learning is becoming popular among developed countries. Many universities have invested a lot of money to implement technology in learning activities, such as developing a learning management system (LMS) (Ashrafi et al., 2022; Chow and Shi, 2014). However, online learning implementation faces many obstacles in developing countries, such as the lack of infrastructure and technical skills of academicians (Anggraeni and Sole, 2018; Chaeruman, 2018; Kaunang and Usagawa, 2017; Kuntoro and Al-Hawamdeh, 2003; Lestariyanti, 2020; Pratama and Arief, 2019; Rafsanjani et al., 2022). In addition, adopting online learning in developing countries is becoming voluntary and limited due to a lack of resources and government support (Acharya and Lee, 2018; Boateng et al., 2016; Tagoe, 2012).

Although there are many challenges of online learning adoption in a developing country, the spread of the covid-19 is becoming a turning point in the learning activities format. Since the spread of the covid-19 has become a pandemic worldwide, all educational institutions in Indonesia have been forced to adjust learning activities to distance learning or online learning using a learning management system (LMS).

The online learning policy has been taken against the spread of the covid-19 virus. However, the obstacles and issues arising from the online learning policy lead to the question of whether online learning activities can continue to be carried out after the covid-19 pandemic is handled. The surveys in Indonesia show that 66% and 87% of students felt unhappy with the online learning policy and wanted face-to-face schools, respectively (Karana, 2020; Kemenpppa, 2020; Unicef, 2020). Another survey shows that most students look forward to returning to school (Handarini and Wulandari, 2020). In addition, regarding the online education context, the continuance usage behaviour has become the main attention of scholars (Panisoara et al., 2020). Although online learning is starting to become popular, the continuance intention of online learning in developing countries such as Indonesia is still in question.

The adoption of technology in learning activities has several benefits. For instance, the technology enables learning activities conducted without the attendance of students and instructors in the school (Al-Samarraie et al., 2018), offers flexibility (Al Rawashdeh et al., 2021; Thepwongsa et al., 2021), enhances collaboration (Alsabawy et al., 2016), and reduces student cost (Al Rawashdeh et al., 2021). However, the shifting of learning activities using online learning also has a negative impact, such as developed stress for teachers and students (Chou and Chou, 2021; Fawaz and Samaha, 2021; Mheidly et al., 2020; Sokal et al., 2020; Truzoli et al., 2021). The stress that arises from the inability to cope with the use of technology is called technostress.

According to the person-environment fit theory (PE fit theory), stress is raised from a poor fit between individual abilities and environmental demands (Chou and Chou, 2021; Pasca, 2014; Qi, 2019). As the close relationship between online learning and technology, technological characteristics should be considered in weighing the poor fit (Califf and Brooks, 2020; Chou and Chou, 2021; Qi, 2019). The current study explores the predictors of the continuance intention toward online learning and utilizes the PE fit theory as a theoretical anchor. Furthermore, previous studies also claimed that continuance usage is more important than LMS acceptance (Ashrafi et al., 2022; Lee, 2010).

The current study provides four main contributions. First, most studies regarding technostress and continuance intention of online learning have been conducted in developed countries such as Taiwan (Chou and Chou, 2021), the US (Califf and Brooks, 2020), South Korea (Joo et al., 2016), China (Li and Wang, 2021), Hong Kong (Qi, 2019), Turkey (Özgür, 2020) technological pedagogical content knowledge (TPACK, Italy (Truzoli et al., 2021) and Spain (Penado Abilleira et al., 2021). However, the topics have less attention from scholars in developing countries. Therefore, the current study will extend the knowledge about the topics among developing countries. Second, most of the previous studies discussed the topics from the teachers' perspective (Chou and Chou, 2021; Jena, 2015; Sokal et al., 2020; Truzoli et al., 2021; Wang and Li, 2019), and the current study captures the topics from the students' perspective. Third, limited study regarding continuance intention considers emotional factors as determinants (Kim et al., 2007; Panisoara et al., 2020). Thus, this study extends the understanding of the topic from different perspectives. Fourth, this study provides a scientific understanding for policymakers in the developing country to consider the right policy regarding online learning during the covid-19 pandemic.

THEORETICAL FRAMEWORK AND HYPOTHESES

Scholars have highlighted continuance intention for many years. The term continuance intention also refers to a behaviour set, including continuance and routinization following the first acceptance (Rahman et al., 2017). Furthermore, continuance intention is becoming a subject of theoretical development (Rahman et al., 2017), such as information system continuance (Amoroso and Chen, 2017; Han et al., 2018) and post-adoption usage (Jia et al., 2017; Ong and Lin, 2016). Therefore, continuance intention to use educational technology refers to post-adoption behaviour and intention to continue using technology in teaching and learning activities (Limayem and Cheung, 2011; Wang et al., 2019).

Many factors predict continuance intention to use educational technology. Most of the scholars explored the continuance intention of technology using the technology acceptance model (TAM) (Han et al., 2018; Wang et al., 2019), expectation-confirmation model (ECM) (Ashrafi et al., 2022; Chow and Shi, 2014; Lee, 2010), and information system continuance/success model (Cheng, 2014; Franque et al., 2021; Jia et al., 2017) as a theoretical anchor. However, since mandated online learning due to the covid-19 pandemic, stress has become an unforeseen issue in developing countries. The stress rises due to the inability to adapt to the new technology (Chou and Chou, 2021; Fawaz and Samaha, 2021; Mheidly et al., 2020; Sokal et al., 2020; Truzoli et al., 2021). This situation is known as technostress. Therefore, exploring the predictors of continuance intention to use online learning that fits the situation is necessary. In addition, there is limited study regarding the continuance intention of online learning that considers emotional factors as determinants (Kim et al., 2007; Panisoara et al., 2020).

The current study uses the person-environment fit theory (PE fit theory) as a theoretical anchor. We postulate that PE fit theory fits with the current situation. The mandated online learning led to teacher and student stress due to the inability to deal with the new learning format (online learning), especially in developing countries, whereby online learning was less popular before the Covid-19 pandemic. During online learning during the covid-19 pandemic, teachers and students have been forced to adjust their habits from face-to-face to fully online learning. Teachers and students also have to adapt to the changes in the syllabus, interactions between teacher-student and student-student, and increased course workload. As revealed by the previous studies, the lack of adapting to distance learning raised anxiety, a stress symptom.

According to PE fit theory, stress is raised from a poor fit between individual abilities and environmental demands (Chou and Chou, 2021; Pasca, 2014; Qi, 2019). In addition, it is necessary to consider technological characteristics in weighing the poor fit (Califf and Brooks, 2020; Chou and

Chou, 2021; Qi, 2019). The technostress includes five types: techno-overload, techno-invasion, techno-complexity, techno-insecurity, and techno-uncertainty (Califf and Brooks, 2020; Tarafdar et al., 2007; Upadhyaya and Vrinda, 2021).

The current study used the terminology of the five technostress based on previous studies (Califf and Brooks, 2020; Tarafdar et al., 2007; Upadhyaya and Vrinda, 2021). Techno-overload is when technology forces users to work faster and longer than usual. Techno-invasion describes as a situation whereby technology forces users to work beyond office hours and blurs their work-related and personal lives. Techno-complexity refers to the situation where the technology makes users feel inadequate skills. Techno-insecurity is a stressful situation where the technology makes users feel threatened about getting fired due to the new technology replacement or to other people with better skills and knowledge. Techno-uncertainty refers to the rapid changes and upgrades of technology that create uncertainty for users. The users have to keep learning about new technology constantly.

Other studies show that the continuance intention of online instruction is closely related to the technostress (Chou and Chou, 2021; Panisoara et al., 2020). As explained previously, there are many obstacles to implementing online learning, especially in developing countries, such as a lack of infrastructure, technical skills, resources (hardware), and government support. These obstacles developed anxiety and tension among teachers and students, leading to stress (Joo et al., 2016; Rafsanjani et al., 2023). During the covid-19 pandemic, all the teaching and learning activities were switched to online learning. On the one hand, this situation has forced all teachers and students to adapt and learn to keep up with the new technology. On the other hand, they must learn the subject or the material simultaneously. This situation is prone to increased teacher and student stress levels (Panisoara et al., 2020).

The scholars have also revealed that technostress has negative effects on personal life (e.g., depression, social or relationship problems), as well as professional life (e.g., poor job performance, reduced job satisfaction, and organizational commitment) (Panisoara et al., 2020; Salo et al., 2019). The negative effects of technostress due to mandated online learning will lead to poor performance and satisfaction. Accordingly, we hypothesized that technostress could be a factor that prevents the academicians, such as students, from continuing to use online learning, especially when all the educational institutions return to normal activities.

H1. Techno-overload negatively affects the continuance intention of online learning

H2. Techno-invasion negatively affects the continuance intention of online learning

H3. Techno-complexity negatively affects the continuance intention of online learning

H4. Techno-insecurity negatively affects the continuance intention of online learning

H5. Techno-uncertainty negatively affects the continuance intention of online learning

Current study

The current study explores the predictor of continuance intention of online learning in a developing country like Indonesia. Online learning faces many challenges in Indonesia due to the lack of infrastructure and the technical skills of academicians. The challenges of online learning implementation promote unforeseen issues such as stress, especially among students. Therefore, we use the technostress as a starting point to explore the predictors. According to the literature review, technostress consists of five types (techno-overload, techno-invasion, techno-complexity, techno-insecurity, and techno-uncertainty).

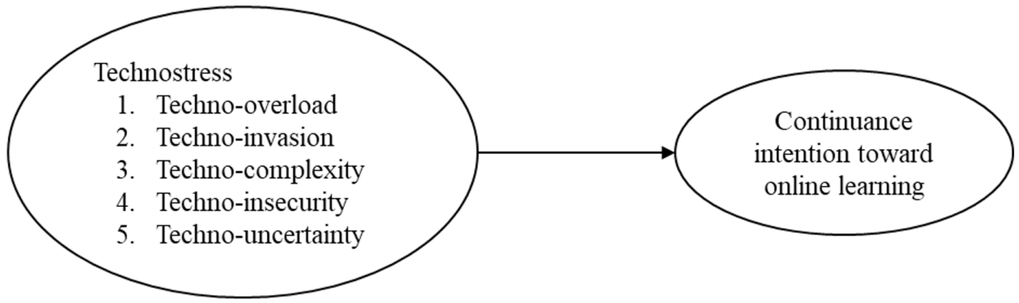

Figure 1: Conceptual model

METHOD

Participants

This study used an online questionnaire to reach the participants. The questionnaire was distributed by email directly to the college students and by networks of educators (lecturer and student association). We explained clearly the research objectives, the significance of the study, and the variables to be investigated on the online questionnaire homepage. The survey was conducted from April until June 2022, while all the universities in Indonesia still conducted an online learning policy. To be eligible for the study, the participants must be college students and take online learning for at least one semester due to the covid-19 pandemic. Four hundred eighty-seven students enrolled in the survey, and 466 were considered valid. The respondents' characteristics of this study are presented in Table 1.

Characteristics		size	%
Gender	Female	338	72.53%
	Male	128	27.47%
Academic Standing	1st-year student	164	35.19%
	2nd-year student	153	32.83%
	3rd-year student	118	25.32%
	4th-year student	31	6.65%
Discipline	Economics, business, management & accounting	157	33.69%
	Law	48	10.30%
	Engineering	56	12.02%
	Arts & Humanities	43	9.23%
	Education	89	19.10%
	Others	73	15.67%

Table 1: Respondents' characteristics (*N* = 466)

Instrument

This study measured the variables using the items from previous studies. We also adjusted and reworded the items to fit the higher education context. We measured the technostress variable through five types: techno-overload, techno-invasion, techno-complexity, techno-insecurity, and techno-uncertainty. We adopted the items developed by Tarafdar et al. (2007), Tarafdar et al. (2010), and Li and Wang (2021). For the continuance intention of the online learning variable, we adopted the items developed by Bhattacherjee (2001), Ashrafi et al. (2022), and Franque et al. (2021).

Data analysis

This study used structural equation modelling (SEM) with partial least squares as an estimation technique in SmartPLS software to analyze the research data. We performed three steps to examine the research model (model specification, outer model evaluation, and inner model evaluation) (Hair et al., 2014). First, we specify the research model based on the literature (figure 1). Second, we evaluate the outer model through confirmatory factor analysis (CFA), including the validity and reliability of the measurement model. Third, we evaluate the inner model through the coefficient of determination (R^2), cross-validated redundancy (Q^2), path coefficients, and the effect size (f^2).

Before conducting data analysis using multiple steps of PLS, we perform data cleaning first. Out of the 487 research participants, 480 met the eligibility requirements; the participants must be college students and take online learning for at least one semester due to the covid-19 pandemic. Among the remaining 480 participants, we identified missing values in the dataset. We dropped the research participant(s) with missing values. As a result, 466 data that met the requirements for further analysis remained.

RESULTS

Outer model evaluation

The first procedure of data analysis is outer model evaluation. We evaluate the outer model through convergent validity (loading factor and AVE), discriminant validity, and composite reliability. The result (table 2) informs that the convergent validity of all constructs is established. It indicates that all items' loading factor is higher than 0.70, and the AVE of all constructs is higher than 0.5 (Hair et al., 2017). The composite reliability of all constructs was upper than 0.70. In addition, we also performed cross-loading through Fornell and Larcker method (1981) to ensure the discriminant validity. The result (table 3) illustrates that the discriminant validity of this study was established.

Inner model evaluation

After the outer model was established, we performed the inner model evaluation through coefficient determination (R^2), cross-validated redundancy (Q^2), path coefficients, and the effect size (f^2). The result (table 4) remarks that the R^2 value is 0.766, indicating that the four technostress types have a substantial predictive power (Hair et al., 2017; Hair et al., 2014). This result also indicates that 76.6 percent of continuance intention toward the online learning variant can be explained by the four types of technostress (techno-overload, techno-invasion, techno-complexity, techno-insecurity, and techno-uncertainty). The Q^2 calculation remarks that four types of technostress have a value of 0.643, which indicates the exogenous constructs (four types of technostress) have a large predictive relevance on endogenous constructs (continuance intention of online learning) (Hair et al., 2017). Furthermore, the result of the f^2 calculation shows that techno-overload, techno-invasion, and techno-uncertainty have a medium to large effect on the continuance intention of online learning. Meanwhile, techno-complexity and techno-insecurity have a small effect (Cohen, 1988; Hair et al., 2014).

Constructs	Item	Loading factor	AVE	Composite reliability
Techno-overload	Ov1	0.829	0.687	0.916
	Ov2	0.744		
	Ov3	0.926		
	Ov4	0.876		
	Ov5	0.754		
Techno-invasion	Inv1	0.811	0.635	0.839
	Inv2	0.768		
	Inv3	0.811		
Techno-complexity	Com1	0.815	0.784	0.916
	Com2	0.919		
	Com3	0.918		
Techno-insecurity	Ins1	0.887	0.770	0.930
	Ins2	0.874		
	Ins3	0.853		
	Ins4	0.895		
Techno-uncertainty	Unc1	0.788	0.635	0.839
	Unc2	0.763		
	Unc3	0.838		
Continuance intention	CI1	0.924	0.844	0.942
	CI2	0,938		
	CI3	0,893		

Table 2: Loading factor, AVE, and composite reliability

	TO	TInv	TC	TIns	TU	CI
TO	0.829					
TInv	0.695	0.897				
TC	0.705	0.714	0.885			
TIns	0.724	0.639	0.745	0.877		
TU	0.569	0.638	0.520	0.528	0.897	
CI	0.718	0.790	0.608	0.653	0.762	0.919

Note: TO = Techno-overload; TInv = Techno-invasion; TC = Techno-complexity; Tins = Techno-insecurity; TU = Techno-uncertainty; CI = Continuance intention.

Table 3: Discriminant validity

Relationship	R^2	Q^2	f^2
Techno-overload → Continuance intention			0.274
Techno-invasion → Continuance intention			0.262
Techno-complexity → Continuance intention	0.766	0.643	0.031
Techno-insecurity → Continuance intention			0.026
Techno-uncertainty → Continuance intention			0.583

Table 4: Inner model evaluation

Last, table 5 shows the hypotheses testing. The result shows that this study rejects the null hypotheses of H1, H2, and H5. This means techno-overload, techno-invasion, and techno-uncertainty significantly affect the continuance intention of online learning. On the other hand, this study fails to reject the null hypotheses of H3 and H4 on a 10% significance level, which means techno-complexity and techno-insecurity have no significant effect on the continuance intention of online learning.

Hyphotesis	Relationship	β-value	S.E.	p-value	Remark
H1	Techno-overload → Continuance intention	-0.361	0.059	0.006	Null hypothesis rejected
H2	Techno-invasion → Continuance intention	-0.325	0.056	0.037	Null hypothesis rejected
H3	Techno-complexity → Continuance intention	-0.076	0.098	0.495	Fail to reject null hypothesis
H4	Techno-insecurity → Continuance intention	-0.041	0.109	0.369	Fail to reject null hypothesis
H5	Techno-uncertainty → Continuance intention	-0.607	0.045	< 0.001	Null hypothesis rejected

Table 5: Path coefficients and hypotheses testing

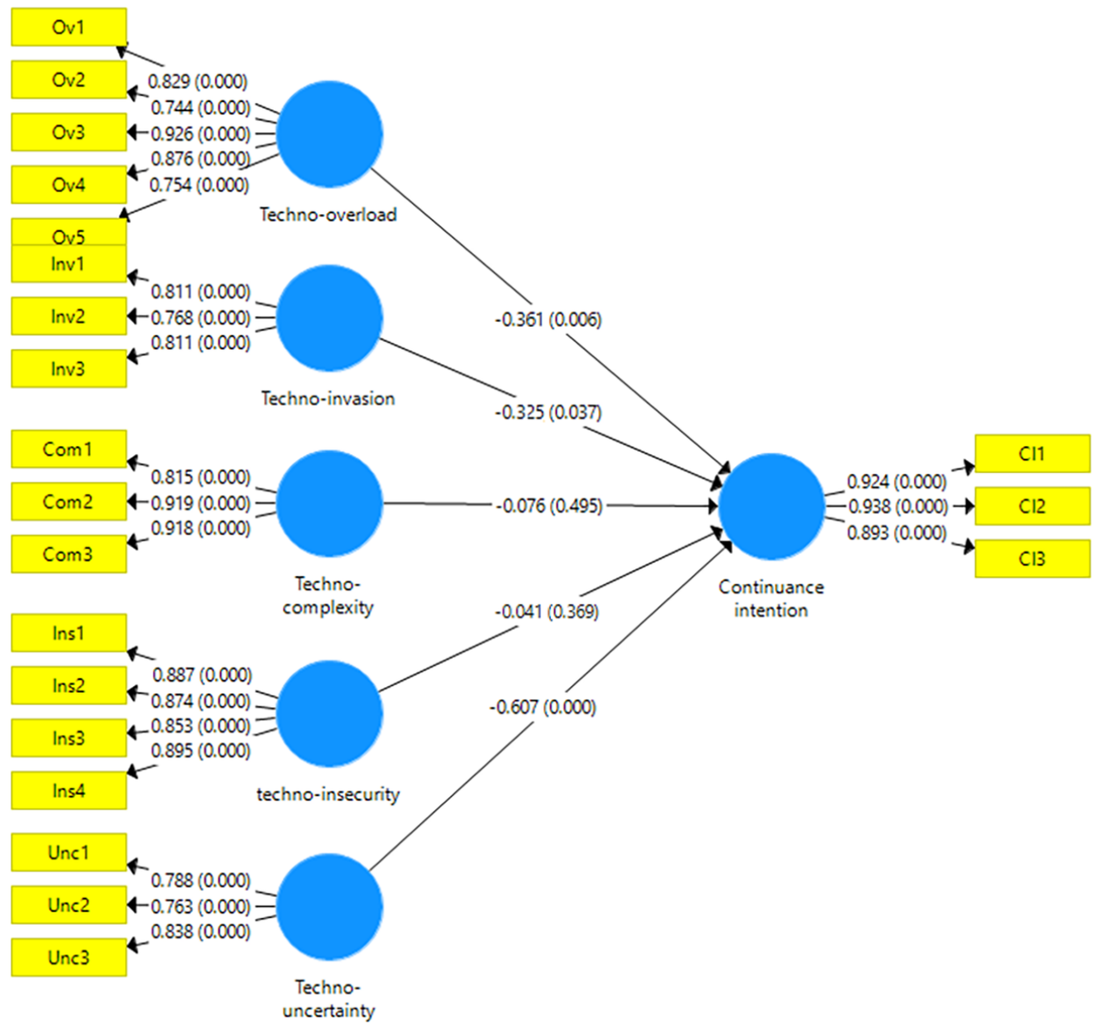

Figure 2: The structural model with standardized path coefficient

DISCUSSION

The research finding shows that only three of five technostress (techno-overload, techno invasion, and techno-uncertainty) have significant negative effects on the continuance intention of online learning. Meanwhile, the other two technostress (techno-complexity and techno-insecurity) have no effect on the continuance of online learning. Despite some hypotheses are rejected, our research model has large predictive power. This is evidenced by the R^2 calculation that remarks 0.766, that's means 76.6 percent of the online learning continuance intention can be explained by the exogenous constructs (technostress). As predicted, the higher students' technostress, the lower the continuance intention of online learning. This study strengthened the previous studies that revealed that technostress and continuance intention of online learning has a negative relationship (Chou and Chou, 2021; Joo et al., 2016; Panisoara et al., 2020). Furthermore, the current finding is also in line with the PE fit theory as a theoretical anchor of the study. PE fit theory refers to the personal ability to deal with environmental demands (Chou and Chou, 2021; Pasca, 2014; Qi, 2019). A good fit leads to positive outcomes and well-being, while a poor fit will raise stress and ill-being.

The current finding shows that the mandated online learning during the covid-19 pandemic has raised students' stress. Most students reported a lack of ability to deal with online learning. Students need to deal with new and unfamiliar technology in online learning, such as learning management systems (LMS) and video conferences. The students reported some obstacles, such as hardware and internet connection problems, experiencing learning difficulties in adapting to the new syllabus, class interaction, and finding a conducive space. Some students also reported feeling the course workload has increased during online learning, and they have to learn more independently than face-to-face learning. In addition, the students have to deal with a tight schedule regarding the time of task completion and submission. These situations could trigger stress (technostress) and reduce the continuance intention of online learning.

In more detail, the first hypothesis remarks on the relationship between techno-overload and the continuance intention of online learning. Techno-overload refers to when the technology forces the users to work faster and longer than usual. The situation fits with the students' experience. They feel the course workload has increased during online learning compared to offline learning. Furthermore, the students also have to face a tight task completion and submission schedule. Hence, using technology during online learning has led students to overload activities. The students must work faster and longer to deal with online learning activities. This finding is in line with the previous studies. The use of technology contributes to longer working days. (Califf and Brooks, 2020; Ragu-Nathan et al., 2008).

The second hypothesis examines the relationship between techno-invasion and the continuance intention of online learning. The research participants reported spending much time independently doing assignments or understanding a particular topic during online learning. Sometimes, to chase deadlines, the students have to sacrifice their weekends. This situation fits with techno-invasion, whereby the technology leads the users to work beyond office hours and blurs their work-related and personal lives. Hence, this finding strengthens the previous finding that technology was interfering with the work-life balance (Califf and Brooks, 2020; Johari et al., 2018).

Regarding the third unconfirmed hypothesis, the link between techno-complexity and continuance intention of online learning. This finding was contrary to the previous findings that the complexity of technology makes the user feel inadequate skills and increases the technostress (Califf and Brooks, 2020; Tarafdar et al., 2007; Upadhyaya and Vrinda, 2021). The following reasons could explain this finding. Some students reported that they have no problem with the complexity of technology during online learning. The students reported they must learn harder to utilize and maximize the new technology at the beginning of online learning. Still, they quickly adapted after the third and fourth weeks. In addition, the complexity of online learning technology makes them interesting and challenging. Hence, we can assume that the students have adequate skills to learn and adapt to the technology during mandated online learning.

A similar situation occurred with the fourth hypothesis. This study failed to confirm the relationship between techno-insecurity and the continuance intention of online learning. This finding contradicts the previous study that revealed that users felt threatened and feared being replaced by someone with better technical skills and knowledge (Califf and Brooks, 2020; Tarafdar et al., 2007; Upadhyaya and Vrinda, 2021). The logical explanation was reported by the students as research participants. The students reported cooperating on utilizing the online learning technology during online learning. Students with better skills and knowledge will teach and explain how to use the technology, such as learning management systems (LMS) features. Therefore, we assume the students do not feel threatened by other students with better technological skills.

Last, techno-uncertainty. The students sometimes reported being confused by the rapid changes and upgrades of online learning technology. For instance, at the beginning of mandated online learning, around March 2020, the features of LMS were quite simple. However, many features were added to LMS a couple of months later. This situation forced the students to keep learning about the new features constantly. Therefore, we assume the students are concerned about quick changes in online learning technology. This finding was in line with the previous result that rapid technological changes create user uncertainty and stress (Tarafdar et al., 2007; Upadhyaya and Vrinda, 2021).

CONCLUSION AND IMPLICATION

Technostress has been a significant negative predictor of continuance intention toward online learning. However, only three of five technostress types fit the current finding (techno-overload, techno-invasion, and techno-uncertainty). The students experienced a congruous situation with three technostress types that play as a trigger for technostress. Meanwhile, the other types of technostress (techno-complexity and techno-insecurity) were unfit for the situation reported by students. The students have no problem with the complexity of online learning technology. In addition, the students also said that they felt no worry about the difference in ability regarding utilizing the online learning technology.

The current finding has theoretical and practical contributions. First, we extend the knowledge of continuance intention toward online learning from another perspective, PE fit theory, rather than the popular model such as the technology acceptance model (TAM), expectation confirmation model (ECM), and information success model. In addition, this study also enriches the understanding of continuance intention that considers emotional factors as determinants, the technostress.

Second, this study also fills a gap about the continuance intention and technostress topic, whereby the previous studies were mostly conducted in developed countries. Compared to the developed countries where online learning is more popular, the current study revealed that the problem that arises from mandated online learning in developing countries is the lack of adaptation regarding the use of technology. Students unfamiliar with online learning technology need time to understand the technology. The situation forced the students to spend much time mastering online learning technology. Then, the students feel the online learning activities increase the course's workload, interfering with their personal lives and forcing them to keep learning continuously due to the quick changes in online learning technology. As a result, the situation triggers technostress and reduces the continuance intention toward online learning.

Third, this study extends the knowledge about technostress and continuance intention from the student's perspective. The previous study revealed that techno-insecurity becomes a problem from the teacher's perspective. The teachers feel threatened and fear being replaced by someone with better skills and knowledge related to technology (Califf and Brooks, 2020). But, from the student's perspective, the peers with better technological knowledge could be tutors rather than competitors. In addition, from the teacher's perspective, techno-uncertainty is not a trigger of technostress because they acclimated to the uncertain working environment (Califf and Brooks, 2020). On the contrary, the rapid changes in online learning technology (techno-uncertainty) for the students are becoming a concern that leads to technostress.

Last, the current finding provides a basic understanding for policymakers in developing countries to consider another policy following the mandated online learning to reduce the negative effect. The current study found that mandated online learning raised unforeseen issues, such as the technostress. Technostress will reduce the continuance intention toward online learning. As highlighted by scholars, online learning has many advantages (Cojocariu et al., 2014; Dhawan, 2020; Singh and Thurman, 2019). Therefore, we recommend that policymakers such as government and university administrators take the policy to reduce the negative effect of mandated online learning. The government should provide adequate infrastructure to run online learning well. The university should adjust the syllabus to reduce the course workload; hence, the students have adequate time to complete the academic work and not interfere with their personal lives. In addition, the universities could provide a supporting team, such as IT experts, to help the students face problems during online learning. Furthermore, universities may conduct a survey to identify high-risk students and give free counselling to reduce the technostress.

In conclusion, the current study has revealed that technostress reduces the continuance intention of online learning among college students, especially in developing countries such as Indonesia. This finding should concern the government and university administrators because online learning has many advantages. We should increase the continuance intention of online learning among Indonesian college students to take advantage of online learning. The closure of educational institutions due to the covid-19 pandemic should become the turning point to increasing online learning and making it popular and familiar, especially in developing countries.

LIMITATION

The current study has several limitations. First, we are using unbalanced gender participants. The current study was dominated by females (72.53%) than males (27.47%) as research participants. As highlighted by scholars, gender is closely related to life and job satisfaction (Joshanloo and Jovanović, 2020; Jovanović, 2017; Okpara et al., 2005). As we know, the construct of satisfaction was closely related to emotional factors such as stress. Second, the previous studies also highlighted that mental illness symptoms (e.g., anxiety, stress, and depression) increased after college entry (Andrews and Wilding, 2004), and the peak appeared between 18 and 25 ages (Brown, 2016). Unfortunately, the current study did not control the two variables (gender and age). Therefore, we are concerned that gender and age could interfere with the current result.

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Full research paper

THE COMPLEX EVALUATION OF THE IMPACT OF COVID-19 PANDEMIC AT UNIVERSITIES: A SOFT COMPUTING APPROACH

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ABSTRACT

The COVID-19 pandemic impacted the educational process since the teaching process has been forced to go online in many countries. This enforced change revealed the weaknesses and strengths of the national educational systems and particular institutions. This article aims to analyse the impact of COVID-19 at selected European universities and assess the satisfaction of students, teachers, IT staff and management. This study is unique for its systematicity and complexity – it aggregates the opinions of all interested groups of stakeholders, distinguishes several time periods (before, during and after the pandemic), and allows the respondents to express hesitance in their evaluation. The evaluation model uses fuzzy sets to capture the uncertainty and to aggregate the opinions of different stakeholder groups. The empirical results show that most of the satisfaction development is the same or similar for all institutions examined. Then, the pandemic strongly influenced the satisfaction of all stakeholder groups at the universities examined. This impact was mostly negative, however, several lessons learnt have been revealed. Therefore, it was shown that it is highly beneficial to include these aspects to obtain a reliable picture of overall satisfaction.

KEYWORDS

COVID-19, education, fuzzy logic, hesitance, opinion

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Highlights

- *A complex model is established that covers all important stakeholder groups at various time stages with respect to the COVID-19 pandemic.*
- *The possibility of expressing hesitance in answers is considered.*
- *The forced switch to the online environment caused a substantial decrease in satisfaction for most stakeholder groups at all involved in terms of almost all factors.*
- *At all involved universities, overall satisfaction improved at the end of the pandemic, however, the final level differs with the countries.*

INTRODUCTION

The COVID-19 pandemic and the related measures applied by national governments have forced many schools all around the world to switch to online teaching mode instead of the regular on-site regime (Marinoni et al., 2020; UNESCO, 2020). For many of them, it was an absolutely first experience with distant learning, which came unexpectedly. For many universities, it cannot be considered a full-featured online teaching but a crisis teaching.

Diverse stakeholders groups were affected differently and usually had different expectations, satisfactions and complaints. These valuable, often hardy to exactly explain, experience should be collected, processed, and explained. Various surveys have been conducted among universities worldwide from different aspects: from general aspects (see, e.g., Duraku and Hoxha, 2021); from psychological aspects (see, e.g., Akour et al., 2020; Sitko-Dominik, 2021; Kim et al., 2021), motivation (Altbach and de Wit, 2020), technical aspects (Van der Graaf et al., 2021). More details are in Section 2. Many studies do not focus on a particular consequence of distance learning, but rather an evaluation of its quality and satisfaction of the stakeholders. The conclusions of these studies often differ substantially. But to our best knowledge, not a single survey has considered the hesitance of respondents caused by various factors. Collecting, processing and interpreting results in this environment is a demanding task. In addition, various stakeholder groups differ in the number of people and the relevant questions. In this environment, questionnaires should be tailored to each group**.** To solve this task, we adopted concepts from fuzzy sets and fuzzy logic in general (e.g., Galindo, 2008; Kacprzyk and Zadrozny, 2009), the theory of aggregation functions (summarized in, e.g., Grabisch et al., 2009; Grabisch, 2003), and the method for flexible data collection (including hesitance) and evaluation of answers proposed in Zapletal et al. (2023).

This article explores the experience and satisfaction with distance learning during the COVID-19 pandemic compared to before and after the pandemic situation (or at least when restrictions were relaxed) at selected European universities. The idea was to ask influenced stakeholder groups at universities about their opinions on the past development of working in an online regime, as well as its current state. This will help to reach three following aims:

- Describe the situation from the perspective of diverse interested groups (students, teachers, management, students' affairs departments, IT staff) at universities. Knowledge of differences between the institutions (cultural, social, technical) and between attitudes of different groups can be the source for further improvement and harmonisation of the systems.
- Understand the developments in the time from the beginning of the pandemic, during the pandemic, and after releasing restrictions. Knowledge of the adaptation of different stakeholders groups in four countries can be compared with the other works and a source for various sociological research.
- Explore the impact of hesitance on answers, i.e., whether respondents have clear opinion, or rather use this option to declare their hesitance. The recorded hesitance can also be a source for further research related to areas of a higher hesitance and the development of hesitance in time.

The analysis done in this paper is based on the survey performed at four European universities (Technical University of Ostrava, Czech Republic; Technical University of Košice, Slovakia; University of Economics Katowice, Poland; University of Santarem, Portugal) in 2021 within the project DANTE - Digital Area for Networking Teachers and Educators no. 2020-1-CZ01-KA226-HE-094368. The first three countries have similar higher education systems, are culturally and geographically close to each other, and were affected by the covid pandemic at the same time, and universities were pushed to the transition to online under similar conditions with little experience in distance education. Meanwhile, the Portuguese university exists in a different environment and has long experience in distance education as it provides educational activities in multiple countries on different continents.

The rest of this paper is organised as follows. First, the state-of-the-art analysis is introduced in Sec. 2. This analysis is focused on (a) mapping the satisfaction with blended learning at universities and (b) requirements relevant to collecting and processing uncertain answers and interpreting the results. This analysis gave space for adopting the methodology which is introduced in Sec. 3. Sec. 4 is devoted to the data collection. Namely, the questionnaire designed within the project and the survey realisation are presented there. The core section of this report is Sec. 5, since the results are introduced and thoroughly discussed there. The article ends with the concluding messages in Sec. 6.

STATE-OF-THE-ART ANALYSIS RELATED TO DISTANCE LEARNING AND SURVEYS

This section introduces existing studies and approaches of distance learning evaluation and requirements for covering hesitance of answers as well as the relevant concepts required for the survey among the participating universities.

Evaluation of blended and distance learning

A sudden switch to lockdown during the COVID-19 pandemic forced teachers and students into online teaching and learning. The UNESCO study (2020) claims that the nationwide closures affected more than 91% of the world student population. This unprecedent change brought many troubles as well as opportunities. It is natural that immediately after this enforced change occurred, a large wave of research was focused on distance learning and the recognised issues. Most of the studies performed are supported by surveys among students, teachers, or even parents; see Duraku and Hoxha (2021). The studies differ in the geo ical location where the survey was conducted and in the levels of education. It should be noted that the COVID-19 lockdown affected the people surveyed not only by closing schools, but also in other areas of their lives. Therefore, it should be taken into account that if the online regime is applied during the "regular" (meant non-pandemic) period, the evaluation of distance learning could be different.

The lack of direct social contacts, the necessity to adopt new skills in a short time, and crucial changes in time management are the most frequently mentioned reasons in the literature. The study presented by Akour et al. (2020) confirmed the negative psychological impact of distance teaching during the COVID-19 pandemic (the study has been implemented in Jordan). Hoofman and Secord (2021) showed that the necessary rapid adaptation of both students and teachers was uneasy and had some negative impacts. They also confirmed the negative impact of the situation on students' mental health. The analysis was more focused on high schools, thus, many evaluation criteria are not applicable in our study. However, an interesting conclusion is that computational knowledge suffered more during lockdown than the knowledge of language, arts, etc. Duraku and Hoxha (2021) explored the possible negative impacts of the sudden change in the teaching regime on teachers' mental health. They showed that forced distance learning during the COVID-19 pandemic has a significant impact on the deterioration of mental health and even behavioural changes for children. Jakubowski and Sitko-Dominik (2021) focused purely on teachers' mental health during the pandemic in Poland because they felt under high pressure, especially during the first part of the lockdown. The study confirmed that the pandemic and related online teaching caused a blurring of the frontiers between teachers' professional and private lives. Kim et al. (2021) also explored the impact of closing and reopening schools on teachers' satisfaction and well-being. A group of 24 teachers from UK basic and secondary schools was surveyed and the results showed that the school governments should support teachers to feel autonomous, competent, and connected with colleagues.

Next, Goudeau et al. (2021) explored that distance learning during the lockdown will probably increase the social class gaps in society. Mishra et al. (2020) concluded that it is necessary to develop multimodal approaches to achieve course content objectives for a better learning outcome to deal with the complexity of online education and emphasised the role of high-quality technical equipment. It is worth highlighting that the study by Mishra et al. (2020) has been applied in India where the conditions are hardly comparable to those of Central and Western Europe. Despite that, many criteria for assessment in India are the same as in the European environment. Duraku and Hoxha (2021) showed the crucial role of good communication among teachers, students, and parents. Furthermore, the satisfaction of the students and teachers is highly dependent (one cannot expect a highly satisfied student if teachers feel frustrated and vice versa), thus they propose that teachers should feel involved and motivated for changes. Van der Graaf et al. (2021) emphasized the necessity of improving the technological support by both hardware and software to provide efficient distance learning. According to Shim and Lee (2020), students and academics argue that distance learning is "inferior" and not of the same quality as face-to-face lessons. Means and Neisler (2020) presented the study that showed that satisfaction and motivation decreased substantially during the pandemic (more than 50% of US students felt dissatisfaction after going online). Altbach and de Wit (2020) saw the main challenge of distance learning during the pandemic in keeping the motivation of students to work hard enough even without face-to-face contact.

On the other hand, there are also studies that reveal the positive impact of distance learning during the pandemic. Almendingen et al. (2021) surveyed Norwegian university students. Their results showed that students got used to distance learning quite quickly (a significant improvement was apparent in a couple of months) because of the high-quality support from online teaching materials and frequent communication with teachers by software. However, students suffered from a lack of social contact during the lockdown. Khalil et al. (2020) performed a qualitative study among medical students in Saudi Arabia. This study came with interesting results that the online modality was well received by students and their performance improved during distance learning.

Some studies also looked into the future and asked questions like "what online tools should also be preserved for times after the pandemic". It would be too simplifying to claim that if students and teachers felt highly satisfied with distance learning during COVID-19, then this way of learning should also be used also in the future (and vice versa). UNESCO (2020) claims that despite all troubles caused by a sudden switch to the online environment, the situation in the last two years provided an unprecedented opportunity to increase the resilience of national education systems and transform them into equitable and inclusive systems. Rapanta et al. (2020) claim that online teaching is an essential part of the professional preparedness of universities anywhere in the world nowadays…

The enthusiasm for maintaining at least some elements of distance learning in the future is also shared with some studies built on surveys. Pokhrel and Chhetri (2021) conducted a survey among teachers and students at different levels of education in Bhutan. The authors found that both students and teachers should be focused on use of different online educational tools and after the normal classes resume, they should be encouraged to continue using them. In the study by Khalil et al. (2020), medical university students in Saudi Arabia would mostly prefer online learning also for the future despite they confessed that they had to deal with several challenges during the lockdown period like technical troubles, troubles during exams, etc.

The studies mentioned above helped us to choose the set of evaluation criteria for our complex model (distinguishing didactical, technical, and social factors seems to be reasonable). The factors must be adapted to the fact that our survey has been done in universities in Western and central Europe. We considered different groups of stakeholders. Teachers and students are straightforward, considering our aim, but we want to make our model more complex. We also asked the other members of staff at universities: IT staff (they play a crucial role during the online regime, like technical support), members of the study affairs department, and university management. Duraku and Hoxha (2021) claim that communication among all these stakeholder groups is even more vital during the distance mode than in the face-to-face mode.

Satisfaction with a school in general is a qualitative measure highly influenced by emotions and hesitance in expressing them. Therefore, it is highly reasonable to allow interviewees to reveal their feelings as accurately as possible by including the uncertainty in answers (classical linguistic evaluation scales such as the Likert scale covering only answers from absolutely yes to absolutely no are not sufficient; see Zapletal et al. (2023)). To the authors' best knowledge, no such study has been published so far (at least for the COVID-19 period).

Another contribution of the study should lie in the aggregation of partial satisfaction of individuals through all considered criteria and for all members of each stakeholder group together. The complexity of the proposed model should help to understand the distance learning process in a more systemic way than in past studies.

The needs and requirements for flexibility in the survey and evaluation of answers

Valuable information can be obtained by collecting and analysing opinions from diverse stakeholder or respondent groups, which usually have different backgrounds and are variously affected by the topics under survey (Albert and Tullis, 2013).

The following requirements should be considered:

- Stakeholder groups naturally have different levels of expertise and skills, as well as they differ in preferences and goals (teachers, students, technical staff, etc.). Therefore, questionnaires should be tailored to each group to improve their cooperation in surveys (Snijkers et al., 2013; Torres van Grinsven, 2015). In addition, the hesitation when providing categorical answers should also be supported.
- Different sizes of these groups. It causes differences in the number of questionnaires filled in by each group, the different number of questions and their granularity and, therefore, the need for a robust and flexible aggregation (Rakovská and Hudec 2019; Švaňa et al., 2021).
- The evaluation should be performed at the individual level, as well as at the level of the respondents' groups and among the groups considering the relevancies of subsets of the groups related to the particular evaluation (Zapletal et al., 2023).

In our opinion, a survey which does not consider these requirements could be considered simplified. Anyway, this work considers the conducted survey in a complex way to cover the hesitance and aggregation of answers influenced by the hesitance. When hesitance should not be collected, the adopted model does not change. It only uses precise (crisp) values instead of fuzzy numbers and elastic quantifiers.

To achieve this, we adopted the fuzzy logic theory and the theory of aggregation functions. The next section explains the preliminaries of these theories and the method initially proposed in Zapletal et al. (2023).

METHODOLOGY AND METHODS

Since the proposed methodology is based upon the uncertainty expressed by hesitance and vague data, preliminaries of the fuzzy sets are introduced in this section.

A fuzzy set A (a subset of universe X) is expressed by the membership function $\mu_A(x)$, which assigns the membership degree α, α ∈ [0, 1], to each $x \in X$ (Zadeh, 1965). The set of x for which the assigned membership degree is equal to 1 is called the core of the fuzzy set (core(A)). The set of x for which the assigned membership degree is positive is called the support of the fuzzy set (supp(A)); see, e.g., Klir and Juan (1995).

Two examples are fuzzy concept, in our case, positive opinion and fuzzy number, in our case, the answer m with hesitation are shown in Figure 1, where the dashed line stands for the precise answer m and the crisp opinion *positive*. Triangular fuzzy numbers are more suitable to express hesitance around a particular answer. The modal point is only in this value, while the level of hesitance is reflected in the skewness of the support. In case of trapezoidal fuzzy set, an interval express answer and, therefore, the hesitance is maximal in its vicinity.

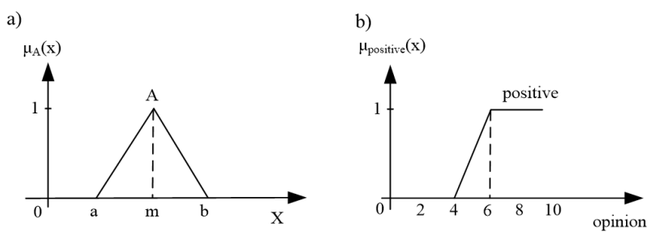

Figure 1: Fuzzy sets: a) triangular fuzzy number *A*(*a*, *m*, *b*) and fuzzy concept *positive opinion* (Zapletal et al., 2023)

In this work, the answers covering hesitance should be aggregated. The extension principle of fuzzy numbers (Ramík and Vlach, 2012; Zadeh, 1996) formalises the summarisation of fuzzy sets and multiplication by a parameter. When piecewise liner membership functions are used, then the extension principle is straightforwardly simplified. Thus, the sum of two fuzzy numbers $A(a_A, m_A, b_A)$ and $B(a_B, m_B, b_B)$ is expressed as

$$A \oplus B = \left(a_A + a_B, m_A + m_B, b_A + b_B\right), \quad (1)$$

while multiplication by parameter is calculated as

$$p \bullet A = \left(p \bullet a_A, p \bullet m_A, p \bullet b_A\right). \quad (2)$$

Note that the parameter p is any non-negative real number (including 0, as multiplication with 0 leads to the singleton 0). Thus, the arithmetic mean of three fuzzy numbers A, B, C is computed as

$$M = \left(p \cdot (a_A + a_B + a_C), p \cdot (m_A + m_B + m_C), p \cdot (b_A + b_B + b_C)\right), \quad (3)$$

where $p = 1/3$.

The next required concept is the possibility measure that a fuzzy number A belongs to the fizzy concept FC. It is calculated as (Galindo, 2008)

$$\mathrm{Pos}(A, FC) = \sup_x \min\left(\mu_A(x), \mu_{FC}(x)\right). \quad (4)$$

An example of three fuzzy numbers and their respective possibilities to belong to the fuzzy concept is depicted in Figure 2.

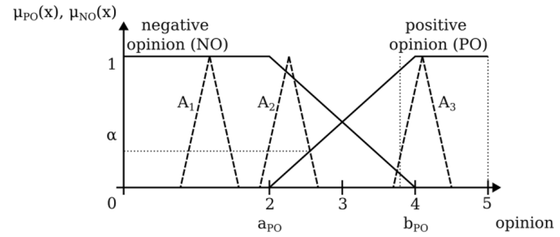

Figure 2: Definition of positive and negative opinion and example of a possibility measure for three fuzzy numbers: Pos(A_1, PO) = 0, Pos(A_2, PO) = *α*, Pos(A_3, PO) = 1

Next, we need a linguistic quantifier for *most of the calculations* to calculate the validity of the sentence: Most of *the respondents have positive (neutral, negative) opinion*. Quantifier *most of* is depicted in Figure 3.

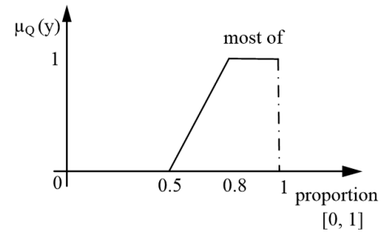

Figure 3: Linguistic relative quantifier *most of*. (Zapletal et al., 2023)

A formal structure of quantified sentence is *Q entities have P*, where *Q* is quantifier and *P* predicate. The validity of such a sentence is calculated as (Yager 1982, Kacprzyk and Zadrozny 2005)

$$v(Q_x(P_x)) = \mu_Q\left(\frac{1}{n}\sum_{i=1}^{n}\mu_P(x_i)\right), \quad (5)$$

where n is the number of entities and $\mu_Q(x)$ $\mu_P(x)$ formalise the quantifier Q and the predicate P, respectively.

In the theory of aggregation functions, three main axioms, monotonicity, and two boundary conditions: $f(0, 0,\ldots, 0) = 0$ and $f(1, 1,\ldots, 1) = 1$ should be met (Grabisch et al., 2009). When not a single respondent answer belongs to the positive opinion, the validity of the summarised sentence is 0. On the contrary, when all the answers express a clear positive opinion, the validity is 1. When the number of positive answers increases, the result of aggregation either remains the same or increases. Therefore, all three axioms of the proposed method for evaluating opinions related to evaluating education are met.

Furthermore, this aggregation way mitigates the influence of careless answers (that is, respondents who provide neighbouring values instead of the desired ones are evaluated similarly (Rakovská and Hudec 2019)) and handles hesitance in responses. Moreover, this approach deals with the group sizes of the problem of the unbalanced respondents and their backgrounds. It causes a different number of questions in each respondent group, because questionnaires are tailored to these groups.

Using this approach, we can compare opinions of different stakeholders' groups regarding the education at the beginning of COVID-19, during the pandemic, and after the relaxation of the pandemic measures at one university and among the participating universities.

An overall opinion for a university considering all stakeholder groups can be calculated by various aggregation functions, because the result for each stakeholder group is in the unit interval. Aggregation by arithmetic mean is a possible solution but oversimplified because groups do not have the same relevance for different criteria. This can be covered by weights, but weight also weak points (see, e.g., Dujmovi, 2018). Aggregation among respondents' groups should consider the relevance of groups and subsets of groups. It could be managed by the fuzzy measure and the discrete Choquet integral. More details related to the theory of this robust approach are in, e.g., Grabisch et al., 2009.

The adopted methodology can be concluded in the following 3 steps:

- Expressing each individual opinion with hesitance using a triangular fuzzy number.
- All opinions provided by a single individual are aggregated for all questions.
- The possibility of belonging to the predefined quantities 'positive' and "negative" opinion is calculated (4).
- The aggregation of individual values is aggregated using linguistic quantifiers 'most of' (5).

INPUT DATA

As mentioned earlier, the survey by the questionnaire has been used to gather the required input data (opinion and hesitance). This questionnaire and the related survey are described in this section.

Structure of the questionnaire

The questionnaire has been built based on the interactive discussion and mutual agreement among the members of the project team from four participating universities. VŠB –

Technical University of Ostrava (Czech Republic), Technical University of Košice (Slovakia), University of Economics in Katowice (Poland) and University of Santarem, (Portugal). The questions were chosen to cover all the important factors that influence the satisfaction of all university stakeholders with the distance learning during the COVID-19 pandemic. The set of questions varies with the stakeholder groups because the whole set is not relevant for all groups.

The following five groups have been considered:

- Teachers (T).
- Students (S).
- University management (M).
- Study affairs office (SA).
- IT staff (IT).

Regardless of the groups, all questions were evaluated using the Likert scale. Value 1 corresponds to the lowest satisfaction with a factor; value 5 corresponds to the highest satisfaction with the given factor. To be able to assess the progress in time, the questions were tied with the three time stages: Before the pandemic (P0), at the beginning of the pandemic (P1), at the realisation of the time of the survey (P2), i.e., more or less at the end of the pandemic, or at the time of a significant reduction of pandemic restrictions. Next, the interviewees could express their level of certainty in provided answers. (0 = I'm absolutely sure with my answer, 1 = I feel a weak hesitance, 2 = I feel strong hesitance and therefore my answer is driven mostly by my feelings). The very last evaluated factor was the weight of each evaluated criterion (1 = weak importance, 2 = medium importance, 3 = strong importance). The list of questions that evaluate satisfaction with past and current states can be found in Table 1.

Question group	Question	Groups of respondents	Periods
Technical issues	Do you consider the quality of the internet sufficient?	S	P1, P2
	Do you consider your HW equipment sufficient?	S, T, IT	P1, P2
	Are you satisfied with the SW platform used at lessons?	S, T, IT	P1, P2
	Are you satisfied with the helpdesk support?	S, T, IT	P1, P2
Teaching issues	Do you find the lessons attractive?	S, T, M	P0, P1, P2
	Do you feel motivated to work hard?	T, S	P0, P1, P2
	Do you find the time demand of your duties adequate?	S, T, IT, SA, M	P0, P1, P2
	Do you think that tests are fair?	S, T, IT	P0, P1, P2
	Do you consider the course evaluation by students at the end of a semester beneficial?	S, T, SA, M	P0, P1, P2
	Do you consider the support by digital study materials sufficient?	S, T	P0, P1, P2
Communication issues	Are you satisfied with the quality of direct communication with students?	T, M, SA	P0, P1, P2
	Are you satisfied with the quality of indirect communication with students?	T, M, SA	P0, P1, P2
	Are you satisfied with the quality of direct communication with teachers?	S, M	P0, P1, P2
	Are you satisfied with the quality of indirect communication with teachers?	S, M	P0, P1, P2
	Are you satisfied with the quality of communication with non-teaching staff?	S, T, M	P0, P1, P2
	Are you satisfied with the communication of information by university management?	S, T, SA, IT, M	P0, P1, P2

Table 1: Questions of the questionnaire with distinguishing groups and time periods.

The triangular fuzzy numbers, representing individual opinions on each question, are established as follows. The core of each number m is equals the selected value from the Likert scale (1 to 5). The support is calculated based on the expressed hesitance level h (from 0 to 2) as an interval:

$$\left[\min\{1, m-h\}, \max\{5, m+h\}\right].$$

That means that the fuzzy number collapses to the crisp value if there is no hesitance in the answer. The bounds are set to respect the levels of the Likert scale.

A fuzzy sets *positive opinion* and *negative opinion* can be found in Fig. 2. The way how these sets have been defined, has been adopted from Zapletal et al. (2023).

Realisation of the survey

The questionnaire has been implemented in Google Forms; see Appendix B. Each university prepared its own language mutation (in Czech, Slovak, Polish, and Portuguese language). All respondents responded voluntarily. All participating students study economics full-time study programmes. Another criterion that had to be met was that all students must be at least in the third year of study (to compare the state before and during the pandemic).

Regarding the teachers, no restrictions have been put in place. Most teachers teach economic-orientated courses. However, teachers of mathematics and informatics also participated in the survey. The IT department includes non-teaching staff responsible for IT support (without further specification). The study affairs department consists of checking whether students meet all legislative requirements and duties. The management group consists of the members of the dean's office (presidents) and vice-deans (vice-presidents), the heads of institutes and departments, or people who guarantee the study programmes.

The number of surveyed individuals at the participating universities and with distinguished respondent groups can be found in Table 2. These numbers respect the size of the institutions surveyed.

No. of respondents	CZ (Ostrava)	SK (Košice)	PL (Katowice)	PT (Santarem)
Students	294	221	333	153
Teachers	55	27	113	52
IT staff	9	2	6	6
Study affairs dept.	10	2	46	27
Management	4	6	12	8

Table 2: Numbers of interviewees

RESULTS

This section presents the results of the survey analysis. To keep the clarity of the outputs, we abbreviated the findings from the participating universities in the following way: VSB – Technical University of Ostrava (CZ), Technical University of Košice (SK) University of Economics in Katowice (PL) and University of Santarem (PT).

The comparison of the revealed levels of satisfaction between universities at a given time period can potentially have some explanatory power. However, one must be very careful with the conclusions. To some extent, the scale's perception can be influenced by the language mutation and other factors. In spite of this fact, a substantially worse evaluation in PT by students, teachers, and IT staff (and the other way around better evaluation by the management) would definitely be worth further investigation. However, we will focus more on the development of the opinions in time. The revealed pattern shows well the impact of distance learning and the pandemic.

By observing the proportion of positive and negative opinions in general, we recorded a decrease in the proportion of satisfied individuals at the beginning of online teaching. At the end of the fully distant teaching period, the proportion of respondents with a positive opinion increased. In many cases, it exceeded the proportion of positive opinion before the pandemic. There are several exceptions where the increase in satisfaction was revealed between all consecutive periods: in the study affairs department in SK and PT, students in PL, management except of PL, and IT department in PL (information about IT staff satisfaction in Slovakia before the pandemic is, unfortunately, missing). These exceptions suggest that the pandemic has been managed extremely well. In the case of the study affairs departments, such development is reasonable since many processes have been digitalised (and thus made more comfortable for the staff). The development from the perspective of the IT department was caused mainly by the significant improvement of IT equipment (and maybe by increased importance of this department during the distance learning period too). The university management is probably very well aware of the demandingness of the COVID period for both teachers and students. Therefore, its increasing trend in satisfaction can be related with the sense of pride towards these groups. It should be noted that the results in CZ have potentially been impacted to some extent by the political cycle. The reason of the pattern in the case of the Polish students is not traceable from the results, but it is for sure good news for both teachers and management of the university in Katowice.

In general, the proportion of students and teachers positive outlook was lower than in the student affairs departments and management at the beginning of the pandemic. It was observed in all countries. The reason might be that processing some bureaucratic issues online is not as demanding as the teaching process. The most significant decrease is recorded in the PT, mainly in case of students. Presumably, in south Europe, people generally prefer direct contact and communication. After the pandemic, in the student affairs department, the proportion of positive opinion is the highest in PL (0.97), while the proportion of positive responses among the students was the lowest in PT (0.72). The positive opinion at the end of the pandemic outperforms the positive opinion before the pandemic, whereas in a few cases, it reaches almost the same value or was slightly below (students in PT). The lowest positive opinion was in the IT department in SK at the start of the pandemic (0.46) and among students in PT (0.63). The maximal positive opinion was recorded in student department affairs in SK and in IT department in PT. The resulting proportion of positive overall opinions is shown in Figure 4.

When one looks at a negative opinion, only in one case most of respondents have a negative opinion: IT department in Slovakia. The main reason is a insufficient level of equipment with technologies and the unfairness of exams in the online environment. In the Department of student affairs, the proportion was highest 0.32 (CZ), among teachers (PT) 0.39, in management 0.41 (PL), among the students 0.47 (PT), and in the IT department 0.86 (SK), which was the highest proportion of negative opinion. All these values were revealed for the beginning of the pandemic.

We recorded similar behaviour among teachers and students (with the exception of Polish and Portuguese students already discussed above). The highest positive opinion is recorded after the pandemic of 0.91 (SK), while the highest negative opinion was 0.32 (PL) at the beginning of the pandemic.

The resulting proportion of negative overall opinions are shown in Figure 5, respectively.

At the end, let us take a look at the impact of the hesitance in the provided evaluations. For this reason, the results have been recalculated ignoring the effect of the uncertainty, i.e., like all respondents were sure about their answers. This is reflected in the aggregated level on the whole respondents' groups managed by the quantifier *most of* (5). For instance, students in PT have more positively rated all the stages when considering hesitance than those without this option (Figure 6). Interestingly, the same observation was recognised in the other

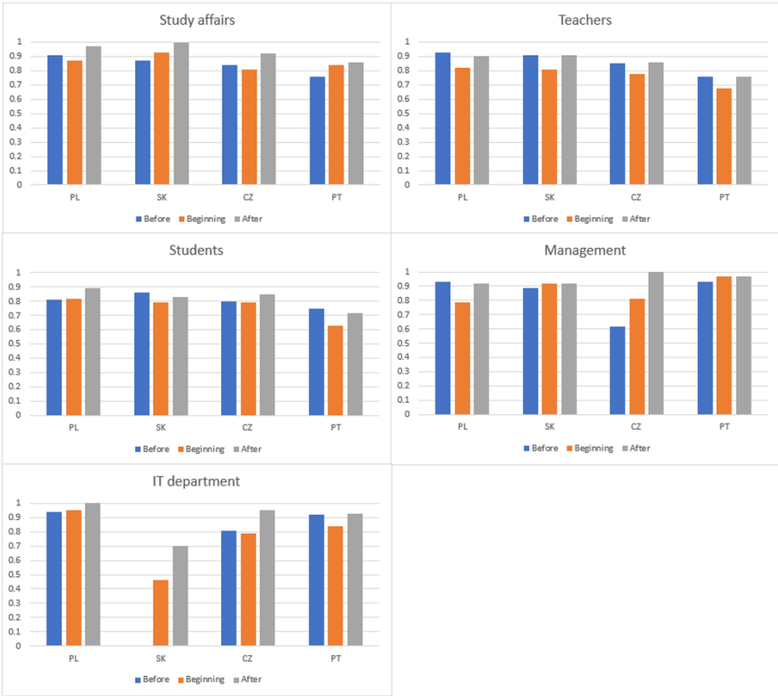

Figure 4: The overall result of the survey among different stakeholder groups – positive opinions.

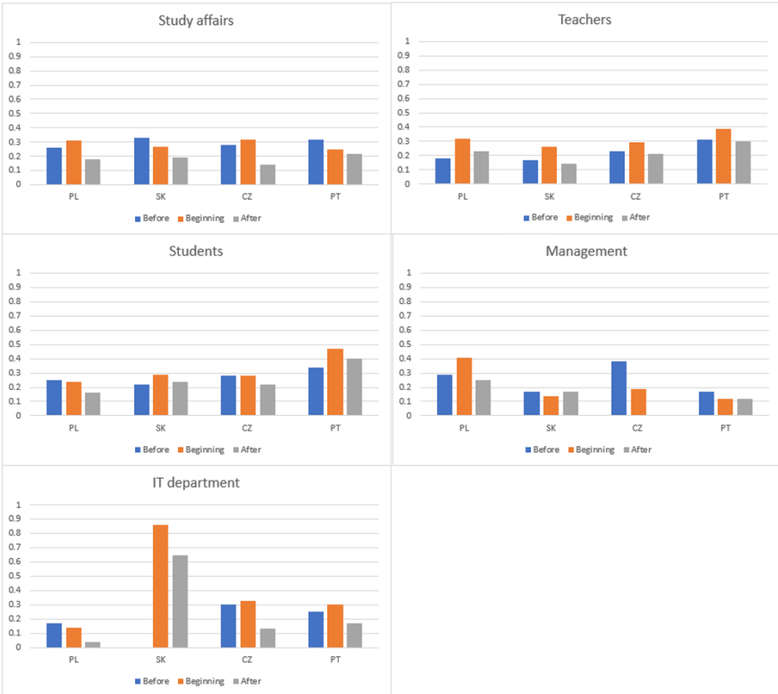

Figure 5: The overall result of the survey among different stakeholder groups – negative opinions.

universities for students and teachers (where the differences are lower). When applying the quantifier *most of* to the negative opinions, the resulting membership degree is equal to 0 for all stakeholder groups. That means that we can be sure that there is no group where most of individuals agree.

Generally, the results with and without hesitance do not change significantly. This is not so surprising result, because the target respondent groups are involved in university activities, i.e., they are more or less familiar with this environment. The results with hesitance have shown a slightly stronger positive opinion than the results when respondents were not able to express hesitance. We recorded that those who responded who are more involved in the survey under evaluation and are more experienced have a lower difference in answers.

This raises a question for future research. It would be welcome to realise survey considering hesitance among the general public for, e.g., topics related to the activities in cities.

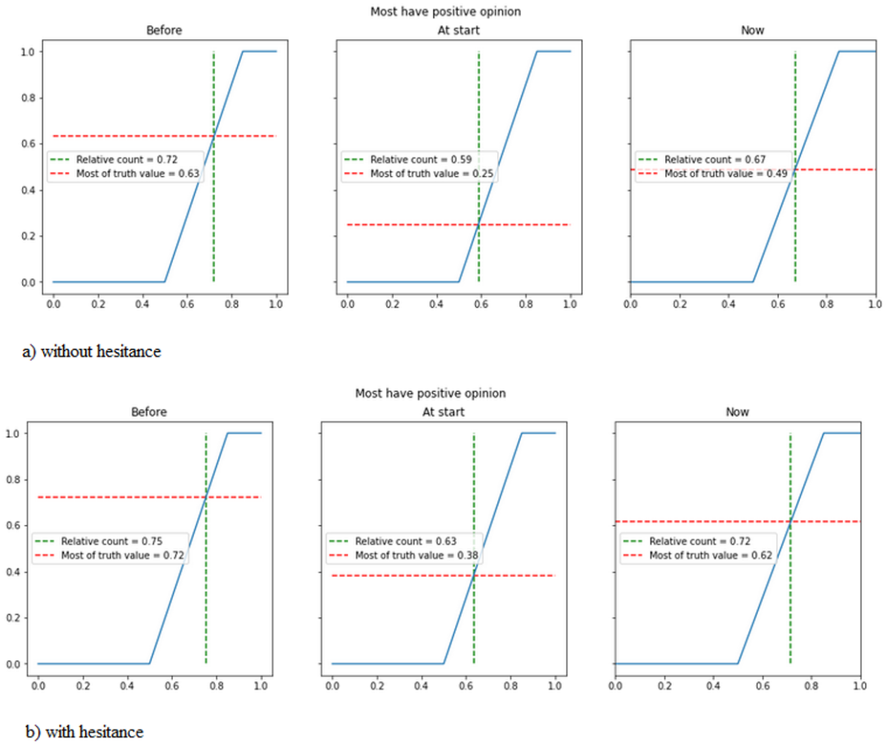

Figure 6: The results of quantified aggregation *most of the students have positive opinion* for students in Portugal: a) without hesitance, and b) with hesitance.

Detailed discussion on the results

To support the aggregated results and explain them better, let us explore more the results of the selected questions. As for the drops of the overall satisfaction between the pre-pandemic period and the beginning of the pandemic, and their return back up (regardless whether below or above the original level), the following issues contributed the most:

- The motivation to work hard decreased rapidly after switching to the online regime for both students and teachers. For all universities except for SK, the values improved (however, not up to the original level). This exception is not so surprising since the teaching process had still been kept partially online in SK. This general pattern indicates how demanding the beginning of the pandemic was in all universities. This result is in line with Gonçalves et al. (2020), Ferraro et al. (2020), and Lassoued et al. (2020).
- The motivation discussed above is strongly related to the attractivity of the lessons. Both these factors followed more or less the same pattern of development. No study has been found that included the attractivity of the lessons in the online environment. However, Chen et al. (2020) revealed a substantially decreased engagement of the students in the lessons, which can be regarded as one of the factors of attractivity.
- University teachers revealed increased time at the beginning of the pandemic (unlike students whose satisfaction in terms of this factor remained almost the same when going online). Due to a lack of experience with online teaching, teacher evaluation is highly reasonable. This result is supported by the study performed by Marek et al. (2021).

- Students and teachers are aware of the better availability of study materials. This factor is rather objective because teachers were forced to write down new materials quickly to make the teaching process manageable for students. Lassoued et al. (2020) concluded their study with the recommendation to provide more online materials to keep the quality and satisfaction of students when learning online.
- All questioned groups (students, teachers, IT staff, management) expressed that the exams online are far from being fair as in the face-to-face regime. This conclusion is fully in line with the analysis by Gonçalves et al. (2020), where Portuguese students were surveyed.
- The quality of direct communication with students decreased rapidly at the beginning of the pandemic at all universities. Some students could feel lost after the sudden switch, demotivated, and the phenomenon of a black passenger can also be one of the reasons. On the other hand, the satisfaction with the direct communication of students with teachers remained more or less the same in time. The only exception is Poland, which can at least partially explain the extraordinary satisfaction of Polish students discussed at the beginning of this section. Worse communication between students and teachers was mentioned in the list of the main obstacles of distance learning by Gonçalves et al. (2020).
- All questioned groups (students, teachers, IT staff, management) are aware of improvement in technical support since the beginning of the pandemic: hardware and software equipment. Universities and students have invested significant financial resources to bridge the pandemic as smoothly as possible. It is a great benefit that this equipment is still available for users even for the future. The issue of bad technical equipment is emphasised especially in studies performed in the developing countries, like Lassoued et al. (2020), but this study confirms that this aspect should not be underestimated in developed economies too.

Unfortunately, it is not possible to compare the aggregated results, since almost no study also compared the opinions for the return to the on-site regime after the pandemic. Almendingen et al. (2021) is an exception where the (positive) progress in satisfaction during the pandemic is revealed. This progress was also confirmed to some extent in this study. It can be expected that some other studies devoted to this issue will be conducted soon. In general, the decrease in satisfaction (despite not being as aggregated as it is presented here) in the case of students and teachers is a common conclusion of most studies, see, e.g., Ferraro et al. (2020) where the quantified decrease in terms of some factors was revealed, or see other studies cited in state of the art analysis in Section 2.

A note to the possible further work

Research has focused on distance learning from various perspectives. But what is still missing is the evaluation of the perspective of disabled students (Rakovská and Kanáliková, 2019). The proportion of disabled students is significantly lower and due to different kinds of disability, creating suitable surveys (past experiences and future preferences) is very demanding.

Another issue, which has not been considered in this study, and which was discussed by some other researchers, is the impact of online learning on the health of stakeholders, see Jakubowski and Sitko-Dominik (2021). Many studies confirmed the increased level of stress and disorders caused by learning and teaching in the online regime; see Marek et al. (2021) or Chen et al. (2020).

If we want to get the overall overview of a university (and compare universities), considering all respondents categories, we should consider so-called coalitions of groups. For example, in the evaluation of the content of (online) teaching, students and teachers are more relevant than technical staff and the student affairs department. When evaluating technical support, the situation is the opposite.

Assigning weights to groups is a problematic and oversimplified solution because it does not consider weights of the aforementioned sets of groups. The answer could be applying so-called capacities by fuzzy measures and aggregation by Choquet integral, see Grabisch (2009). The special cases of this integral are arithmetic and weighted arithmetic mean (in the case when all groups are equally important, or importance is different considering each group independently, respectively). Hence, we will be able to cover the simplified as well as more complex requirements for evaluation among groups by one function. This way is also promising for evaluation. Thus, it is an important topic for future research.

In our work, we applied the possibility measure (4). The possibility measure expresses an optimistic answer's matching degree to the concept. On the other hand, the necessity measure expresses pessimistic, i.e., is significantly restrictive (Galindo, 2008), which might in many cases lead to a degree equal to 0. A convex combination of these two measures could be a solution. But it raises the question of adjusting the parameter value expressing the position between possibility and necessity in the form

$$\mu(A,FC) = \lambda \cdot \mathrm{Pos}(A,FC) + (1-\lambda)\,(Nec(A,FC)), \qquad (5)$$

where $\lambda \in [0,1]$ and $Nec(A,FC) = \inf_x \max\left(1-\mu_A(x), \mu_{FC}(x)\right)$. It leads to a more complex form of evaluation. Anyway, it is a topic for future research.

CONCLUSIONS

The performed survey brought multiple contributions. First, a very robust model portable to any university (and after some modifications also to secondary schools) has been developed. Second, all important university stakeholders have been asked to get a better picture of the situation. As Duraku and Hoxha (2021) claimed, the satisfaction of different stakeholder groups is expected to be significantly dependent. Third, we allowed the respondents to express their feelings very detailedly since they could answer how hesitant they feel in their answer and how important a given factor is for them.

As for the results, it is quite surprising that all partner universities revealed a similar pattern in the responses. We confirmed the conclusions presented by Shim and Lee (2020) and Means and Neisler (2020), which showed that it is more difficult to keep the motivation of students and teachers in the online regime than the regular face-to-face option. Overall satisfaction decreased with switching to the online environment and increased at the end of the lockdown but to different degrees. In some cases, the increased values do not reach the initial values. The reasons should be revealed in future works. On the other hand, the results showed significant progress during the pandemic regarding almost all considered criteria.

The conclusions were further confirmed by the results from Slovakia where distance learning was still partially applied even at the time when the survey was launched. It was the only country where satisfaction did not return to pre-pandemic levels in most areas. We can only guess whether the decrease in satisfaction during the pandemic corresponds to the negative impact on mental health, as Akour et al. (2020), and Hoofman and Secord (2021) claimed in their studies. Despite the decrease of overall satisfaction with distance learning, we should emphasise several important benefits: better support by digital materials, better skills with distant communication, improved software and hardware support. In the future, the aggregation of the opinions of particular stakeholder groups would be worth exploring. This would give rise to the complete ranking of the evaluated units (universities or, e.g., faculties).

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APPENDIX

APPENDIX A – PYTHON CODE

Fuzzify and aggregate distance learning survey results

We start by importing required libraries

```
import csv

import numpy
from matplotlib import pyplot as plt
```

We tell Jupyter where to find the survey results

```
FILE_PATH = '../tram_residents.csv'
```

We start the processing by loading the responses. Each line in the CSV file contains the answers of a single respondent. `csv.reader` automatically creates a Python tuple for each row.

```
respondents_answers_raw = []

with open(FILE_PATH, 'r') as fd_survey_results:
    csv_reader = csv.reader(fd_survey_results)
    csv_reader.__next__()
    for respondent_raw in csv_reader:
        respondents_answers_raw.append(respondent_raw)
```

Now we use the text-number maps to transform the answers of all respondents to a numerical form This will create a `(degree_of_agreement, hesitance)` tuple for each aswer.

```
def answers_to_numbers(respondent_answers):
    num_questions = int(len(respondent_answers[1:]) / 2)
    answers = [respondent_answers[i*2+1] for i in range(num_questions)]
    hesitances = [respondent_answers[i*2+2] for i in range(num_questions)]
    answers = list(map(int, answers))
    hesitances = list(map(int, hesitances))
    answers = list(zip(answers, hesitances))
    return answers

respondents_answers = list(map(answers_to_numbers, respondents_answers_raw))

for r in respondents_answers:
    print(r)
```

```
def fuzzify_answer(answer):
    core = answer[0]
    spread = answer[1]
    left = max(1, core - spread)
    right = min(5, core + spread)
    return left, core, right

def get_mean(answers):
    core = numpy.mean([a[1] for a in answers]) # Simply the mean of all cores
    left = numpy.mean([a[0] for a in answers]) # Simply the mean of all left borders of all supports
    right = numpy.mean([a[2] for a in answers]) # Simply the mean of all right borders of all supports
    return left, core, right

respondents_answers_fuzzy = list(map(lambda r: list(map(fuzzify_answer, r)), respondents_answers))
respondents_means = list(map(get_mean, respondents_answers_fuzzy))

for i, r in enumerate(respondents_answers):
    print(i, 'Answers:', r, 'Mean:', respondents_means[i])
```

```
for i, answers in enumerate(respondents_answers_fuzzy):
    plt.title('Respondent %d' % i)
    plt.figure(figsize=(10, 5))
    for answer in answers:
        plt.plot(answer, [0, 1, 0], color='#5588ff', label=str(answer))
        plt.fill_between(answer, [0, 1, 0], color='#5588ff', alpha=0.3)
    plt.plot(respondents_means[i], [0, 1, 0], color='#ff8855', label=str(respondents_means[i]))
    plt.fill_between(respondents_means[i], [0, 1, 0], color='#ff8855', alpha=0.3)
    plt.xlim(0.5, 5.5)
    # plt.legend()
    plt.show()
    plt.close()
```

APPENDIX B – SELECTED QUESTION OF THE QUESTIONNAIRE IN GOOGLE FORMS

Question 1/17: Do you feel motivated enough to work hard?

Part 1: Study affairs

Did/do you feel motivated enough to work hard? *

	Absolutely yes	Rather yes	Neither yes nor no	Rather no	Absolutely no	I have no opinion
Before the pandemic	○	○	○	○	○	○
At the beginning of the distance learning	○	○	○	○	○	○
Now	○	○	○	○	○	○

Do you feel any hesitance in your evaluation? *

	No, I'm completely sure with my evaluation.	Yes, I slightly hesitate.	Yes, I feel strong hesitance and my answers were driven by feelings.
Evaluation of the past situation.	○	○	○
Evaluation of the current situation.	○	○	○

How important is this issue for you? *

	1	2	3	
Lowest	○	○	○	Highest

Do you see some proposals for improvement?

Your answer

Back Next Clear form

CONTRIBUTION OF LOCUS OF CONTROL, SELF-EFFICACY, AND MOTIVATION TO STUDENT ACHIEVEMENT: A META-ANALYTIC STRUCTURAL EQUATION MODELLING

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ABSTRACT

This meta-analysis examined whether motivation mediated the relationship between self-efficacy, locus of control, and academic achievement. Thirty-seven studies providing correlation estimates for 40 different samples were included in the analysis. The data from these studies were fitted to three models using a two-stage structural equation modelling method. In stage 1, a total correlation matrix was created by combining the correlations. In stage 2, this matrix was used for examining the models. First, a proposed model was fitted to examine the effect of self-efficacy and locus of control on achievement through motivation. Second, an alternative model was tested by drawing a direct line from self-efficacy to achievement. Third, another model was tested by examining the mediating role of motivation between self-efficacy and achievement. The analyses suggested that academic achievement significantly correlates with self-efficacy (r = 0.218) and motivation (r = 0.237). Motivation significantly correlates with self-efficacy (r = 0.415) and locus of control (r = 0.216). However, locus of control does not correlate with self-efficacy and achievement ($p > 0.05$). Self-efficacy and locus of control positively influence motivation. Self-efficacy influences achievement both directly and indirectly through motivation. The findings provide a general overview of how these variables correlate and affect student achievement.

KEYWORDS

Academic achievement, locus of control, meta-analysis, motivation, self-efficacy

HOW TO CITE

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Highlights

- *Self-efficacy and motivation are significant correlates of academic achievement.*
- *Self-efficacy and motivation are significantly correlated.*
- *Self-efficacy and locus of control positively influence achievement via motivation.*
- *Self-efficacy both directly and indirectly affect academic achievement.*
- *Locus of control is a non-significant correlate of self-efficacy and achievement.*

INTRODUCTION

As of their existence, influenced by their curiosity and survival instincts, humans have always attempted to accomplish certain things as reasons for living. When we think of humans who managed to light a fire in the early ages of humanity, the feeling they had when they fulfilled the deed they desired is a connotation of joy from accomplishing a task. In today's world, the same feeling resembles the feeling that a person who creates beautiful paintings feels proud of what they achieved in their artwork or the sense of satisfaction that a mechanic experiences by managing to repair a vehicle. Considering these examples in the context of education, the good results students obtain regarding the learning outcomes of any course denote their achievement in education. Although good results obtained in educational environments are referred to by names such as achievement and performance, generally, we can call all these characterizations academic achievement. Lindholm-Leary and Borsato (2006: 176) define academic achievement as 'communicative (oral, reading, writing), mathematical, science, social science, and thinking skills and competencies that enable a student to succeed in school and society'. In other words, academic achievement represents the performance

outcomes that indicate the extent to which a person has achieved certain goals in educational settings, particularly those that are the focus of school, college, and university activities (Steinmayr et al., 2014). Academic achievement is primarily affected by variables such as motivation (Amrai et al., 2011; Feng et al., 2013), self-efficacy (Goulão, 2014; Mahyuddin et al., 2006), socioeconomic status, school environment (Berkowitz et al., 2017), and environment (Baharudin and Luster, 1998).

Although various factors affect academic achievement in education, motivation is one of the most significant ones (Francis et al., 2004). Motivation can be defined as motives that drive us to perform or not to perform an action and as underlying reasons for our behaviours (Křeménková, 2019). Ryan and Deci (2002) divide motivation into three categories, namely intrinsic motivation, extrinsic motivation, and amotivation. Intrinsic motivation refers to one's inherent satisfaction with an action, whereas extrinsic motivation refers to one's doing non-inherent behaviours depending on external reasons (Ryan and Deci, 2000). Amotivation is a state of having no motivation to act. According to these definitions, when motivation is considered an impulse that drives a person to act or enables a movement to continue, it could substantially influence new learning, skills, and behaviours and thereby should be considered in educational environments because of this influence. In this context, we can assume a natural relationship exists between students' motivation and academic achievement, or at least their pursuit of achievement. Considering the definitions and classifications concerning the concept of motivation, the fact that it positively or negatively affects academic achievement is something expected in an educational environment. As such, many research studies have addressed the relationship between motivation and academic achievement (Bozkurt and Bircan, 2015; Johnson et al., 2014; Li and Pan, 2009; Liu and Hou, 2018; Trevino and DeFreitas, 2014).

Another variable whose relationship with academic achievement is examined the most is self-efficacy. The concept of self-efficacy was addressed first by Bandura (1977) in Social Learning Theory. Social Learning Theory suggests that the most fundamental structure behind the actions of individuals is self-efficacy belief. Bandura (1997) defines self-efficacy as a person's belief in their ability to plan and execute actions they need when achieving specific goals. According to him, four major sources shape self-efficacy beliefs: mastery experiences, vicarious experiences, social persuasion, and physiological and emotional states (Bandura, 1995). Although Bandura sees mastery experiences as the most effective way of creating a strong sense of self-efficacy, he emphasizes that they should be considered as a matter of creating an action plan to keep up with ever-changing living conditions rather than keeping up with current habits. He argues that vicarious experiences, the second source of self-efficacy, occur as a result of indirect experiences facilitated by social models. Social persuasion, the third source of self-efficacy, denotes the verbal persuasion of individuals that they can do a task and therefore ensures that the behaviour they think is adequate instead of self-doubt when problems arise in that task. In the last concept, shown as the source of self-efficacy, Bandura touched on physiological and emotional states, emphasizing that sometimes individuals trust physical and emotional states to develop self-efficacy and that stress reactions and tension are signs of poor performance. Considering Bandura's views on self-efficacy, students' beliefs about their academic achievement give them an idea of what they can do next with their current knowledge and skills. In other words, they establish a direct relationship between their self-efficacy and academic achievement. This relationship also influences students' success or failure, depending on their self-efficacy beliefs.

The last variable whose relationship with academic achievement is addressed within the scope of this study is the locus of control. Individuals hold a number of beliefs about the extent to which they have control over their lives. Stating that these beliefs are reinforced in two ways based on internal and external processes, Rotter (1966) defined locus of control as having a sense of control over sources of reinforcement in one's own life. Simply put, locus of control is a general concept, indicating expectancies regarding the extent to which reinforcements stem from internal and external control (O'Brien, 1984). Internal control denotes individuals' beliefs that positive or negative situations they encounter originate from themselves, whereas external control denotes individuals' beliefs that what happens to them is due to situations that do not originate from themselves. The concept of locus of control, grounded in social learning theory, also indicates spaces where forces determining how positive or negative events in life are perceived centre on (Yeşilyaprak, 2004). Locus of control is built on these two levels of generalized expectancies by individuals. Individuals with an internal locus of control believe that reinforcements or events that take place stem from their own behaviours or personal characteristics. However, individuals with an external locus of control understanding believe that the events that happen to them stem from greater and unpredictable external factors, such as chance, luck, fate, and belief (Rotter, 1990). The relationship between academic achievement and locus of control is examined in many studies, and the general conclusion is that these variables are positively correlated. When some of these studies are examined in terms of locus of control, there is a positive relationship between the internal locus of control and academic achievement, and students with an internal locus of control are more successful in their academic lives (Richardson et al., 2012; Findley and Cooper, 1983). In other words, internality predicts higher academic achievement, whereas externality predicts lower academic achievement (Nowicki, 2016).

Although both the locus of control and self-efficacy are related to control literature and grounded in social learning theory, locus of control evaluates individuals' beliefs about whether the outcomes are generally attributed to internal or external factors, whereas 'self-efficacy measures one's confidence in being able to achieve an important goal' (Au, 2015: 427). Various studies have examined the correlation between the variables described here. Au (2015) found that internal locus of control and self-efficacy significantly predicted students' perceived control over their course performance. Preston and Latta (1978) reported that locus of control moderated female students' academic motivation scores in predicting their academic achievement.

A meta-analytic study by Richardson et al. (2012) also showed that internal locus of control, self-efficacy, and intrinsic motivation significantly positively correlated with academic achievement. As such, Bahçekapılı and Karaman (2020) found that self-efficacy had a significant direct and indirect effect on student achievement, whereas the external locus of control had a significant negative direct and indirect effect on their achievement scores. Both these variables significantly mediated the relationship between personality traits and academic achievement. Yet, internal control did not influence achievement scores.

In addition, Khorsidi et al. (2019) reported that achievement motivation and locus of control were significant positive correlates of academic achievement, while academic procrastination was a significant negative correlate. Their tested model indicated that motivation mediated the relationship between academic procrastination and locus of control with student achievement, where a decreased academic procrastination and an increased locus of control resulted in increased academic achievement. Furthermore, Wu et al. (2020) tested whether learning engagement and self-efficacy mediated the relationship between intrinsic and extrinsic motivation and academic achievement. Their findings indicated that both intrinsic and extrinsic motivation significantly predicted self-efficacy and exerted a significant indirect influence on student achievement through learning engagement. However, self-efficacy had a non-significant effect on academic achievement. Another study showed that self-efficacy was a strong predictor of intrinsic motivation (Skaalvik et al., 2015). These studies have examined the direct and indirect effects of locus of control, self-efficacy, and motivation on academic achievement tested along with some other variables. Their results showed that each one of these variables could mediate the relationship between the other two variables and achievement. Yet, some theoretical (Yeşilyaprak, 2004) and empirical information discussed earlier generally suggest that motivation may mediate the relationship between self-efficacy, locus of control, and academic achievement. Thus, the researchers proposed the model illustrated in Figure 1 based on these theoretical and empirical insights. No meta-analytic review examined these variables together to discover the best-fitting model that better explains academic achievement, addressed the discrepancies in primary research findings reflected in Table 2. This study aimed to examine whether motivation mediates the relationship between self-efficacy and locus of control and academic achievement and their predictive power by fitting the proposed model graphically shown in Figure 1.

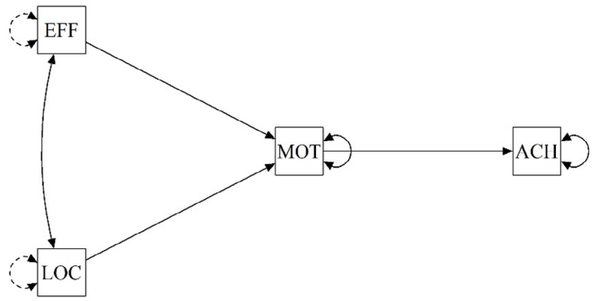

Figure 1: The proposed model

MATERIAL AND METHODS

Literature search

In order to identify the relevant studies, two researchers independently searched the following online databases during July and August 2022 without limiting the search to specific years: Google Scholar, ERIC, Web of Science, ProQuest, and the Turkish Higher Education Counsel (CoHE) Thesis Centre. The following keywords and combinations were used as search terms in English: ('locus of control' OR 'LOC') AND ('achievement' OR 'performance') AND ('motivation' OR 'self-efficacy'). In addition, the reference lists of studies were examined to access more studies. As a result, 151 studies were retrieved.

Study selection criteria

Research reports matching the following study selection criteria are deemed eligible for this meta-analytic structural equation modelling (MASEM) study. First, studies should provide a minimum of three correlation coefficients for the association between any of the variables of focus in this review (i.e., locus of control, self-efficacy, motivation, and academic achievement). Otherwise, the analyses cannot be conducted because of too much missing data. Second, they should use parametric correlation tests, assuming a normal distribution. Third, studies examining the locus of control or motivation should provide the correlation values for both the external and internal locus of control and motivation to obtain a synthetic effect size and include in the analysis. This is because some studies provide correlation data based on only the internal or external subscales of these constructs, whereas others provide the correlations based on their total scores. Fourth, the scores obtained from the tests or scales used in primary studies should have similar interpretations. Fifth, the sample of studies should consist of students.

All 151 studies were screened against these criteria. First, we screened the studies by title and abstract, excluding discussion papers and off-topic studies. As such, the analysis did not include studies providing only one or two correlation

coefficients or using non-parametric tests. Some studies only examined the correlation between the internal locus of control or motivation and other variables and therefore were excluded. In addition, studies reporting unequal sample sizes for the association between the variables were not included. As such, we included 37 studies meeting all the study selection criteria, which yielded 40 correlation estimates. The inclusion and exclusion processes of studies are illustrated in Figure 2.

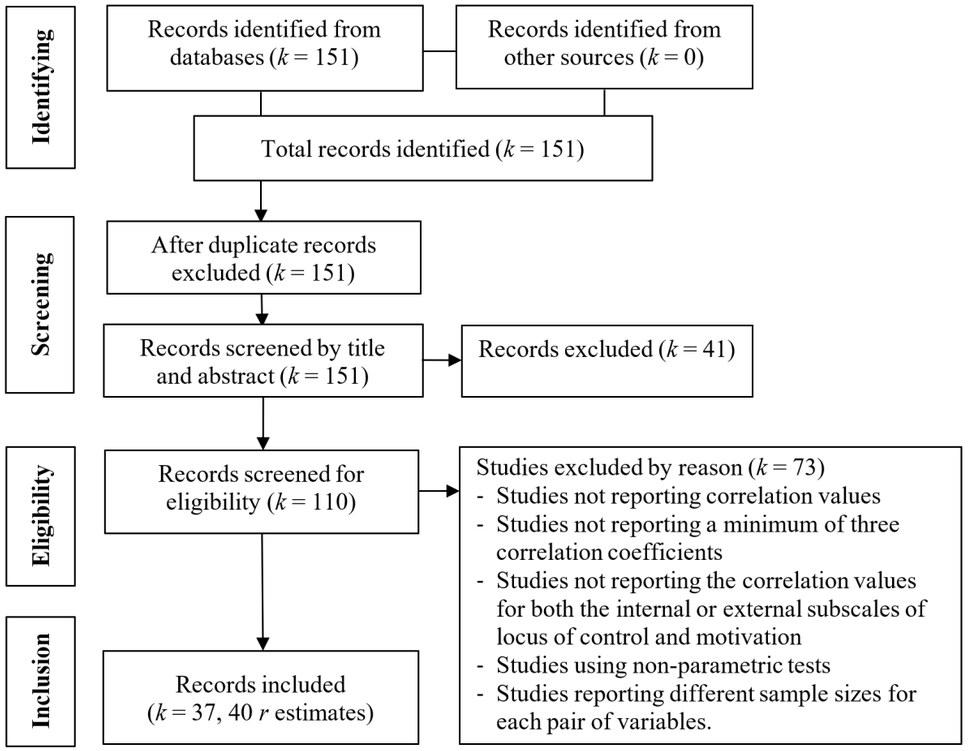

Figure 2: The Inclusion and Exclusion Processes of Primary Studies

Quality assessment

To examine the quality of studies included in the analysis, we employed a quality assessment form for quantitative studies developed by Kmet, Lee and Cook (2004). This form includes fourteen quality indicators with detailed guidelines. However, the authors suggest only using items applicable to research methods used in primary studies and calculating the quality score accordingly. Studies fully, partially, and not meeting the criteria are given scores of 2, 1, and 0, respectively. The total quality score is obtained by summing full and partial scores obtained for a specific study divided by the total possible sum, which is 10 in this study. The threshold for quality scores could be chosen between 55% and 75%, showing relatively liberal and conservative cut-off values. Considering the research methods used in selected studies, we evaluated them using the following five quality indicators: 'Question / objective sufficiently described? Study design evident and appropriate? Subject…characteristics sufficiently described? Results reported in sufficient detail? Conclusions supported by the results?' (Kmet, Lee and Cook, 2004: 5). The quality assessment was conducted independently by two researchers. Accordingly, the overall quality scores obtained for selected studies ranged from 60 to 100% on average, showing sufficient quality to be included in the analysis.

Coding study characteristics

Studies deemed eligible for this MASEM were coded by author name(s), publication year, primary purpose, research method, sex, mean age, country, and publication type. As shown in Table 1, the selected studies were conducted between 1980 and 2021.

ID	Author(s), Year	Primary Purpose	Method	Sample	% Sex		Mean Age	Country	Publication Type
					Male	Female			
1	Akomolafe et al., 2013	To investigate the role of self-efficacy, motivation and self-concept in predicting secondary school students' academic performance.	Correlational	Secondary	51.31	48.70	15.28	Nigeria	Article (EN)
2	Bahçekapılı and Karaman, 2020	To develop a model that predicts the students' academic achievement by their characteristics such as personality traits, self-efficacy, and locus of control.	Correlational	Tertiary	61.90	38.10	30.90	Turkey	Article (EN)
3	Bjørnebekk et al., 2013	To investigate the joint effects of achievement motives, self-efficacy, and achievement goals as predictors of academic achievement.	Longitudinal	Tertiary	19.48	80.52	27.5	Norway	Article (EN)
4	Cazenave, 1993	To correlate self-concept, perception toward school environment, achievement motivation, locus of control, and attendance with reading achievement.	Correlational	Secondary (G6, 8)	39.31	60.69	12.5	USA	Thesis (EN)
5	Dogan, 2015	To explore the relations among student engagement, academic performance, self-efficacy, and academic motivation.	Correlational	Secondary and High	38	62	16.7	Turkey	Article (EN)
6	Ebrahim, 1998	To investigate the effects of locus of control, working memory, motivation components, and verbal ability on foreign language learning.	Correlational	Tertiary	—	—	—	USA	Thesis (EN)
7	Ejiobi-Okeke and Samuel, 2021	To investigate secondary school students' achievement motivation and locus of control as predictors of their academic achievement.	Correlational	Secondary	—	—	—	Nigeria	Article (EN)
8	Fini and Yousefzadeh, 2011	To investigate the relationship between achievement motivation, locus of control and educational achievement.	Correlational	High	47.39	52.61	—	Iran	Article (EN)
9	Goote, 2014*	To examine the relationship between self-esteem, locus of control, and learning motivation to academic achievement.	Survey	Tertiary	—	—	—	USA	Thesis (EN)
10	Graham, 2007	To expand the understanding of possible psychosocial predictive measures of student success.	Casual-Comparative	Tertiary	58.55	41.45	18.7	USA	Thesis (EN)
11	Jadhav, 2007	To examine personality attributes of locus of control, self-efficacy, and conscientiousness on goal commitment and performance.	Correlational	Tertiary	—	—	—	USA	Thesis (EN)
12	Khorsidi et al., 2019	To investigate the relationship between academic procrastination, locus of control and achievement motivation with academic achievement.	Correlational	Tertiary	48.79	51.21	20.92	Iran	Article (PER)
13	Landine and Steward, 1998	To investigate the relationship between metacognition and academic achievement, motivation, locus of control, and self-efficacy.	Correlational	High (G12)	51.85	48.15	18	Canada	Article (EN)

ID	Author(s), Year	Primary Purpose	Method	Sample	% Sex		Mean Age	Country	Publication Type
					Male	Female			
14	Lewis, 2017	To examine the role of locus of control and self-efficacy in shaping student academic performance.	Correlational Cross-sectional	Tertiary	14.10	85.90	31.55	Trinidad and Tobago	Thesis (EN)
15	Li, Liu et al., 2020*	To investigate the possible mediating and moderating factors in the relationship between peer relationships and science literacy.	Correlational	High (G9)	50.80	49.20	14.74	China	Article (EN)
16	Li, Peng et al., 2020	To examine the mediating and moderating roles of self-efficacy and motivation in the relationship between peer relationships and mathematics achievement.	Correlational	High (G9)	50.84	49.16	14.85	China	Article (EN)
17	Martinez, 2003*	To investigate the predictors of academic achievement.	Survey	Secondary (G7-8)	—	—	13.00	USA	Thesis (EN)
18	Montejano, 2014	To explore how perceived parental involvement, locus of control, self-efficacy, and acculturation predict academic achievement.	Correlational	High (G9,11,12)	49	51	—	USA	Thesis (EN)
19	Nurwendah and Suyanto, 2019	To reveal the relationship among self-motivation, self-efficacy, and achievement.	Correlational	High	—	—	—	Indonesia	Paper (EN)
20	Ogunmakin and Aomolafe, 2013	To examine the contribution of academic self-efficacy and locus of control to students' performance.	Correlational	Secondary	—	—	—	Nigeria	Article (EN)
21	Payne, 2011	To investigate whether self-efficacy, locus of control, and access and proficiency in technology are associated to success.	Correlational	Tertiary	14.53	85.47	29	USA	Thesis (EN)
22	Salami, 2008	To investigate the relationship between psychopathology and students' academic performance and the moderator effects of study behaviour, self-efficacy, and motivation.	Correlational	Secondary	47.90	52.10	16.40	Nigeria	Article (EN)
23	Salazar and Hayward, 2018	To investigate whether self-efficacy constructs positively impact students' motivation, performance, and expectations for achievement.	Correlational	Tertiary	71.90	28.10	—	USA	Article (EN)
24	Skaalvik et al., 2015	To understand the mediating effects of self-efficacy and perceptions of teachers' emotional support on the relationship between past achievement and current motivation for schoolwork.	Correlational	Secondary (G8-10)	49.30	53.70	—	Norway	Article (EN)
25	Snodgrass, 1989	To examine the relationship between locus of control, achievement motivation, knowledge of study skills and academic performance.	Correlational	Tertiary	—	—	—	USA	Thesis (EN)
26	Stevens et al., 2004	To evaluate a theoretical model that describes relationships involving personal qualities, including self-efficacy, and motivational orientation, and variables associated with mathematics achievement.	Correlational	High (G9-10)	—	—	14.72	USA	Article (EN)

ID	Author(s), Year	Primary Purpose	Method	Sample	% Sex		Mean Age	Country	Publication Type
					Male	Female			
27	Suphi and Yaratan, 2012	To assess the relationship between learning approaches, locus of control, demographic factors, self-efficacy and academic achievement.	Correlational	Tertiary	45.60	54.40	21	Cyprus	Article (EN)
28	Tella et al., 2009	To find out the extent to which locus of control, interest in schooling and self-efficacy can predict academic achievement.	Correlational	Secondary	60	40	13.5	Nigeria	Article (EN)
29	Thompson, 2005	To determine the relationships among self-efficacy, internal locus of control, external locus of control, achievement goal orientation, and academic performance.	Survey	Tertiary	56	44	26	USA	Thesis (EN)
30	Turner et al., 2009	To examine the relations among authoritative parenting style, academic performance, self-efficacy, and achievement motivation.	Correlational	Tertiary	34.80	65.20	19.27	USA	Article (EN)
31	Waseem and Asim, 2020	To build the regression model of self-esteem, self-efficacy, and locus of control as the predictors of academic performance.	Survey	Tertiary	61.33	48.67	—	Pakistan	Article (EN)
32	Wilhite, 1990	To examine the relationship between self-efficacy, study behaviour and academic course achievement by comparing self-efficacy and locus of control as predictors of achievement.	Correlational	Tertiary	—	—	—	USA	Article (EN)
33	Willens, 1980	To examine the relationship between the academic achievement and socioeconomic status, verbal ability, locus of control, achievement motivation, and persistence.	Correlational	Tertiary	—	—	—	USA	Thesis (EN)
34	Wu et al., 2020	To shed light on the mechanisms that govern how different types of motivation affect learning engagement and performance.	Correlational	Tertiary	29.70	70.30	—	China	Article (EN)
35	Yağcı, 1999	To investigate the relationship between locus of control, motivation and academic achievement.	Correlational	High (G12)	54.66	45.34	—	Turkey	Thesis (TR)
36	Yang et al., 2018	To explore the contributions of student reading motivation, reading self-efficacy, and family literacy environment to reading achievement.	Correlational	Primary	50.60	49.40	9.7	Abu Dhabi	Article (EN)
37	Yüner, 2020	To describe the current status of the relationships between prospective teachers' academic self-efficacy, academic motivation and academic success.	Survey	Tertiary	25.80	74.20	—	Turkey	Article (EN)

*Note: * Provides correlation estimates for two independent groups, G = Grade, EN = English, TR = Turkish, PER = Persian.*

Table 1: Characteristics of Selected Studies

Most studies were correlational followed by some survey and longitudinal studies. The sample of studies consisted of students from primary to tertiary education levels, including both male and female students. Students were of ages 9.7–30.9 on average, though not all these age ranges represent all studies. Most studies were conducted in the USA (k = 15) followed by other Western, European, Asian, and African countries. The majority of studies (k = 23) were published in peer-reviewed journals followed by master's or doctoral theses (k = 13), and peer-reviewed conference papers (k = 1). Most studies were written in English. Only one was in Turkish and one in Persian. However, both included English abstracts, containing the data needed for this study. All studies examined the relationship between a minimum of three variables. Some studies examining both the internal and external locus of control (Bahçekapılı and Karaman, 2020; Thompson, 2005; Yağcı, 1999) and motivation (Ebrahim, 1998; Turner et al., 2009; Wu et al., 2020; Yang et al., 2018; Yüner, 2020) did not provide correlation coefficients based on total scores relating to these constructs like most selected studies included in the analysis. Therefore, combined correlation coefficients were obtained based on data from such studies. These were combined using subgroup analysis to obtain a single synthetic effect. In this process, the Comprehensive Meta-Analysis Software (Borenstein et al., 2014) was used to handle such complex data structures representing dependent and independent groups. The raw correlation coefficients showing the relationships between the variables and valid sample sizes extracted from the primary studies are listed in Table 2.

Data analysis

A two-stage MASEM approach proposed by Cheung (2015a) was employed in this study to test the appropriateness of several models using R (v.4.2.2; R Development Core Team, 2022), metaSEM R package (v.1.3.0; Cheung, 2015b), and meta R package (v.6.2.1; Balduzzi et al., 2019). In stage 1, the correlation matrices prepared for each study using R codes in Jak (2015) were combined under a random-effects model to obtain summary correlation effect size estimates (weighted r) for the association between each pair of variables, as in pairwise meta-analyses (Cheung, 2015a, 2015b). According to the meta-analysis scholars, primary studies included in meta-analytic reviews are carried out by different researchers using different research designs, populations, and measures in various settings are likely to produce varying results (Borenstein et al., 2009; Cheung, 2015a). Therefore, they suggest pooling the observed effect size estimates under a random-effects model, letting the effect sizes vary across studies. As study characteristics showed (Table 1), studies included in this review are conducted in different countries with different samples and sample sizes, yielding conflicting results (Table 2). Considering scholars' suggestions and variability among the included primary studies, we decided to pool the raw correlation coefficients under a random-effects model. The summary effects were interpreted under Funder and Ozer's (2019) very small (0.05), small (0.10), medium (0.20), large (0.30), and very large (0.40) correlation effect size classification. The significance of heterogeneity between studies was evaluated using the Q statistics. In addition, the magnitude of heterogeneity between effect sizes (I^2) was interpreted per Higgins et al.'s (2003) small (25%), moderate (50%), and high (75%) classification of effect size variability, though these values are not absolute measures of heterogeneity (Borenstein et al., 2017). Publication bias was inspected using funnel plot, Egger's test, and rank correlation test.

In stage 2, the pooled correlation matrix of multiple correlation matrices obtained in stage 1 was used to test and compare several structural equation models through MASEM (Cheung, 2015a; Jak, 2015). Three models were tested in this review, where the first model tested the mediating role of motivation among the association between the independent variables, self-efficacy and locus of control, and the dependent variable, academic achievement. However, the second model tested the direct effect of self-efficacy on achievement as an alternative model. The third model was tested by excluding locus of control from the model because of not correlating with self-efficacy and academic achievement. To fit the models, an asymmetric matrix (A matrix) specifying the regression coefficients among variables and a symmetric matrix (S matrix) specifying 'the variance-covariances of the variables' (Cheung, 2015a: 162) was created, using the laavan R package (v.0.6.15; Rosseel, 2012). The goodness-of-fit indices of the fitted models were evaluated by examining the RMSEA, SRMR, CFI, and TLI model fit measures following Hu and Bentler's (1999) recommended cut-off values. Accordingly, RMSEA and SRMR values of ≤ 0.05 plus CFI and TLI values of ≥ 0.95 are good model-fit indicators. Also, Hoyle (2012) notes that the TLI value can exceed 1 when a model's χ^2 is smaller than its degree of freedom. However, the AIC and BIC measures were considered while deciding on a superior model among the competitor models, where the smallest value indicated the most suitable model (Schermelleh-Engel and Moosbrugger, 2003).

RESULTS

Summary effects

A random-effects model was employed to combine 40 correlation coefficients extracted from 37 primary studies (N = 16946). Table 3 presents the summary effects (weighted r) with their corresponding 95% confidence intervals (CI) and heterogeneity measures. Accordingly, the analyses yielded very small and statistically non-significant positive summary effect size estimates for the associations between the locus of control and academic achievement (0.053, 95% CI [−0.046, 0.153]) and self-efficacy (0.013, 95% CI [−0.135, 0.162]), respectively. However, statistically significant and moderate positive summary effects were obtained for the associations between self-efficacy and achievement (0.218, 95% CI [0.133, 0.303]), between motivation and achievement (0.237, 95% CI [0.193, 0.280]), and between locus of control and motivation (0.216, 95% CI [0.106, 0.327]). In contrast, a statistically significant and very large positive summary effect was obtained for the association between self-efficacy and motivation (0.415, 95% CI [0.332, 0.499]). These results indicate that higher self-efficacy and motivation can lead to higher academic achievement and higher self-efficacy and locus of control can lead to higher motivation, but locus of control barely leads to higher self-efficacy and academic achievement. The Q-test showed significant effect size variability (Q (108) = 2189.3, p < 0.01). As seen in Table 3, the I^2 values ranged between 80.42% and 96.24%, showing a proportion of high variability across the observed effects due to variation in true effects that is not due to sampling error.

Studies	Valid *N*	LOC-ACH	EFF-ACH	MOT-ACH	LOC-EFF	LOC-MOT	EFF-MOT
1. Akomolafe et al., 2013	398	n.r	0.390	0.420	n.r	n.r	0.430
2. Bahçekapılı and Karaman, 2020	525	−0.064	0.136	n.r	−0.019	n.r	n.r
3. Bjørnebekk et al., 2013	231	n.r	0.120	0.220	n.r	n.r	0.520
4. Cazenave, 1993	146	0.120	n.r	0.290	n.r	0.310	n.r
5.Dogan, 2015	578	n.r	0.500	0.110	n.r	n.r	0.400
6. Ebrahim, 1998	91	−0.110	n.r	0.202	n.r	−0.095	n.r
7. Ejiobi-Okeke and Samuel, 2021	231	0.326	n.r	0.345	n.r	0.601	n.r
8. Fini and Yousefzadeh, 2011	211	0.15	n.r	0.150	n.r	0.160	n.r
9. Gootee, 2014a	190	0.220	n.r	0.122	n.r	0.135	n.r
10. Gootee, 2014b	124	0.143	n.r	0.168	n.r	0.123	n.r
11. Graham, 2007	234	n.r	n.r	n.r	0.209	0.402	0.195
12. Jadhav, 2007	165	0.188	0.419	n.r	0.193	n.r	n.r
13. Khorsidi et al., 2019	494	0.170	n.r	0.260	n.r	0.270	n.r
14. Landine and Steward, 1998	108	−0.270	−0.380	0.420	0.410	n.r	n.r
15. Lewis, 2017	268	−0.227	0.121	n.r	−0.392	n.r	n.r
16. Li, Liu et al., 2020a	303	n.r	0.120	0.250	n.r	n.r	0.690
17. Li, Liu et al., 2020b	293	n.r	0.050	0.200	n.r	n.r	0.590
18. Li, Peng et al., 2020	527	n.r	0.085	0.202	n.r	n.r	0.639
19. Martinez, 2003a	53	0.117	0.395	0.238	n.r	n.r	n.r
20. Martinez, 2003b	42	0.121	0.558	0.431	n.r	n.r	n.r
21. Montejano, 2014	380	−0.146	0.192	n.r	−0.083	n.r	n.r
22. Nurwendah and Suyanto, 2019	230	n.r	0.302	0.225	n.r	n.r	0.389
23. Ogunmakin and Akomolafe, 2013	364	0.060	0.360	n.r	0.310	n.r	n.r
24. Payne, 2011	117	−0.134	0.219	n.r	−0.346	n.r	n.r
25. Salami, 2008	476	n.r	0.320	0.260	n.r	n.r	0.280
26. Salazar and Hayward, 2018	160	n.r	0.170	0.050	n.r	n.r	0.220
27. Skaalvik et al., 2015	823	n.r	0.635	0.472	n.r	n.r	0.664
28. Snodgrass, 1989	107	−0.030	n.r	0.290	n.r	0.210	n.r
29. Stevens et al., 2004	358	n.r	0.470	0.310	n.r	n.r	0.380
30. Suphi and Yaratan, 2012	99	−0.096	0.337	n.r	−0.191	n.r	n.r
31. Tella et al., 2009	500	0.365	−0.466	n.r	−0.321	n.r	n.r
32. Thompson, 2005	231	0.100	0.052	n.r	0.417	n.r	n.r
33. Turner et al., 2009	264	n.r	0.250	0.095	n.r	n.r	0.406
34. Waseem and Asim, 2020	452	0.399	0.350	n.r	0.254	n.r	n.r
35. Wilhite, 1990	184	0.380	−0.160	n.r	0.100	n.r	n.r
36. Willens,1980	44	−0.420	n.r	0.450	n.r	−0.180	n.r
37. Wu et al., 2020	1930	n.r	0.120	0.056	n.r	n.r	0.276
38. Yağcı, 1999	547	−0.430	n.r	0.317	n.r	0.244	n.r
39. Yang et al., 2018	4146	n.r	0.420	0.150	n.r	n.r	0.100
40. Yüner, 2020	322	n.r	0.120	0.191	n.r	n.r	0.456
Number of Studies		24	29	28	13	11	16

Note: LOC = Locus of Control, MOT = Motivation, EFF = Self-Efficacy, ACH = Achievement, n.r = no correlation reported

Table 2: Correlation Coefficients Extracted from Selected Studies

Although all funnel plots indicated asymmetrical distributions of the observed outcomes around the mean correlation effects sizes (see the Appendix), Egger's regression test indicated that these asymmetries were statistically non-significant (p > 0.05), except for the mean correlation effect size of the association between self-efficacy and motivation (p < 0.01). However, the rank correlation test indicated no publication bias in any of the meta-analyses (p > 0.05).

Relations	k	N	Weighted r	95% CI		p	τ²	I²
				LL	UL			
LOC-ACH	24	5673	0.053	−0.046	0.153	0.292	0.048	95.08%
EFF-ACH	29	14527	0.218	0.133	0.303	< 0.001	0.046	95.48%
MOT-ACH	28	13427	0.237	0.193	0.280	< 0.001	0.010	80.42%
LOC-EFF	13	3627	0.013	−0.135	0.162	0.859	0.065	96.24%
LOC-MOT	11	2419	0.216	0.106	0.327	< 0.001	0.029	92.90%
EFF-MOT	16	11273	0.415	0.332	0.499	< 0.001	0.027	92.80%

Note: LOC = Locus of Control, MOT = Motivation, EFF = Self-Efficacy, ACH = Achievement, LL = Lower Limit, UL = Upper Limit

Table 3: Summary effects and heterogeneity measures from stage 1 MASEM

Test of models

At this stage of the analysis, the mediation role of motivation was tested among self-efficacy, locus of control, and academic achievement based on the proposed model (Model 1). In addition, an alternative model was tested by drawing a direct line from self-efficacy to academic achievement (Model 2). Table 4 provides the model fit indices for the models tested using stage 2 of MASEM. As Table 4 indicates, the model tested (Model 1) using motivation as a mediator variable was statistically significant ($\chi^2(2) = 6.955$, $p < 0.05$). However, all other model fit indices indicated a good fit (RMSEA = 0.012, SRMR = 0.046, TLI = 0.937, CFI = 0.979).

Model	χ²(df)	p	RMSEA	RMSEA 95% CI		SRMR	TLI	CFI	AIC	BIC
				LL	UL					
Model 1	6.955 (2)	0.031	0.012	0.003	0.022	0.046	0.937	0.979	2.955	−12.521
Model 2	0.063 (1)	0.802	< 0.001	< 0.001	0.013	0.005	1.024	1.000	−1.937	−9.675

Table 4: Goodness-of-fit indices obtained for each model

According to path coefficients in Figure 3, students' self-efficacy ($\beta = 0.44$, 95% CI [0.35, 0.53]) and locus of control ($\beta = 0.21$, 95% CI [0.09, 0.34]) significantly influenced their motivation. Self-efficacy and locus of control significantly influenced academic achievement through motivation ($\beta = 0.25$, 95% CI [0.21, 0.29]). In addition, self-efficacy and locus of control accounted for 24% of the variance in motivation and all these three variables accounted for 6% of the variance in academic achievement. However, Figure 3 shows that self-efficacy and locus of control do not significantly co-vary, but both directly contribute to student motivation and indirectly to their academic achievement.

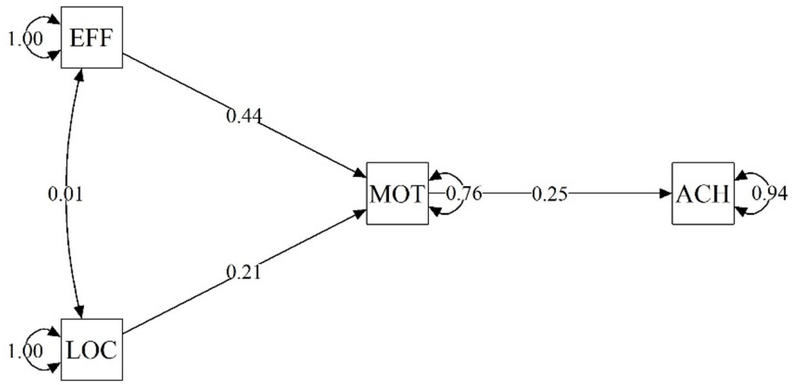

Figure 3: Motivation as a mediator variable (Model 1)

An alternative model (i.e., Model 2) was tested to examine the direct effect of self-efficacy on academic achievement. Although the proposed model (Table 4) indicated a good fit, the alternative model fitted the data perfectly (χ^2 (1) = 0.063, $p > 0.05$, RMSEA < 0.001, SRMR = 0.005, TLI = 1.024, CFI = 1.000). Here, the χ^2 value of Model 2 was smaller than its degree of freedom, and thereby the TLI value slightly exceeded 1, indicating a very well-fitting model. According to the path coefficients illustrated in Figure 4, self-efficacy had a significantly small direct effect on academic achievement ($\beta = 0.14$, 95% CI [0.04, 0.25]. In contrast, it had a significantly higher direct influence on motivation ($\beta = 0.41$, 95% CI [0.32, 0.50]). Both self-efficacy and locus of control accounted for 22% of the variance in motivation and through motivation they significantly influenced academic achievement ($\beta = 0.18$, 95% CI [0.11, 0.24]), accounting for 7% of the variance. These findings show that self-efficacy both directly and indirectly influences academic achievement.

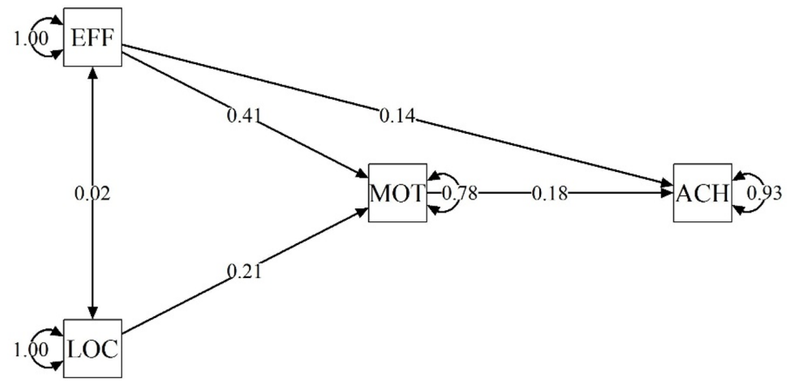

Figure 4: Direct effect of self-efficacy on achievement (Model 2)

As the locus of control was a statistically non-significant correlate of self-efficacy and academic achievement, the mediation role of motivation was retested by excluding the locus of control from the model (Model 3). This model was tested based on fifteen studies providing all three correlation coefficients between self-efficacy, motivation, and academic achievement. According to pairwise meta-analyses conducted under a random-effects model between these variables (Table 5), the correlation effect size estimates for the association between self-efficacy (0.274, 95% CI [0.186, 0.362]) and motivation (0.216, 95% CI [0.156, 0.276]) were positive and statistically significant, indicating a moderate effect. Contrarily, the analysis yielded a very large positive significant effect size estimate for the association between self-efficacy and motivation (0.429, 95% CI [0.345, 0.513]). The effect sizes were also heterogeneous (χ^2 (42) = 1048.32, $p < 0.01$), and the I^2 index ranged between 88.75% and 95.75%, showing high variability among the observed effects due to variation in true effects.

Relations	k	N	Weighted r	95% CI		p	τ²	I²
				LL	UL			
EFF-ACH	15	11039	0.274	0.186	0.362	< 0.001	0.028	95.75%
MOT-ACH			0.216	0.156	0.276	< 0.001	0.012	88.75%
EFF-MOT			0.429	0.345	0.513	< 0.001	0.025	95.19%

Table 5: Summary effects and heterogeneity measures from stage 1 MASEM with three variables

These combined correlation effect sizes were used to fit Model 3 (Figure 5). Since this model was saturated with a zero degree of freedom, no model fit index was produced. According to path coefficients, self-efficacy had a very large direct effect on motivation ($\beta = 0.43$, 95% CI [0.34, 0.51]) and a moderate direct effect on achievement ($\beta = 0.22$, 95% CI [0.11, 0.34]). It explained 8% of the variance in motivation. Self-efficacy also had a small indirect effect on achievement through motivation ($\beta = 0.12$, 95% CI [0.03, 0.21]). Altogether, self-efficacy and motivation accounted for 9% of the variance in academic achievement.

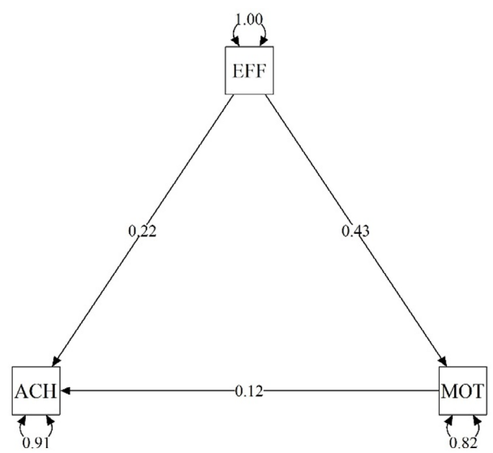

Figure 5: The mediation role of motivation between self-efficacy and achievement (*k = 15*)

DISCUSSION AND CONCLUSION

This study examined the relationship between students' academic achievement, self-efficacy, motivation, and locus of control through MASEM. For this purpose, correlation coefficients between these four variables were collected from the literature. In the first stage of MASEM, we calculated the mean effect size estimates for the association between these four variables by extracting 40 correlation coefficients from 37 studies and combining them under a random-effects model. According to the results, there were moderate and significant ($p < 0.05$) correlations between academic achievement, self-efficacy, and motivation ($r = 0.218$ and $r = 0.237$, respectively). In contrast, there was no significant relationship between academic achievement and locus of control ($p > 0.05$). According to these results, students' academic achievement increases as their self-efficacy and motivation increase. However, no such relationship exists between their locus of control and academic achievement. The findings regarding the association between academic achievement, self-efficacy, and motivation are congruent with the past meta-analytic reviews examining the association between academic achievement and self-efficacy (Goetze and Driver, 2022; Honicke and Broadbent, 2016; Multon, Brown and Lent, 1991; Richardson et al., 2012; Stajkovic et al., 2018, Talsma et al., 2018) and the association between academic achievement and motivation (Richardson et al., 2012). For instance, Honicke and Broadbent (2016) conducted a meta-analysis of 53 studies examining the relationship between self-efficacy and academic performance. They obtained a moderate correlation effect size for the association between these two variables ($r = 0.33$). Another meta-analysis study reported significantly positive correlation effect sizes for the association between academic achievement and motivational ($r = 0.321$), social ($r = 0.210$), and emotional factors ($r = 0.172$; Quílez-Robres et al., 2021). All these existing meta-analyses indicated that self-efficacy and motivation are positive correlates of academic achievement. Supporting the finding regarding the association between locus of control and academic achievement, a meta-analysis conducted with 23 studies yielded a very small non-significant mean correlation effect size estimate (0.02, 95% CI [-0.11, 0.12]; Çoğaltay, 2017). Yet, other past meta-analyses contradict this finding (Richardson et al., 2012; Findley and Cooper, 1983). For instance, Richardson et al. (2012) found a small and significant correlation effect size regarding the association between internal locus of control and students' academic performance ($k = 13$, $r = 0.13$, 95% CI [0.04, 0.22]). However, Yeşilyaprak (2004) argues that locus of control is not a variable that directly enables and initiates learning but directly influences student achievement expectations from learning outcomes and motivation, indirectly affecting their learning performance.

There was a very large significant ($p < 0.05$) correlation between students' course motivation and self-efficacy ($r = 0.415$), whereas there was a significant ($p < 0.05$) moderate correlation between motivation and locus of control ($r = 0.216$). However, there was no significant relationship between students' self-efficacy and locus of control ($p > 0.05$). According to these results, as students' motivation towards a course increases, their self-efficacy and internal locus of control increase. Contrarily, there is no such relationship between students' self-efficacy and their locus of control. Supporting the findings of this study, past research also shows that motivation positively correlates with self-efficacy (Ariff et al., 2022; Wu et al., 2020), locus of control (Preston and Latta, 1978), and learning performance (Cocca and Cocca, 2019). In contrast, the correlation effect size for the association between self-efficacy and locus of control rejected the results of some primary studies reporting a significant correlation between the two variables (e.g., Bahçekapılı and Karaman, 2020; Drago et al., 2018). For instance, Drago et al. (2018) reported that self-efficacy and locus of control were significant predictors of academic performance. As with the relationship between locus of control and academic achievement, self-efficacy and locus of control had no significant direct relationship but they may indirectly influence each other through other variables not included in this review.

In the second stage of MASEM, we established various models (proposed, alternative, and three-variable models) between academic achievement, motivation, self-efficacy, and locus of control and tested their goodness-of-fit. In model 1 (proposed model), we examined the effect of self-efficacy and locus of control on academic achievement with the mediation of motivation. Considering its goodness-of-fit indices, this model indicated acceptable model data fit. According to the path graphic (Figure 3), self-efficacy had a significant very large effect on motivation ($\beta = 0.44$) and locus of control had a significant moderate effect ($\beta = 0.21$). Self-efficacy and locus of control accounted for 24% of the variance in students' motivation towards a course. Motivation had a significant moderate effect on academic achievement ($\beta = 0.25$). Further, self-efficacy and locus of control accounted for 6% of the variance in academic achievement through motivation. Supporting these findings, Li, Peng et al. (2020) concluded that self-efficacy significantly predicts motivation, and the variables of peer relationships and motivation significantly predict academic achievement. Alternatively, Wu et al. (2020) found that motivation significantly influences self-efficacy. Bandura (1995: 18) claims that 'the higher students' beliefs in their efficacy to regulate their motivation and learning activities, the more assured they are in their efficacy to master academic subjects'. The model examined by Khorsidi et al. (2019) supported the finding regarding the moderate effect of locus of control on motivation and the effect of motivation on academic achievement, while they reported that locus of control had a small effect on achievement.

In addition to the proposed model, we established a direct relationship between self-efficacy and academic achievement in model 2 (alternative model). According to the goodness-of-fit indices of this model, the model perfectly fitted the data. Considering the path graphic (Figure 4), self-efficacy had a very large significant effect on motivation ($\beta = 0.41$), while locus of control had a significant moderate effect ($\beta = 0.21$). Self-efficacy and locus of control accounted for 22% of the variance in students' motivation towards a course. Motivation and self-efficacy had a significantly small effect on academic achievement ($\beta = 0.18$ and $\beta = 0.14$, respectively).

In this model, all variables accounted for 7% of the variance in academic achievement. Both the proposed and alternative models explained a considerable amount of variance in motivation, and the effect sizes were similar. Yet, this model showed that self-efficacy may have a smaller direct effect on achievement but a very large effect on motivation. In other words, supporting Bandura's (1995) claim quoted earlier, students who have higher self-efficacy may develop higher motivation and thereby demonstrate higher academic performance. Bandura (1995) also confirms the correlation between self-efficacy beliefs and academic achievement but adds that the magnitude of this association varies across cultures. Similarly, Zimmerman (1995: 208) argues that 'self-efficacy fosters engagement in learning activities' and 'such beliefs affect level of achievement as well as motivation'. Additionally, a meta-analytic cross-lagged study by Talsma et al. (2018) found that self-efficacy and academic performance positively affect each other. Put differently, self-efficacy significantly affects academic performance. However, academic performance has a significantly larger subsequent effect on self-efficacy than the effect of self-efficacy on performance. Therefore, considering these comments, drawing a direct line from self-efficacy to academic achievement and a line to motivation may have improved the goodness-of-fit of this model, through one cannot ignore the role of locus of control here. However, although control beliefs are important, they are insufficient to motivate students to pursue academic activities (Zimmerman, 1995). If students do not believe that they are capable of mastering 'academic demands, they tend to avoid them even though outcomes are academically achievable' (Zimmerman, 1985: 217). Therefore, both self-efficacy and locus of control together seem to play critical roles in improving student outcomes. All these findings relating to model 2 parallel studies discussed in support of findings related to the proposed model.

As the locus of control had a non-significant correlation with academic achievement and self-efficacy ($p > 0.05$), we excluded it from the model and established a three-variable model with the mediation of motivation. In this case, the model was saturated and the goodness-of-fit indices were not calculated. In saturated models, defined as perfectly fitting model with zero degrees of freedom (Hoyle, 2012), all variables are correlated with estimated means (Cheung, 2015a), where the correlations between variables are evaluated. When the model was examined, the direct effect of self-efficacy on academic achievement was significant and moderate ($\beta = 0.22$), while its effect on motivation was significantly very large ($\beta = 0.43$). However, motivation had a significantly small effect on academic achievement ($\beta = 0.12$). Self-efficacy and motivation accounted for 9% of the variance in academic achievement. Although there are only small differences between the amounts of explained variance by the three models, the saturated model is somewhat better than the other two models in explaining the total variance in academic achievement. Removing the locus of control from the model increased the direct effect of self-efficacy on achievement compared to the second model. Yet, locus of control and self-efficacy play a significant role in predicting student motivation, thereby positively influencing their academic achievement. All the predictor variables examined in this review can exert a considerable direct or indirect positive influence on students' academic achievement. However, self-efficacy and locus of control account for motivation better than all these three variables together explaining academic achievement.

Limitations and implications

This study is limited from several perspectives. First, the analyses showed that locus of control and self-efficacy did not directly correlate with each other. Other variables such as peer relationships, self-concept, self-esteem, and learning engagement may mediate the correlation between these two variables, as motivation mediated the relationship between locus of control and academic achievement. Future studies could examine other alternative models by including these and similar variables. Second, the correlation data did not represent all studies, as studies examining the relationship between at least three variables were included in the analysis, and no study examined all variables in the same study (see Table 2). Including studies with one or two correlations in the study can cause too many missing values that may not allow the program to run the analysis. Therefore, primary studies focusing on the relationship between all these variables are needed to enable further analyses through meta-analytic reviews of this kind. Third, the effect sizes obtained in this review were heterogeneous. Therefore, the mean correlation effect sizes could have been influenced by extraneous variables such as different data collection tools used in primary studies and various education levels that future studies may want to address through moderator analyses. In addition, the conclusions drawn from this study are limited to the findings of primary studies retrieved from only five databases and the search terms used. Searching more databases and journals could have yielded more relevant studies. These limitations may reduce the generalizability of our findings, which future studies may address by replicating this study.

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APPENDIX

FUNNEL PLOTS FOR EACH PAIRWISE META-ANALYSIS