



ARTICLE



<https://doi.org/10.1057/s41599-025-05470-y>

OPEN

Educational myths among teachers: prevalence and refutational intervention for belief change

Yeliz Tunga^{1✉}, Berkan Celik² & Kursat Cagiltay³

Educational myths tend to be very popular among teachers worldwide, and they have the potential to mislead teachers in their instructional decisions and practices. Following a comprehensive and holistic approach, this study, firstly, aims to reveal the prevalence of educational myths among in-service teachers, the channels through which these myths disseminate among teachers, and their impact on teachers' professional practices. Secondly, this study assesses the effectiveness of three distinct refutation text types (refutation-only, refutation with explanation, and refutation with anecdotal explanation) in altering teachers' beliefs concerning educational myths. The study employed mixed method research with 518 primary and middle school teachers participating. Data were collected using surveys with close and open-ended questions. An experiment involving 132 teachers, divided into three groups (refutation-only, $n = 41$; refutation with anecdotal explanation, $n = 45$; and refutation with explanation, $n = 46$), was conducted to change teachers' beliefs in educational myths. Results indicated that educational myths are common among teachers, with multiple intelligences, learning styles, and violent digital games being the most prevalent. The primary dissemination channels of myths are teachers' undergraduate education. Teachers often consider educational myths in their lessons and other educational activities. The study also revealed that anecdotal interventions are more effective in dispelling myths. The significant takeaway from this study is that educational myths are commonly accepted by the teachers, and it is very difficult to change their beliefs after they were exposed to them. The study highlights the persistence of educational myths and the challenges in debunking them, suggesting implications for teacher training and evidence-based professional development.

¹Faculty of Education, Manisa Celal Bayar University, Manisa, Türkiye. ²Faculty of Education, Van Yuzuncu Yil University, Van, Türkiye. ³Faculty of Education, TED University, Ankara, Türkiye. ✉email: yeliz.tunga@cbu.edu.tr

Introduction

Urban educational myths refer to widespread but scientifically unsupported beliefs about how learning and teaching should occur (De Bruyckere et al., 2015, 2020). These misconceptions, although appealing in educational discourse, lack empirical validation and can lead to ineffective pedagogical decisions. Research across various countries has consistently shown that such myths are prevalent among teachers (Ferrero et al., 2016; Newton & Salvi, 2020; Torrijos-Muelas et al., 2021). Among the most frequently endorsed myths are the learning styles, multiple intelligences, Maslow's hierarchy of needs pyramid, negative effects of violent digital games, and 21st-century skills. What follows is a brief overview of these common myths and the scientific critiques surrounding them.

Despite the widespread belief that students learn best when instruction matches their preferred sensory modality (visual, auditory, kinesthetic), there is no robust empirical evidence supporting the effectiveness of this practice (Kirschner, 2017; Newton & Salvi, 2020; Pashler et al., 2008). Studies showed that more than 90% of teachers still endorse this myth (Bukina et al., 2023; Ferrero et al., 2016; Janati Idrissi et al., 2020; Tovazzi et al., 2020; Tunga & Çağiltay, 2023). Most concepts of learning styles categorize people into distinct groups, but objective research offers very little support for learning style practices. Furthermore, nearly every study claiming to back learning styles falls short on basic scientific validity (Kirschner, 2017). Additionally, the current evidence does not adequately support integrating learning style assessments into educational practice to enhance academic results (e.g., Clinton-Lisell & Litzinger, 2024; Pashler et al., 2008). Moreover, these studies also indicated that the majority of teachers persist in believing myths, such as the 10% brain usage myth, the myth of hemispheric dominance (left and right-brained learners), and multiple intelligences. The multiple intelligences theory, popularized by Gardner (1983), suggests individuals have distinct kinds of intelligences. Teachers who apply this theory have certainly done valuable work by recognizing individual differences. However, the theory's foundations appear somewhat shaky. Notably, even Howard Gardner himself believes it has often been misinterpreted in education by creating just as many different tests to measure each child's performance in every single intelligence. This completely distorts the original theory (De Bruyckere et al., 2015). This theory has been influential in education; however, empirical attempts to validate distinct intelligences and their instructional implications have yielded limited support (Waterhouse, 2006). The theory's appeal often overshadows its lack of testability and application reliability. Maslow's hierarchy of needs, particularly the pyramid structure, is often used in education to suggest a fixed order of student needs. Maslow's pyramid is easily one of the most famous in science. However, he never actually drew a pyramid. While Maslow certainly described a hierarchy, he did not present it in the famous pyramid shape we know today (Bridgman et al., 2019; De Bruyckere et al., 2015). Recent studies indicate that the rigid hierarchical structure oversimplifies human motivation, failing to accurately show how needs are truly prioritized or met in everyday life (Compton, 2018). Perhaps the most lasting part of Maslow's theory is his concept of organizing fundamental human motivations into a hierarchy. This arrangement suggested that some motives are simply more pressing than others, which then take priority over still others (Kenrick et al., 2010). Yet, the theory has its flaws. For instance, someone dealing with health issues can still simultaneously desire beauty and wisdom (De Bruyckere et al., 2015). As a result, there is limited empirical support for the idea that one set of needs must be fully met before others become motivational (Compton, 2018; Wahba & Bridwell, 1976). The influence of video games on aggression has fueled decades of

discussion in both scholarly and public spheres. These games are frequently depicted as significant drivers of aggressive behavior (Lacko et al., 2024). On the contrary, the notion that violent digital games directly lead to aggression in children is highly debated. The majority of the studies, including meta-analyses showed no or negligible context-dependent evidence suggesting playing violent games directly leads to aggressive behavior (e.g., Ferguson, 2015; Przybylski & Weinstein, 2019). A recent study only found a small effect between violent video games and subsequent physically aggressive behavior (Burkhardt & Lenhard, 2022). Finally, the concept of 21st-century skills, though well-intentioned, often lacks specificity and empirical grounding. The concept of 21st-century skills has sparked a lot of discussion, debate, and criticism (De Bruyckere et al., 2020; Tight, 2021). Looking at the skills deemed important, the obvious takeaway is that core, generic, key, transferable, and 21st-century skills are essentially the same thing (Tight, 2021). A review of 21st century skills revealed a noticeable gap in educators' understanding of 21st-century skills and what these skills really entail (Kain et al., 2024). Over the last few decades, the idea of 21st-century skills has become a widely uncritically accepted educational buzzword (Lucas, 2019). Despite the agreement on the importance of the 21st Century Skills, there is still no single, unified way to define them (Joyne et al., 2019). What is more, these skills are not new and have actually been essential since the very beginning of human civilization (De Bruyckere et al., 2020). Thus, attributing these skills exclusively to the 21st century is an overstatement and constitutes an exaggerated claim. While technology proficiency is an important component of 21st-century skills, equating the entire concept with digital literacy is reductive. Core 21st-century frameworks (e.g., P21, OECD) emphasize a much broader set of competencies, including critical thinking, collaboration, and adaptability (Kereluik et al., 2013; Mishra & Mehta, 2017).

Endorsing such myths may result in the inefficient use of time and resources and may adversely affect educational quality (Janati Idrissi et al., 2020; Pashler et al., 2008; Pasquinelli, 2012). Therefore, there is an urgent need to develop effective interventions aimed at reducing belief in educational myths. While some studies have tested the impact of training programs on myth reduction, the effectiveness of such training programs vary. Although teachers gain better knowledge of brain function and learning, many continue to endorse neuromyths (Im et al., 2018; Macdonald et al., 2017; Rogers & Cheung, 2020). An alternative approach involves the use of refutation texts, which confront misconceptions directly by juxtaposing them with scientific evidence. This method has proven effective in reducing belief in myths across various domains, including vaccines (Vaughn & Johnson, 2018), climate change (Danielson et al., 2016), genetically modified foods (Heddy et al., 2017), and educational psychology (Kowalski & Taylor, 2009), as well as neuromyths specifically (Bukina et al., 2023; Lithander et al., 2021).

Although refutational studies have been conducted over the years, the number of refutation studies focusing on educational myths is notably lower compared to other research domains. Essentially, there is limited understanding regarding the effectiveness of refutational texts in dispelling educational myths, particularly the most persistent ones, and the specific type of refutation text that should be utilized remains unclear. Moreover, how teachers consider and address educational myths when designing and teaching their lessons remains underexplored. In this context, this study holds two main purposes, aiming for a comprehensive and holistic approach. Firstly, it aims to determine the prevalence of educational myths among in-service teachers, the channels through which these myths disseminate among teachers, and their impact on teachers' professional

practices. Secondly, this study assesses the effectiveness of three distinct refutation text types (refutation-only, refutation with explanation, and refutation with anecdotal explanation) in altering teachers' beliefs concerning educational myths. Based on these purposes, this study focuses on the following research questions:

1. What is the prevalence of educational myths among teachers?
2. What are the dissemination channels of most endorsed educational myths?
3. What effects do different refutation-based interventions (refutation-only, refutation with scientific explanation, and refutation with anecdotal explanation) have on dispelling educational myths?
4. How, if at all, do teachers participating in the experiment incorporate widely endorsed educational myths into their lesson planning and classroom practices?

Literature review

The origins and dissemination of myths. The origins of myths can be located in various sources and myths can be spread either intentionally or unintentionally. According to the Organization for Economic Co-operation and Development (OECD) (2002) report, myths can begin with a misunderstanding, a misinterpretation, or even an intentional distortion of scientific studies. Indeed, the report implies that the nature of science itself, which relies on a trial-and-error mechanism, can sometimes inadvertently contribute to the creation of myths.

Science is built upon a hypothesis-testing process in which researchers propose hypotheses based on observations, and these hypotheses either become theories or are refuted. Myths can emerge in this process when a hypothesis is disproven. Correcting such misconceptions, once retracted from scientific literature, often struggles to disseminate the updated status. These retractions create gaps in people's understanding. Without viable alternative information, individuals may persist in believing retracted misinformation, allowing it to endure (Ecker et al., 2014). For example, the myth of learning styles was a highly popular study subject in the field of education until 2000s. Even though it is now widely recognized that learning styles are a myth, recent studies have shown that the majority of teachers still believe in the concept (Newton & Salvi, 2020).

After a myth originates, its dissemination occurs through various means (Lewandowsky et al., 2012). In earlier times, myths were primarily spread among people through rumors, but in recent years, the media and the internet have significantly contributed to the propagation of myths. A notable example illustrating the impact of media on myth dissemination is the movie 'Lucy', which was based on the myth that humans only use 10% of their brain. Besides traditional media, the internet, including social media platforms, has played a significant role in the dissemination of myths. Lewandowsky et al. (2012) highlighted the impact of Web 2.0 development, which allows user-generated content to be accessible to every internet user. At times, commercial services also contribute to myth dissemination. For instance, the BrainGym curriculum brain games are aimed at enhancing the neglected hemisphere of the brain (left brain-right brain), and companies selling seminars and inventories regarding learning styles serve as notable examples (Çağıltay & Tunga, 2022; OECD, 2007). Another prominent channel for disseminating myths is education itself, where a considerable amount of misinformation can be acquired in universities or through in-service education programs (Rogers & Cheung, 2020; Torrijos-Muelas et al., 2021). Studies indicate that even faculty members

maintain beliefs in myths, such as learning styles and multiple intelligences (van Dijk & Lane, 2020).

Conceptual change and refutations text. There is a widespread belief among teachers that dispelling misconceptions is often even more challenging than teaching an entirely new concept. Chi (2009) indirectly alluded to this by categorizing learning into three distinct conditions based on learners' prior knowledge. The first condition involves students with no prior knowledge of the concept. The second includes students who possess some knowledge but lack a comprehensive understanding of the concept. The third, and perhaps the most challenging, arises when students hold inaccurate knowledge about the concept. In such cases, learning necessitates conceptual change rather than simply filling gaps or adding new knowledge, which involves rectifying or substituting mistaken ideas held in the mind (Vosniadou, 2013). This process can also be explained using Piaget's concepts of accommodation and assimilation (Posner et al., 1982). Assimilation occurs when new information fits comfortably within pre-existing schemas, which can be seen as conceptual growth. Conversely, accommodation happens when schemas need to be restructured to incorporate new information, known as conceptual change.

Various theoretical studies have focused on how conceptual change occurs (see review of Treagust & Duit, 2008). The Knowledge Revision Components Framework (KRcC) (Kendeou et al., 2014) asserts that the process of knowledge revision involves integrating old knowledge stored in long-term memory with newly acquired information. This framework operates on the assumption that information stored in long-term memory cannot be eradicated but can be activated by learners. Ecker et al. (2014) explained that memory does not work like a blackboard. On the contrary, human memory has evolved to maintain stable representations in our minds, and pieces of information stored in memory are rarely completely wiped out and overwritten. Instead, they tend to persist in the background, and access to them gradually diminishes. Therefore, prior knowledge activation is necessary to ensure conceptual change.

To facilitate conceptual change and learning, a variety of text types have been used, such as expository texts and refutational texts. Expository texts are composed of scientific facts in detail without referring to misconceptions and are usually employed in textbooks (Tippett, 2010). On the other hand, refutation texts, a specialized form of text, comprise two essential components: the myth statements themselves and explicit refutations (Tippett, 2010). Expository texts have failed to promote conceptual change and learning, whereas refutational texts are seen as promising tools for ensuring conceptual change (Sinatra & Broughton, 2011). A meta-analysis by Schroeder and Kucera (2022) indicated that refutational texts are much more effective than non-refutational texts in conceptual change and learning studies. Refutation texts aim to stimulate both the inaccurate old information and the newly established correct information, facilitating knowledge revision (Kendeou et al., 2014). Different kinds of refutational texts have been employed, but research focusing on the most effective refutational text type yields inconsistent results, which might be due to the demographic differences and preferences of participants (Tippett, 2010). Anecdotal refutational texts, which are based on teachers' professional experiences rather than purely scientific explanations, are one such type. Menz et al. (2021) hypothesized that this kind of refutational text could be more beneficial for dispelling myth endorsement within the teachers' community based on a study of Bråten and Ferguson (2015) that revealed teachers did

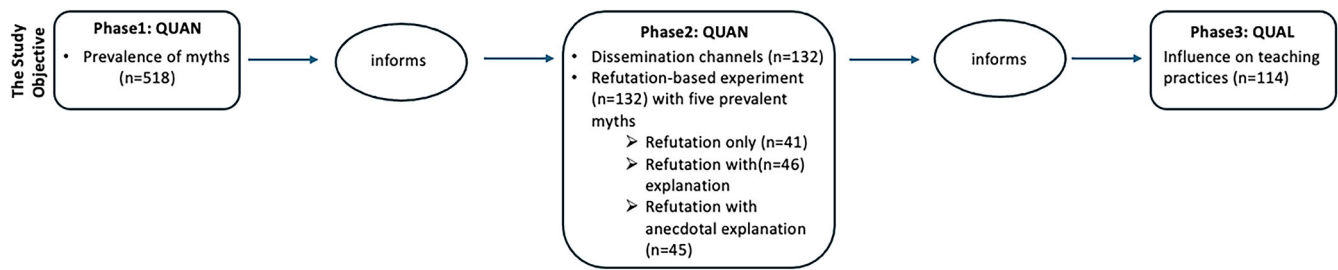


Fig. 1 Overall research design of the study.

not rely on research findings to design and implement their educational decisions.

The literature review explored the origins, dissemination, and persistence of educational myths, highlighting how these myths arise from misunderstandings or distortions of scientific facts and are propagated through various channels, including media, the internet, commercial services, and education itself. The persistence of myths like learning styles among teachers underscores the challenge of correcting such misconceptions. Conceptual change, essential for dispelling myths, involves replacing inaccurate knowledge with accurate information, a process facilitated by refutational texts. Refutational texts, which directly address and refute myths, have proven more effective than expository texts in promoting conceptual change. However, the effectiveness of different types of refutational texts, such as anecdotal refutational texts, varies and requires further investigation. While the literature establishes the widespread prevalence of educational myths and the general effectiveness of refutational texts in promoting conceptual change, there is limited research on the most effective type of refutational text for altering teachers' beliefs. Specifically, the potential of anecdotal refutational texts, which draw on teachers' professional experiences, remains underexplored. This study aims to address this gap by assessing the effectiveness of various refutational text types in changing teachers' beliefs about educational myths.

Methodology

Research design. This study aimed to investigate the prevalence of educational myths among Turkish in-service primary and middle school teachers, dissemination channels of the myths, and their influence on teachers' teaching practices. This study also assessed the effectiveness of three distinct refutation text types (refutation-only, refutation with explanation, and refutation with anecdotal explanation) in altering teachers' beliefs concerning educational myths. For these purposes, this study followed a comprehensive and holistic approach and employed a multi-phase mixed-methods design (Creswell, 2014). Multi-phase mixed methods research involves multiple phases, often combining quantitative, qualitative, or both types of studies, focused on a common objective. Common in evaluation studies, each phase builds on the next to address the overall goal of the research. Figure 1 shows the overall research design of the study.

The first phase of this study began by assessing the prevalence of myths among teachers. The results from this phase informed the second phase, in which the primary dissemination channels of the five most prevalent myths were examined. Additionally, an intervention was conducted to test and compare the effectiveness of three types of refutation (refutation-only, refutation with scientific explanation, and refutation with anecdotal explanation) in altering teachers' beliefs about these myths: multiple intelligences, learning styles, violent digital games, Maslow's hierarchy of needs pyramid, and 21st-century skills. Lastly, the second phase informed the third phase, which explored how, if at

all, teachers incorporate the most endorsed educational myths into their lesson planning and classroom practices. All results were merged in the discussion. With this research design, this study ensured a systematic, replicable approach to studying educational myths and testing debunking strategies. In order to prevent social desirability and participant bias, the "myth" keyword was not used in the measurement instruments. Participants, measurement instruments, experiment design, data collection procedure, and data analysis were explained in the respective sections below.

Participants. Participants were recruited through convenience sampling across diverse geographic regions in Turkey. The participants of this study are 518 primary and middle school in-service teachers of Turkey. Of these participants, 421 (81.3%) were female, and 97 (18.7%) were male. The ages of participants were between 24 and 60 ($M = 39.60$, $SD = 6.93$). Ranging from 1 to 38, the participants had varying years of teaching experience ($M = 16.25$, $SD = 6.88$). More than half of the participants ($n = 322$, 62.2%) teach at primary school level, 34% ($n = 176$) teach at middle school level, and 3.9% ($n = 20$) teach at both levels. Only a small proportion of participants ($n = 41$, 7.9%) had taken a course related to neuroscience. All participants work in public schools under the Ministry of National Education and volunteered for this study. The experimental sub-study ($n = 132$) used a purposive sampling method to select participants based on specific criteria, which is the number of myths they endorse, to capture diverse perspectives relevant to the research question, and they were randomly assigned to intervention groups. Of these participants, 107 (81.1%) were female and 25 (18.9%) were male. The participants' ages ranged from 25 to 58 years ($M = 39.31$, $SD = 7.02$), and their teaching experience ranged from 2 to 35 years ($M = 16.02$, $SD = 7.11$). A majority of these participants ($n = 81$, 61.4%) teach at the primary school level, while 45 participants (34.1%) teach at the middle school level, and 6 (4.5%) teach at both levels. A very small number of participants ($n = 9$, 6.8%) had taken a course related to neuroscience.

Measurement instruments. The data were collected using online instruments, including close and open-ended questions.

Personal information form and educational myth questionnaire. The measurement instrument consisted of two main sections. The first section included a personal information form designed to collect demographic data, such as gender, field of expertise, teaching experience, and participants' reading habits regarding popular science and peer-reviewed academic publications.

The second section comprised 16 statements, all of which reflect widely circulated myth statements that are scientifically inaccurate, despite their common acceptance in educational contexts. A large proportion of the items were derived from previously validated neuromyth surveys (Dekker et al., 2012; Herculano-Houzel, 2002), including myths, such as learning

styles, hemispheric dominance, the Mozart effect, and the 10% brain usage myth. Additionally, five further myth statements—concerning the effects of violent video games, Maslow's hierarchy of needs, digital natives, multiple intelligences theory, and the 10,000 hours principle—were incorporated based on the works of De Bruyckere et al. (2015, 2020). Participants were asked to respond to each statement by choosing one of the following options: Correct, Incorrect, or Do not know. Each statement represented a commonly held but scientifically inaccurate educational myth. Therefore, selecting "Correct" indicated that the participant endorsed the myth, while selecting "Incorrect" reflected rejection of the myth (i.e., not endorsing the myth), in line with current scientific evidence. The "Do not know" option captured participants' uncertainty or lack of familiarity with the statement.

All items were developed in Turkish. Their wording was reviewed for linguistic clarity and appropriateness for the target audience. Furthermore, the items were evaluated by experts in terms of conceptual clarity, language accuracy, and scientific validity. In the process of item formulation and adaptation, previously conducted studies within the Turkish context (Dündar & Gündüz, 2016; Karakus et al., 2015; Tunga & Çağiltay, 2023) were also taken into consideration.

Dissemination channels survey. To identify the dissemination channels for the myths, teachers were questioned regarding their exposure to each myth item. A range of options was provided for teachers to specify the channels through which they encountered these myths. These options encompassed exposure 'during their undergraduate education', 'from colleagues', 'from friends', 'from exam books', 'from popular science books', 'from the internet and/or social media', and 'from the professional training I received'. Teachers were given the opportunity to select multiple dissemination channel options.

Belief change question. To evaluate teachers' belief change for the myths after the intervention, a question with three options (Did not change, Undecided, or Changed) was asked to teachers.

Open-ended question. After querying the dissemination channels, an open-ended question was posed for the myths to investigate their influence on teachers' professional practices for the teachers in the experiment. The question asked: 'Do you consider this statement when designing or conducting your lessons? If yes, kindly explain briefly the actions you take.' This inquiry aimed to discern the direct impact of these myths on teachers' teaching practices.

Experiment design. The experiment included three refutational text materials prepared by the researchers. Expert opinions were sought, and the texts were revised accordingly. Expert review ensured that the intervention materials have potential to debunk myths accurately without any bias. The structure of the refutational materials is explained below:

Refutation only. This version of refutation texts consists solely of two components—the myth statement followed by a concise refutation sentence stating "This is false, without providing any elaborated explanation (myth + "This is false").

Refutation with explanation. In this version, the refutational texts include a detailed scientific explanation supported by citations from relevant scientific studies (myth + scientific explanation + citations).

Refutation with anecdotal explanation. This version of refutational text contains an anecdotal form of explanation without

scientific citations. The content in this version aligns with the refutation with the explanation version but is presented in a much more informal language (myth + informal, story-based refutation).

For the experiment, participant teachers ($n = 462$) who endorsed five prevalent myths were randomly assigned to three intervention groups ($n = 154$) to minimize selection bias and invited to participate in the second phase of the study via email. Not all participants responded, specifically, 46 teachers agreed to receive refutation with explanations, 45 agreed to receive refutation with anecdotal explanations, and 41 agreed to receive refutation-only materials. In total, 132 teachers participated in the second phase of the study. The comparison of demographic characteristics across intervention groups was conducted to ensure group equivalence and to strengthen the internal validity of the study. It was found that the groups showed no significant differences in their background characteristics with respect to age ($p > 0.05$), years of teaching experience ($p > 0.05$), gender ($p > 0.05$) and the level of education taught ($p > 0.05$). These results indicate that the groups were demographically balanced, which strengthens the reliability of any observed differences in belief change outcomes across intervention types. Teachers were sent the related refutational texts via an online form. During this phase, teachers were asked to indicate whether their beliefs about the five most prevalent myths had changed after being exposed to the refutational texts. A sample of the refutational texts is provided in the Appendix.

Data collection procedure. The study was conducted between April and May 2022. Before the study, ethical permission was obtained from the Human Research Ethics Committee, and informed consent was obtained from the participants. This study consisted of three stages. The first stage of this study commenced by assessing the prevalence of myths among teachers through an educational myth questionnaire, which also included a personal information section. A total of 518 teachers responded to this survey. Subsequently, the participants' responses to the 16 presented myths were evaluated. From these, the five most prevalent myths—namely, multiple intelligences, learning styles, Maslow's hierarchy of needs pyramid, violent digital games, and 21st-century skills—were identified as the most endorsed myths. In the second phase, the experiment was conducted to test the effectiveness of three refutational interventions and teachers' belief change was evaluated via the belief change question. Additionally, the primary dissemination channels for the five prevalent myths were identified by the dissemination channels survey, using closed-ended items. In the third phase, an open-ended question was used to explore how these erroneous beliefs (myths) influence teachers' teaching practices and to examine their educational implications. To prevent multiple or duplicate submissions and to ensure that each teacher provided only one response, the form system required participants to log in using their email addresses. While email addresses were initially collected with the responses, researchers anonymized the data by assigning unique participant IDs. Following the completion of the experiment, all email addresses were permanently deleted to protect participant confidentiality.

Data analysis. As previously explained under the measurement instruments section, participants were asked to evaluate each myth statement by selecting one of three options: Correct, Incorrect, or Do not know. Selecting the "Correct" option indicated that the participant endorsed the myth, meaning the participant believed in that myth and accepted the scientifically inaccurate claim to be true. In contrast, selecting the "Incorrect"

option indicated that the participant did not endorse the myth and correctly rejected it, meaning the participant did not believe in that myth and accurately identified the statement as a myth. The frequencies of “Correct”, “Incorrect” and “Do not know” options were computed for each myth statement and each participant. To determine the degree to which each participant believed in educational myths, the total number of “Correct” options across all statements selected by the participants was summed because selecting the “Correct” option indicated the participant’s endorsement of the myth in the context of the measurement instrument.

Then, descriptive statistics, including measures of central tendency, were employed to present the prevalence of 16 myths among teachers. Pearson’s chi-square test for independence was employed to compare the effectiveness of different types of refutational interventions on teachers’ belief change for the myths. Bonferroni correction was done for the multiple comparisons, and the p value was taken as 0.01 (0.05/5). The strength of the associations was evaluated using Cramer’s V coefficient. The dissemination channels of most endorsed educational myths were analyzed using descriptive statistics. The assumptions of the analyses were checked, and the necessary assumptions were met for the quantitative analyses.

For analyzing the qualitative data on the influence of educational myths on teaching practice, thematic analysis was employed to determine the educational implications of myth endorsement. The inductive approach was followed for the analysis, and the data were coded following open coding. Particularly, reflexive thematic analysis was followed by the steps of Braun and Clarke (2006): Getting acquainted with the data, producing initial codes, thinking about themes, examining the themes, labeling themes, and creating the report. To enhance rigor and mitigate researcher bias, two coders independently analyzed a 20% subset of responses, achieving strong inter-coder reliability (0.89). While thematic analysis prioritizes interpretive depth instead of numerical agreement, this step provided consistency in initial coding. Discrepancies were resolved through discussion until consensus was reached, and the refined codebook was then applied to the full data. To further strengthen trustworthiness, multiple validation strategies were used. Preliminary findings were reviewed by an external researcher unaffiliated with the study (peer debrief). Representative quotes in the findings were provided under the relevant codes to ground interpretations in the data, and the raw data of the responses were saved for trail. Finally, the context in which the study was conducted was described in detail to facilitate the transfer of findings to similar settings.

Results

Prevalence of myths among teachers. The total number of endorsed myth statements, which are labeled as “Incorrect” answers in Table 1, was calculated to determine the overall myth prevalence among teachers is shown in the Table 1. It ranged from 3 to 14 with a mean of 11.39 ($SD = 1.93$). Parallel to this, the number of correct responses to the statements was also summed up to indicate the severity of myths among teachers. The correct responses ranged from 0 to 11 with a mean of 2.32 ($SD = 1.57$). This signals that the majority of teachers did not recognize the myths. Overall, more than 50% of the teachers endorse 14 of the 16 neuromyths. Five of these were the most prevalent myths. 99% of the teachers believed that students learn better the information presented in accordance with their learning style (e.g., auditory, visual, kinesthetic). 95.8% of the teachers believed that there are different types of intelligence, such as verbal, mathematical, spatial, rhythmic, kinesthetic,

introvert, and extrovert. Similarly, 95.8% of the teachers believed that violent digital games lead children and young people to violence and aggressive behavior in real life. 89.2% of the teachers were in favor of the statement “Maslow’s pyramid of needs diagram shows people’s basic needs in order of importance”. In the same way, 89.2% of the teachers were in favor of the statement “To be successful in today’s world, it is necessary to have a set of skills called 21st century skills”. Fortunately, 60% of the teachers did not believe in the statement “Boys are better at math than girls.” Regarding the statement “A minimum of 10,000 h of planned work is required to become a globally recognized expert in a field”, more than half of the teachers stated that they did not know about this statement, and very few believed in this statement. Table 1 provides the distribution of teachers’ answers to myth statements.

Myths dissemination channels. Regarding the most prevalent five myths, teachers were surveyed to ascertain the sources through which they acquired knowledge of these statements, thus uncovering their dissemination channels. Table 3 presents the sources from which teachers reported learning or hearing about five distinct myths. It is important to note that teachers had the option to select more than one dissemination channel for each myth statement. This data informs researchers and educators about the prevalence of myths and their distribution, helping them develop strategies to correct and prevent these misconceptions in educational settings, ultimately enhancing the quality of teaching and learning.

As evident from Table 2, the primary source of dissemination for the myths surrounding multiple intelligences ($f = 110$, 83.33%), learning styles ($f = 109$, 82.58%), and Maslow’s hierarchy of needs pyramid ($f = 110$, 83.33%) appears to be undergraduate education. Subsequently, these myths also proliferate through the professional training received by teachers. The majority of the teachers have encountered these three myths either during their undergraduate studies or through their professional training. The findings also highlighted that the remaining prevalent myths, namely, violent digital games ($f = 86$, 65.15%) and 21st-century skills ($f = 103$, 78.03%), were primarily acquired through the professional training programs in which teachers participate.

Intervention: the effectiveness of refutational interventions to dispel educational myths. In order to alter teachers’ beliefs concerning the five most prevalent educational myths, they were exposed to refutation-only text, refutation with explanation, and refutation with anecdotal explanation. After reading the refutational explanations, teachers were asked whether they had been convinced that the statements are myths and therefore incorrect. Figure 2 below shows three refutational interventions with respect to belief change.

Despite scientific evidence debunking these myths, most teachers still hold onto those. Table 3 presents the frequencies and Chi-square results related to teachers’ belief change, indicating whether their beliefs shifted or remained undecided following the intervention.

Three interventions were used to explore whether educational myths can be dispelled. A 3×3 Pearson’s chi-square test for independence was conducted to discover which intervention was effective in dispelling five educational myths. Pearson’s chi-square test results showed a significant association between the type of intervention (refutation, refutation explanation, and anecdotal) and teachers’ belief change in five prevalent educational myths: Multiple intelligences ($\chi^2(4) = 34.98$, $p < 0.01$), learning styles ($\chi^2(4) = 25.93$, $p < 0.01$), violent digital

Table 1 Distribution of teachers' answers to myths.

Myth Statements	Correct* n (%)	Incorrect** n (%)	Do not know n (%)
Students learn better the information presented in accordance with their learning style (e.g., auditory, visual, kinesthetic).	513 (99%)	2 (0.4%)	3 (0.6%)
There are different types of intelligence, such as verbal, mathematical, spatial, rhythmic, kinesthetic, introvert and extrovert.	496 (95.8%)	15 (2.9%)	7 (1.4%)
Violent digital games lead children and young people to violence and aggressive behavior in real life.	496 (95.8%)	8 (1.5%)	14 (2.7%)
Maslow's pyramid of needs diagram shows people's basic needs in order of importance.	462 (89.2%)	18 (3.5%)	38 (7.3%)
To be successful in today's world, it is necessary to have a set of skills called 21st-century skills.	462 (89.2%)	31 (6%)	25 (4.8%)
Storing memory in the brain is like storing information in a computer. Each memory is held in a small part of the brain.	426 (82.2%)	48 (9.3%)	44 (8.5%)
Students who use the right hemisphere of their brain dominantly are more successful in creative academic tasks, and students who use the left hemisphere of their brain dominantly in rational academic tasks.	410 (79.2%)	55 (10.6%)	53 (10.2%)
The effectiveness of learning can be demonstrated on a pyramid. For example, as demonstrated in Dale's cone of experience, people remember 10% of what they read, 26% of what they hear, and 30% of what they see.	406 (78.4%)	48 (9.3%)	64 (12.4%)
Our brain can do more than one attention-demanding task at the same time.	405 (78.2%)	87 (16.8%)	26 (5%)
Digital natives need a different education than previous generations.	396 (76.4%)	23 (4.4%)	99 (19.1%)
Listening to classical music develops children's intelligence.	351 (67.8%)	58 (11.2%)	109 (21%)
There are critical periods in childhood when some things cannot be learned later.	345 (66.6%)	128 (24.7%)	45 (8.7%)
We only use 10% of our brain.	262 (50.6%)	188 (36.3%)	68 (13.1%)
We learn 70% of what we learn informally, 20% from others, and only 10% through formal education.	258 (49.8%)	88 (17%)	172 (33.2%)
A minimum of 10,000 h of planned work is required to become a globally recognized expert in a field.	124 (23.9%)	94 (18.1%)	300 (57.9%)
Boys are better at math than girls.	86 (16.6%)	311 (60%)	121 (23.4%)

Note: All statements are myths. *: When participants select the "correct" option, this means they believe in that myth. **: When they select the "incorrect" option, this means they reject that myth.

Table 2 Distribution of the origins of the myths.

Dissemination channels	Multiple intelligences		Learning styles		Violent digital games		Maslow's pyramid		21st-century skills	
	f	%	f	%	f	%	f	%	f	%
During undergraduate education	110	83.33	109	82.58	39	29.55	110	83.33	36	27.27
From the professional training I received	61	46.21	61	46.21	86	65.15	63	47.73	103	78.03
From the internet and/or social media	32	24.24	34	25.76	29	21.97	28	21.21	62	46.97
From my colleagues	26	19.70	23	17.42	34	25.76	21	15.91	30	22.73
From exam books	24	18.18	19	14.39	4	3.03	32	24.24	9	6.82
From popular science books	20	15.15	24	18.18	39	29.55	23	17.42	39	29.55
From my friends	13	9.85	16	12.12	29	21.97	14	10.61	21	15.91

Note: Percentages (%) show the percentage of respondents among all participants (n = 132).

games ($\chi^2(4) = 20.39$, $p < 0.01$), Maslow's of hierarchy of needs pyramid ($\chi^2(4) = 39.69$, $p < 0.01$), and 21st century skills ($\chi^2(4) = 46.31$, $p < 0.01$). The results further indicated that anecdotal intervention type is associated with more belief change for multiple intelligences (Cramer's $V = 0.364$), learning styles (Cramer's $V = 0.313$), violent digital games (Cramer's $V = 0.278$), and 21st century skills (Cramer's $V = 0.419$) whereas refutation explanation intervention type is associated with more belief change for Maslow's of hierarchy of needs pyramid (Cramer's $V = 0.388$). Regarding the strength of these

associations, Cramer's V coefficient values showed a moderate to large effect.

Influence of educational myths on teaching practice. For each of the five most prevalent myths, teachers ($n = 114$) in the experiment were asked whether they take them into consideration when designing or teaching their lessons. The results were then analyzed thematically for each prevalent myth. Almost all teachers expressed agreement in considering these myth statements

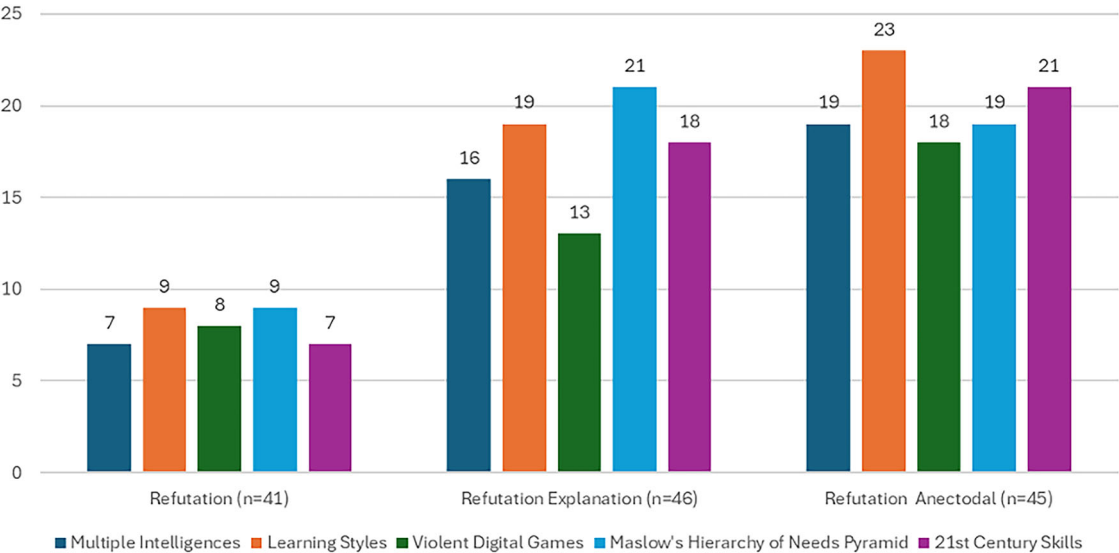


Fig. 2 Belief change for three distinct refutation conditions.

Table 3 Frequencies and chi-square results for belief change status.										
	Refutation (n = 41)			Refutation with explanation (n = 46)			Refutation Anecdotal (n = 45)			$\chi^2(4)$
	NC	U	C	NC	U	C	NC	U	C	
Myth1	32 78%	2 4.9%	7 17.1%	10 21.7%	20 43.5%	16 34.8%	18 40%	8 17.8%	19 42.2%	34.98*
Myth2	28 68.3%	4 9.8%	9 22%	10 21.7%	17 37%	19 41.3%	15 33.3%	7 15.6%	23 51.1%	25.93*
Myth3	29 70.7%	4 9.8%	8 19.5%	15 32.6%	18 39.1%	13 28.3%	21 46.7%	6 13.3%	18 40%	20.39*
Myth4	31 75.6%	1 2.4%	9 22%	6 13%	19 41.3%	21 45.7%	17 37.8%	9 20%	19 42.2%	39.69*
Myth5	32 78%	2 4.9%	7 17.1%	6 13%	22 47.8%	18 39.1%	16 35.6%	8 17.8%	21 46.7%	46.31*

Note: Myth1: multiple intelligences, Myth2: learning styles, Myth3: violent digital games, Myth4: Maslow's pyramid, Myth5: 21st-century skills, NC: did not change, U: undecided, C: changed, *: $p < 0.01$.

for their lessons and other education-related activities. Subsequently, the thematic analysis results were presented.

Multiple intelligences. Regarding multiple intelligence, teachers stated that they consider multiple intelligences while planning their courses, conducting their courses, and evaluating their courses. The codes revolve around teachers' recognition of multiple intelligences, approaches to teaching, considering multiple intelligences for using diverse methods to engage students and support student centric teaching, and enabling differentiated assessments.

Recognizing various intelligence types: Teachers are committed to recognize multiple intelligences of their students. They always keep those in mind as a roadmap when structuring their lessons. They -incorrectly- think that this recognition allows them to create a multifaceted learning environment where each student can excel based on their unique strengths and abilities. Teachers stated:

"I take care to think of appropriate activities to stimulate the learning of students with different intelligence types."

"Knowing that not all students are in the same intelligence category, I determine their intelligence categories..."

Incorporating multiple intelligences into lessons: By acknowledging various forms of intelligence, teachers ensure that their teaching methods cater to students with diverse intelligence types. Therefore, they incorporate multiple intelligences into their lessons through varied teaching approaches and diverse teaching techniques. In this way, teachers think that they are able to create creative and engaging educational activities. Teachers mentioned:

"By using different educational materials, I aim to make the learning process more active and reach students with different intelligence types."

"I try to produce course content suitable for visual and kinesthetic intelligence types with materials, posters and games. I try to support students with auditory intelligence with audio materials and content. I try to include activities that suit each student's intelligence type in some way."

"Yes, while teaching an objective, I do different learning activities for students with different intelligence types, such as games, songs, and pictures."

Using multiple intelligences for student-centric teaching: Teachers observe individual intelligence types and follow student-centric teaching and individualized instruction for creating engaging and multisensory learning activities based on multiple intelligences. Teachers expressed:

"I prepare an individualized teaching plan based on a personalized teaching technique considering multiple intelligences."

"I observe each child's learning channel and interests and determine the activity content accordingly."

"Yes, I use different multi-sensory materials to engage multiple senses following multiple intelligences."

Using multiple intelligences for offering differentiated assessments: Understanding these different intelligences helps teachers offer varied flexible assessments, including projects, and activities that allow students to showcase their talents and learn in ways that resonate best with them. Teachers stated:

"When I give research homework, I leave it flexible. Students can express their understanding through painting, poetry, song, drama, movement or any alternative way they choose."

"I apply a planning and evaluation process, taking into account that my children have different types of intelligence."

Using multiple intelligences for guidance activities: counselor teachers also leverage multiple intelligences to help students with respect to personality traits, vocational interests, talents, and career planning. They also use multiple intelligences for psychological counseling and guidance sessions and seminars catering to varied intelligences for a more comprehensive guidance experience. Teachers reported:

"Since my branch is Guidance, I mostly use types of intelligence to help students on issues, such as personality types, professional interests and abilities, and career planning."

"Even though I do not convey academic information, I try to create diversity in psychological counseling and guidance when I provide classroom guidance and seminars by using content that will appeal to the student's intelligence types to create internal awareness."

Learning styles. Teachers' recognition and incorporation of various learning styles stand as the central point in their instructional strategies. By recognizing the diversity of learning styles, teachers purposefully structure their lessons to accommodate these variations, aligning educational activities with different styles while also integrating multiple intelligences. Instead of using separate materials for each learning style, some teachers integrate a variety of teaching techniques, such as group activities, hands-on experiences, teamwork, drama, and multimedia resources to engage students' different senses. Moreover, this student-centric approach extends further as teachers create personalized teaching plans tailored to individual learning styles and interests, fostering a dynamic and inclusive learning environment.

Recognizing learning styles: Teachers are committed to recognize learning styles for structuring their lessons. They consider the diversity of learning styles in planning their lessons. It also appears that they attempt to link learning styles to multiple intelligences. Teachers shared:

"Since different categories of intelligence reveal different learning styles, I try to choose appropriate methods and materials that will facilitate student learning."

"While preparing visual and auditory activities, I prepare interactive activities and games from Web 2.0 tools. I try to plan activities that appeal to many different intelligence areas, such as social stories and sand therapy."

"I use the learning styles test..."

"I include visual, auditory, kinesthetic learning styles in a learning objective."

Incorporating learning styles into lessons: Being highly aware of learning styles, teachers incorporate learning styles into their lessons. For this, they try to align their educational activities with different learning styles and carry out different educational activities based on students' different learning styles. They focus on catering to different learning styles and engage students' multiple senses in the learning process through diverse teaching approaches and techniques, such as occasional group activities, hands-on activities, teamwork, drama, games, and interactive methods, in addition to multimedia learning resources, such as videos, recordings, and audio-visual aids. Teachers remarked:

"I make the students do team work. I include activities that will appeal to different learning styles in my lesson plan."

"I make sure that the slides I use or the games I design or find on the counter appeal to more than one sense of the students."

"I am an English teacher and the course materials are designed to appeal to different learning styles."

Using learning styles for student-centric teaching: Teachers have a comprehensive approach to teaching that considers the diverse needs and learning styles of their students individually. They create personalized teaching plans based on individual learning styles. For that, teachers observe individual learning styles and adapt activities based on students' interests. Teachers articulated:

"I observe the learning channel and interests of each child and determine the activity content accordingly."

"For students who I think have an auditory learning style, I make it easier for them to memorize a topic that they need to memorize in the mathematics lesson by singing it as an improvised song."

Violent digital games. The thematic analysis of the responses highlights a multi-faceted approach within educational settings concerning violent digital games, violence, and safety. Teachers primarily focus on awareness and education, employing various informative strategies, seminars, and conscious material selection to enlighten both students and parents. Behavioral guidance emerges prominently, emphasizing redirection towards non-violent activities, offline engagement, and the promotion of alternative, educational games. Additionally, there is a strong

emphasis on risk mitigation and safety measures, including precautions against inappropriate content and the fostering of awareness regarding online risks. Collaboration with parents and involving students in the process underscores a holistic approach, ensuring psychological and social well-being, cultivating healthy communication, and addressing the impact of violent content on the classroom environment.

Raising awareness: Teachers try to raise awareness among students and parents through informative methods, seminars, and conscious material selection in an educational setting.

Informative approaches: Teachers disseminate information and guidance to both parents and students about digital games including violence. It involves educational efforts focused on providing information, possibly through various means, such as discussions, handouts, or workshops. Teachers described:

"I inform the parents about violent digital games."

"I provide guidance and information to students on this subject."

Seminars and presentations: Teachers perform awareness activities, such as seminars or presentations to discuss solutions or strategies to mitigate violent digital game issues or challenges, such as advising parents on imposing restrictions on internet usage to prevent violent digital game play for children. Teachers reported:

"I often talk about digital games at meetings with parents. We discuss ideas and suggestions on what we can do about violent digital games. We organize seminars with the support of the counselor."

"Yes, I try to raise awareness among my students by organizing seminars on this subject from time to time."

"Since I am in primary school, my children are young, so I see violent digital games as a big problem and I try to keep my students away from such games by teaching them traditional children's games. I also try to raise awareness of families through organizing parent information seminars."

Conscious material selection: Teachers select their educational materials carefully. They have a commitment to refrain from showing violent videos or content during classes to create a positive and conducive learning environment while ensuring that the materials used are appropriate, beneficial and free from violence. Additionally, they incorporate educational games into lessons to make learning more engaging and effective. Teachers noted:

"I use educational games in my lessons to direct my students to educational games."

"The effect of violent games and cartoons on the classroom environment is quite high. I do not let my students watch violent videos or films and play digital games containing violence."

Changing students' focus: Teachers collectively showcase strategies and efforts aimed at redirecting students' focus towards beneficial, non-violent activities and facilitating offline engagements, ultimately contributing to their behavioral guidance and overall development.

Redirection & alternative activities: Teachers take an approach to guiding student behavior by redirecting their focus towards non-violent and behaviorally beneficial activities. This

involves recommending games that promote desirable behaviors and do not contain violent elements, aiming to steer their focus towards informative and constructive content. Teachers remarked:

"I recommend games that are non-violent and that will provide desired behavior."

"I try to direct my students to more educational games. First of all, I teach them to use the internet and digital media correctly."

"To this end, I make my students play educational games, read books on anger management and do drama activities."

Facilitating offline activities: Teachers have efforts to help students engage in offline activities, moving away from excessive digital gaming or screen time. It involves planning extracurricular activities outside school that encourage students to distance themselves from digital games. Moreover, the approach emphasizes supporting and encouraging students to spend time physically interacting with friends in real-life situations, fostering interpersonal relationships and social skills. Teachers expressed:

"I help my students get away from digital games by planning activities outside of school."

"I support my students to spend physical time in real life and with their friends."

Risk mitigation and safety measures: Teachers focus on various aspects, such as helping their students understand the risks associated with technology and digital games, taking safety precautions and involving them in finding ways to mitigate the risks associated with violent digital games and establishing healthy communication.

Awareness of online risks: Teachers endeavor to provide their students with the ability to use technology safely, warn against the risks of digital games and try to raise awareness of their students' families on this issue. Teachers stated:

"I do informative activities for my students to use technology safely."

"I warn my students and their families not to play violent digital games."

Safety precautions: Teachers take safety precautions by stressing the avoidance of certain games among students, encouraging educational gaming alternatives, and highlighting the importance of parental supervision and awareness. Teachers described:

"I make my students avoid playing such violent digital games."

"I try to raise awareness among parents about these issues, and I give parents the duty of supervision."

Student involvement: Teachers foster partnerships with their students and work together towards finding ways to mitigate the risks associated with violent digital games and establishing healthy communication. Teachers shared:

"I try to find different games with the students."

"I do group work so that students can establish healthy communication with each other while being away from the games."

Maslow's hierarchy of needs pyramid. In the educational landscape, the focal point lies in understanding and fulfilling the hierarchical needs of students, drawing inspiration from Maslow's Hierarchy of Needs Pyramid. Teachers' responses commonly reflected attention to students' basic needs, particularly regarding nutrition and safety, aligns in part with Maslow's framework. However, while some teachers referenced Maslow's structure,

their emphasizing the importance of addressing students' basic needs practices may also stem from developmental concerns and broader understanding of child development and well-being rather than an explicit theoretical adherence to Maslow's hierarchy. Educators within this context place a strong emphasis on recognizing and addressing these basic needs as a precursor to advancing towards higher-order educational objectives.

Recognition of basic needs: Teachers acknowledge that a student's physiological, safety, belongingness, and esteem needs must be met for effective learning. As educators, understanding the fundamental needs of students forms the cornerstone of effective pedagogy within an educational framework inspired by Maslow's Hierarchy of Needs Pyramid. Teachers reported:

"A hungry student cannot be ready to learn. If there is no sense of trust, you cannot communicate. I carry out teaching activities by taking all these into consideration."

"I pay attention to Maslow's steps. I work with students in disadvantaged groups whose basic needs are not met."

"Activities are planned from the base of the pyramid to the top."

Basic needs evaluation: Teachers continuously evaluate students' needs to address any unmet requirements that may hinder their educational progress. Teachers emphasize the importance of continuous observation and assessment in identifying and remedying any unmet needs that might hinder a student's progress, highlighting the proactive approach taken to create an optimal learning environment. Teachers shared:

"In order for students to understand the lesson, I make sure that their physical needs are met as much as possible."

"I first check whether my students' basic needs are met, and if they are not, I do my best to help them. Then I support them on their path to self-actualization."

"I make use of the hierarchy of needs when trying to provide motivation in my lessons."

Hierarchy of needs in education: Teachers emphasize the importance of fulfilling basic needs before addressing higher-order needs in the learning process. Furthermore, they underscore the hierarchical nature of educational needs, emphasizing the necessity of addressing basic needs prior to venturing into higher-order educational objectives. Teachers explained:

"I think it is not right to expect the same success from every student because it is not the right approach to expect a student whose basic needs have not been met to reach higher levels."

"It is not healthy to move on to other needs without meeting basic needs."

"The individual whose compulsory needs cannot be met does not need the next step."

21st century skills. Teachers take 21st century skills seriously and actively participate in continuous professional development to stay current with technological advancements and apply their knowledge in the classroom. Teachers lay as much emphasis on

technology integration and digital literacy, and they often associate 21st century skills with technology incorrectly. Regarding the 21st century skills, teachers try to promote 21st century skills in their students. For this, they perform activities to nurture their students' skills. Given these, teachers see 21st century skills as a must have skill. Only one teacher thinks these skills are timeless, not just for the 21st century.

Continuous professional development: Teachers attend training and workshops for self-improvement and keeping themselves updated with technological developments so that they can incorporate newly learned information and skills into their teaching. Teachers remarked:

"I attach importance to my professional development on this subject and try to keep myself as up-to-date as possible in terms of education and technology. For example, I attended Microsoft's training for educators equipped with 21st century skills and I try to reflect what I have learned to my lessons and students."

"I attend training to update myself."

"I try to improve myself by attending in-service training in order to follow innovations. I include group work in the lessons and enable students to collaborate and make presentations."

Technology integration and digital literacy: Teachers associate 21st century skills with the use of digital technology. For these reasons, they feel the need to integrate technology into their lessons (especially Web 2.0 technologies), utilize digital resources for learning and focus on developing students' digital literacy. Teachers articulated:

"Digitalization for 21st century skills is necessary to keep up with the age. As time progresses, those who are behind the times are doomed to decay."

"21st century skills are based on using technology. I use smart boards."

"In our courses, we mainly teach lessons that increase students' digital competencies."

"Especially digital literacy is at the forefront. We are trying to raise digitally literate individuals."

21st-century skills development: Teachers focus on their students' 21st century skill development. Particularly, they try to foster critical thinking and problem-solving. They also encourage innovation, teamwork, and collaboration through involving students in projects. Teachers explained:

"I include topics, such as critical thinking, digital literacy, environmental awareness, effective communication, avoiding information pollution, innovation, social awareness both in the classroom and in the students' research and design process."

"In order for my students to have these skills, I make them aware of their abilities and support them in every aspect."

"When planning my lessons, I take care to plan activities that will develop critical thinking, problem solving, communication with friends and creative thinking."

Discussion

The present study found that the majority of teachers endorsed several myths, with more than 50% believing in 14 of the 16 myths identified. Learning styles, multiple intelligences, violent digital games, Maslow's hierarchy of needs pyramid, and 21st century skills were identified as the most endorsed myths. Specifically, nearly all teachers believed in the idea that tailored learning styles improve learning outcomes. A high percentage also endorsed the myth of multiple intelligences. These results are not surprising, as similar findings have been in evidence in several different studies over a long period of time (Dekker et al., 2012; Herculano-Houzel, 2002; Janati Idrissi et al., 2020; Khramova et al., 2023; Menz et al., 2021; Torrijos-Muelas et al., 2021; Tunga & Çağiltay, 2023).

The myths of learning styles and multiple intelligences have always been teachers' favorite myths. Some studies, such as Menz et al. (2021) even reported that teachers continued to believe these two myths even after being informed that they are myths. Scholars like Nancekivell et al. (2020) found that teachers, especially those working with younger students, believed that learning style is an inborn trait that also affects students' cognitive abilities. Tunga and Çağiltay (2023) discussed that teachers are a humanistic community, and this strong support for learning styles and multiple intelligences can be associated with the humanistic messages these myths convey. They stated that statements containing such messages, which emphasize the potential and inherent worth of each student, are most approved by teachers, while statements that emphasize inequalities, including gender comparisons and male dominance, are less believed by teachers. The present study also found consistent findings with their assertion; the myth item "Boys are better at math than girls" was found to be one of the least endorsed myths. This suggests that while teachers may readily accept myths that align with their humanistic views, they are less likely to endorse those that perpetuate inequalities. This alignment with humanistic values highlights the importance of addressing and correcting misconceptions within the context of teacher education and professional development, ensuring that myths do not undermine efforts to provide equitable and effective education for all students.

The study also found that teachers predominantly believed in the link between violent digital games and real-life aggression, the concept of Maslow's hierarchy of needs pyramid, and the importance of 21st-century skills for success. However, research has shown that there is no substantial link between playing video games and antisocial or aggressive behaviors (De Bruyckere et al., 2015; Dorantes-Argandar, 2021). Research indicates that video games can contribute positively to children's social and cognitive skills, such as better eye-hand coordination, improved spatial skills, and enhanced mental rotation abilities (Markey et al., 2020). Similarly, Maslow's hierarchy of needs, while popular in educational settings, has been challenged as a myth. Recent research suggests that the pyramid oversimplifies human motivation and does not accurately reflect how needs are prioritized or fulfilled in real life (Compton, 2018).

Furthermore, the notion of 21st-century skills as unique to our time has also been questioned. The skills often labeled as 21st century, such as critical thinking, problem-solving, and collaboration, are in fact timeless and have always been essential for success in any era (De Bruyckere et al., 2015). The qualitative findings revealed that many teachers associate 21st-century skills primarily with a distinct set of skills centered around the use of technology primarily. This suggests a narrower interpretation of these skills and does not reflect a comprehensive understanding of the broader 21st-century skills, which include competencies beyond technology as well. While this association is evident in

several responses and shared across teachers, it should not be generalized to represent the entire sample without further corroboration. Additionally, this perspective indirectly validates that those other skills labeled as 21st-century skills, such as communication and collaborative working, are not only essential in the current era but have always been crucial for success. This misunderstanding underscores the need for a broader and more nuanced understanding of these skills, recognizing their timeless importance and their broader applications beyond just technological competence. Addressing this misconception is vital for enhancing educational practices and ensuring that teachers are equipped to foster a well-rounded set of skills in their students, which are necessary for their long-term success.

The results also shed light on the dissemination channels of these myths. It was found that undergraduate education serves as a primary source for myths related to multiple intelligences, learning styles, and Maslow's hierarchy of needs pyramid. Additionally, professional training programs significantly contribute to the dissemination of these myths. Conversely, the myths surrounding violent digital games and 21st-century skills are primarily acquired through professional training programs attended by teachers. These findings highlight the fact that myths are not inherently learned by teachers themselves; rather, they are taught by university professors, underlining the critical role of educators in perpetuating or dispelling misconceptions. Rogers & Cheung (2020) have observed an increase in myth endorsement among teachers during their education in teacher education programs over the years. Students' statements confirmed that their belief in myths was reinforced by faculty members and course materials. Previous studies (Newton & Miah, 2017; van Dijk & Lane, 2020) have shown that academicians also have endorsed various myths, so the results are sadly not surprising and also consistent with studies investigating the dissemination channels of myths.

The study also investigated the influences of myth adoption on teaching practice. Teachers were asked whether they considered the five most endorsed myth statements while designing and implementing their teaching activities. Thematic analysis revealed that teachers incorporate multiple intelligences and learning styles into their lesson planning and teaching. They plan activities with these concepts in mind, recognizing and addressing various intelligence types and learning styles. Additionally, they use instruments to evaluate their students' intelligence types and learning styles. It was also noted that teachers often use these terms interchangeably, indicating concept confusion between them, a finding similarly reported by Papadatou-Pastou et al. (2021). Their practice seems aimed at creating teaching activities that engage various senses through the use of audio and visual materials, which actually aligns with the cognitive theory of multimedia learning, although their intention was not based on a correct understanding.

Other prevalent myths, including those about violent digital games, Maslow's Hierarchy of Needs Pyramid, and 21st-century skills, also influence teachers' practices. Teachers focus on raising awareness among students and parents about the risks associated with violent digital games through seminars, presentations, and informative approaches. Several responses suggested that some teachers view the fulfillment of basic needs as a prerequisite for learning; in other words, they contend that fulfilling basic needs precedes higher-order educational objectives. Although this belief resembles Maslow's framework, the data do not confirm a comprehensive endorsement of the entire hierarchy model. This can also stem from a broader understanding of child development. As a result, teachers prioritize understanding and meeting students' basic needs and emphasize the continuous evaluation of these needs to ensure a conducive learning environment. Additionally,

teachers actively engage in continuous professional development to integrate technology and digital literacy into their teaching, viewing technology integration as essential for developing 21st-century skills. Emphasis is placed on fostering critical thinking, problem-solving, innovation, teamwork, and collaboration among students.

The qualitative data analysis yielded results that appear to contradict the existing literature, which suggests that the adoption of neuromyths may negatively affect educational practices. In contrast, the findings of the present study indicate that teachers, despite relying on scientifically inaccurate beliefs, seem to strive to enhance their teaching practices. In line with these findings, a study by Horvath et al. (2018) comparing award-winning teachers—recognized for their teaching performance—with non-award-winning teachers found no significant differences between the two groups in terms of myth adoption. This finding raises further questions about the assumed negative consequences of myth adoption in educational practice.

However, it cannot be concluded whether the efforts resulting from myth adoption, as observed in this study, were beneficial for students or, conversely, detrimental, potentially leading to a waste of valuable instructional resources and time. The actual impact of myth adoption in educational contexts could be more accurately determined through intervention-based comparative studies. Notably, such studies were already conducted years before the widespread recognition of learning styles and multiple intelligences theory as myths. Yet, they generally failed to provide empirical evidence supporting the effectiveness of these approaches, often reporting weak or non-significant effects on student achievement. (Clinton-Lisell & Litsinger, 2024; Pashler et al., 2008). Despite this, the amount of instructional effort and resources consumed in implementing myth-driven practices remains largely unknown. Existing studies have predominantly focused on outcome measures, frequently overlooking the preparatory work and instructional processes involved. As a result, even though such practices may appear harmless, endorsing scientifically inaccurate information in educational contexts is inherently problematic. It risks normalizing misconceptions and may lead to hidden costs—such as the misallocation of instructional time and pedagogical effort—that have yet to be systematically examined. It seems that, until such studies are conducted, the safest and most efficient approach is to recommend and implement evidence-based teaching practices in order to avoid the unnecessary expenditure of these valuable resources.

The last but not least significant part of this study concerns combating myth endorsement by comparing the effectiveness of different refutation types. Three distinct refutation types, anecdotal and scientific explanations, and a refutation-only group were compared. Results showed that anecdotal interventions were more effective in changing beliefs related to multiple intelligences, learning styles, violent digital games, and 21st century skills, while scientific explanation interventions were more effective for Maslow's hierarchy of needs pyramid. The refutation-only intervention was found to be the least effective, resulting in belief changes in the least number of teachers. The refutation literature has already shown that although refutation texts are more beneficial than expository texts, providing only refutation texts is not an effective strategy to overcome myth endorsement (Schroeder & Kucera, 2022; Sinatra & Broughton, 2011). The limited success of refutation-only interventions can be explained by the Knowledge Revision Components (KReC) Framework (Kendeou et al., 2014). KReC suggests that changing beliefs is not about deleting old misconceptions but about integrating new information with existing knowledge. Since misconceptions persist and can reactivate, simply refuting them was not enough for the teachers. Without adequate elaboration, as found in the

anecdotal or scientific explanation conditions, teachers may not fully engage with or integrate the correct information, preventing effective belief revision. In terms of comparison of refutational text type, the findings are contradicted to the existing study (Menz et al., 2021) which revealed that preservice teachers changed misinformation more they read empirical version of refutations rather than anecdotal. This discrepancy could be attributed to several factors, including differences in participant demographics, such as age and gender distribution. Specifically, the Menz et al. (2021) study involved preservice teachers with an average age of 22.08 years ($SD = 3.35$), whereas our study involved in-service teachers with an average age of 39.31 years ($SD = 7.02$). The differing effectiveness of anecdotal intervention can be understood through the lens of Conceptual Change Theory (Posner et al., 1982). This theory suggests that people revise their mistaken ideas when their current beliefs feel inadequate, and new ways of thinking seem both understandable and reasonable. For in-service teachers, anecdotal refutations might have felt more relatable and personally meaningful, thus better meeting the criteria for changing their beliefs. This outcome can also be explained through Cognitive Dissonance Theory (Festinger, 1957). Anecdotal evidence, with its relatable and contradictory experiences, is likely to generate greater emotional dissonance, prompting a re-evaluation of beliefs. In contrast, while accurate, scientific explanations might not provoke the same affective tension required for genuine belief change. More experienced teachers might value experience-based advice more highly, which could explain the greater effectiveness of anecdotal interventions in this context. Furthermore, our study had a higher proportion of female participants, which might also influence the effectiveness of different refutation types. While anecdotal interventions showed greater effectiveness in this study, it is premature to draw definitive conclusions about their superiority over empirical refutations. More research is needed to build a robust evidence base that can guide educators and policymakers in their efforts to promote accurate knowledge and dispel misconceptions in education. Besides, the limited number of studies specifically comparing these two types of refutational interventions' effects on teachers makes it difficult to make strong inferences. A comprehensive understanding of the mechanisms behind belief changes and the factors influencing the efficacy of different refutation types is essential for developing effective strategies to combat educational myths.

Limitations and suggestions for future studies. The study used only the immediate responses of teachers when they received refutation interventions. To determine whether these results are consistent over time or if the continued influence effect emerges, it is necessary to conduct longitudinal studies. Additionally, while this study investigated the prevalence of a large number of myths, the refutation interventions primarily addressed the five most strongly endorsed myths. Future research should expand the scope of refutation interventions to include a broader range of myths, including those that are less strongly adopted. Furthermore, the study compared only a limited number of refutation styles. There are other types of refutations, including those supported by audio and visual formats, whose effectiveness on teacher audiences could also contribute significantly to the literature. Investigating these additional formats may provide valuable insights into the most effective methods for debunking educational myths and enhancing teaching efficacy. A comprehensive approach would better inform the development of targeted educational practices aimed at debunking myths and improving instructional outcomes. While the sample of this study offers valuable insights into educational myth prevalence and the

refutational materials (see Appendix) allow for replication, the use of convenience sampling limits the broad generalizability of the findings. However, the results may still apply to similar educational contexts, particularly those with comparable teacher training systems and cultural settings.

Conclusion

The present study highlights the persistent belief in educational myths among teachers, with particular emphasis on the myths of learning styles, multiple intelligences, and the link between violent digital games and real-life aggression, 21st skills and the myth of Maslow's hierarchy of needs pyramid. Despite interventions, these myths remain strongly held, underscoring the challenge of conceptual change in educational settings.

The dissemination of myths through undergraduate education and professional training programs emphasizes the critical role of these institutions in either perpetuating or dispelling misconceptions. Therefore, it is crucial to provide training on these topics to faculty members in education faculties. Additionally, it is also important to inform teachers and faculty members that relying solely on popular science can contribute to myth endorsement. They should be encouraged to consult more reliable and up-to-date sources, as scientific information evolves over time. By raising awareness and promoting accurate information, the quality of teacher education can be improved, ultimately enhancing educational practices.

The study also found that anecdotal refutations were more effective than scientific explanations in changing certain beliefs, though both were more effective than providing refutations alone. However, teachers displayed a strong resistance to changing their views on deeply ingrained myths, such as learning styles and multiple intelligences, suggesting the need for more robust and ongoing interventions.

In conclusion, addressing misconceptions within teacher education programs and professional development initiatives is crucial for enhancing teaching and learning practices. Further research, including longitudinal studies and the exploration of various refutation formats, is essential to develop effective strategies for combating educational myths and fostering accurate knowledge among educators.

This study clearly showed that teachers still believe in educational myths, highlighting a need for focused action. While these beliefs often come from well-intentioned efforts to help students, their continued presence demands more attention. Recommendations can be made for teacher educators, policymakers, and school administrators to lessen the influence of these myths and promote evidence-based teaching practices.

For teacher educators. Teacher education programs are crucial in either challenging or strengthening these myths. Since undergraduate education was identified as a major source for several myths, these programs absolutely must adopt an approach rooted in research.

Designing myth debunking training. Faculty should directly address common myths in their coursework for active correction. This includes discussing where these myths came from, why they are popular, and why science does not support them because it is not enough to just avoid mentioning them. Undergraduate programs should ensure teacher candidates understand these concepts clearly and give them chances to apply their correct understanding in lesson planning and classroom observations.

Improving research literacy. Pre-service teachers need the skills to critically evaluate educational claims and tell the difference

between strategies based on evidence and appealing but unsupported ideas. Training should cover how to read and understand research articles, not just rely on summaries or popular science.

Using diverse ways to refute myths. The study showed that anecdotal refutations worked better than scientific explanations for some myths. This suggests using a mix of both methods. Stories, case studies, and classroom examples can make abstract concepts more relatable.

For policymakers. Policymakers are responsible for guiding teacher education and professional development at a system level. The fact that these myths persist despite decades of evidence tells us that current structures are not working.

Requiring evidence-based curriculum in teacher preparation. Accreditation bodies should demand that teacher education programs explicitly tackle and correct common educational myths. This should include clear standards and external reviews to ensure that what is taught aligns with current research. This can help both pre-service and in-service teachers separate myths from valid educational practices.

Supporting long-term intervention research and professional development. Most studies, including this one, only look at immediate changes in belief. We need long-term studies to see if conceptual changes last and what kinds of interventions lead to lasting shifts. In parallel, professional development should be based on solid empirical findings, not outdated ideas or commercially attractive materials to achieve effective and research-backed instructional training.

For school administrators. At the school level, administrators are perfectly positioned to influence teacher beliefs and practices through leadership, mentoring, and professional development.

Reviewing current practices. Schools should check if their teaching materials or activities reflect outdated or myth-based approaches. This might involve phasing out tools like learning style inventories or multiple intelligence-based lesson templates and replacing them with more appropriate strategies.

Providing chances for critical reflection. Teachers need safe, structured spaces to question their long-held beliefs and try out new approaches. Encouraging peer collaboration, journal reflections, or discussion groups can help support this process.

Organizing professional learning focused on myths. Workshops and training sessions should not just present new strategies; they should also challenge ineffective ones. Sharing findings from studies like this one can help teachers better understand the wider implications of their classroom choices. Teachers often get ideas from popular books, videos, or social media. Administrators should guide staff toward high-quality resources and lead by example in using current research for instructional decisions.

Data availability

The data of this study are not publicly available. The data are, however, available from the authors upon reasonable request.

Received: 30 July 2024; Accepted: 26 June 2025;

Published online: 22 October 2025

References

- Bråten I, Ferguson LE (2015) Beliefs about sources of knowledge predict motivation for learning in teacher education. *Teach Teach Educ* 50:13–23. <https://doi.org/10.1016/j.tate.2015.04.003>
- Braun V, Clarke V (2006) Using thematic analysis in psychology. *Qual Res Psychol* 3(2):77–101. <https://doi.org/10.1191/1478088706qp0630a>
- Bridgman T, Cummings S, Ballard J (2019) Who built Maslow's pyramid? A history of the creation of management studies' most famous symbol and its implications for management education. *Acad Manag Learn Educ* 18(1):81–98. <https://doi.org/10.5465/amle.2017.0351>
- Bukina TV, Khramova MV, Smirnov NM, Kurkin SA, Hramov AE (2023) Prevalence of neuromyths among pre-service teachers. *Humanit Soc Sci Commun*. 10(950). <https://doi.org/10.1057/s41599-023-02412-4>
- Burkhardt J, Lenhard W (2022) A meta-analysis on the longitudinal, age-dependent effects of violent video games on aggression. *Media Psychol* 25(3):499–512. <https://doi.org/10.1080/15213269.2021.1980729>
- Chi, MTH (2009). Three types of conceptual change: belief revision, mental model transformation, and categorical shift. In: Vosniadou S (ed) *International handbook of research on conceptual change*. Routledge, pp 61–82
- Clinton-Lisell V, Litzinger C (2024) Is it really a neuromyth? A meta-analysis of the learning styles matching hypothesis. *Front Psychol* 15:1428732. <https://doi.org/10.3389/fpsyg.2024.1428732>
- Compton WC (2018) Self-actualization myths: what did Maslow really say? *J Humanist Psychol* 64(5):743–760. <https://doi.org/10.1177/0022167818761929>
- Creswell JW (2014) *Research design: qualitative, quantitative, and mixed methods approaches* (4th ed). Sage
- Çağiltay K, Tunga Y (2022) Eğitsel nöromitler. In: Keleş E (ed) *Eğitimsel sinirbilim*. Nobel Akademik Yayıncılık, pp 71–97
- Danielson RW, Sinatra GM, Kendeou P (2016) Augmenting the refutation text effect with analogies and graphics. *Discourse Process* 53(5–6):392–414. <https://doi.org/10.1080/0163853X.2016.1166334>
- De Bruyckere P, Kirschner PA, Hulshof CD (2015) *Urban myths about learning and education*. Academic Press
- De Bruyckere P, Kirschner PA, Hulshof CD (2020) *More urban myths about learning and education: challenging eduquacks, extraordinary claims and alternative facts*. Routledge
- Dekker S, Lee NC, Howard-Jones P, Jolles J (2012) Neuromyths in education: prevalence and predictors of misconceptions among teachers. *Front Psychol* 3(OCT):1–8. <https://doi.org/10.3389/fpsyg.2012.00429>
- Dorantes-Argandar G (2021) Playing violent videogames is unrelated to antisocial behavior in Mexican children. *Entertainment Comput*. 39. <https://doi.org/10.1016/j.entcom.2021.100439>
- Dündar S, Gündüz N (2016) Misconceptions regarding the brain: the neuromyths of preservice teachers. *Mind Brain Educ* 10(4):212–232. <https://doi.org/10.1111/mbe.12119>
- Ecker UKH, Swire B, Lewandowsky S (2014) Correcting misinformation—A challenge for education and cognitive science. In: Rapp D N, Braasch J L G (eds) *Processing inaccurate information: theoretical and applied perspectives from cognitive science and the educational sciences*. The MIT Press, pp 13–37
- Ferguson CJ (2015) Do angry birds make for angry children? A meta-analysis of video game influences on children's and adolescents' aggression, mental health, prosocial behavior, and academic performance. *Perspect Psychol Sci* 10(5):646–666. <https://doi.org/10.1177/1745691615592234>
- Ferrero M, Garaizar P, Vadillo MA (2016) Neuromyths in education: prevalence among Spanish teachers and an exploration of cross-cultural variation. *Front Hum Neurosci* 10(OCT2016):1–11. <https://doi.org/10.3389/fnhum.2016.00496>
- Festinger L (1957) *A theory of cognitive dissonance*. Stanford University Press
- Gardner H (1983) *Frames of mind: the theory of multiple intelligences*. Basic Books
- Heddy BC, Danielson RW, Sinatra GM, Graham J (2017) Modifying knowledge, emotions, and attitudes regarding genetically modified foods. *J Exp Educ* 85(3):513–533. <https://doi.org/10.1080/00220973.2016.1260523>
- Herculano-Houzel S (2002) Do you know your brain? A survey on public neuroscience literacy at the closing of the decade of the brain. *Neuroscientist* 8(2):98–110. <https://doi.org/10.1177/107385840200800206>
- Horvath JC, Donoghue GM, Horton AJ, Lodge JM, Hattie JA (2018) On the irrelevance of neuromyths to teacher effectiveness: Comparing neuro-literacy levels amongst award-winning and non-award winning teachers. *Front Psychol* 9:364249. <https://doi.org/10.3389/fpsyg.2018.01666>
- Im SH, Cho JY, Dubinsky JM, Varma S (2018) Taking an educational psychology course improves neuroscience literacy but does not reduce belief in neuromyths. *PloS One* 13(2):e0192163. <https://doi.org/10.1371/journal.pone.0192163>
- Janati Idrissi A, Alami M, Lamkaddem A, Souirti Z (2020) Brain knowledge and predictors of neuromyths among teachers in Morocco. *Trends Neurosci Educ* 20(May):100135. <https://doi.org/10.1016/j.tine.2020.100135>
- Joynes C, Rossignoli S, Amonoo-Kuofi EF (2019) 21st century skills: evidence of issues in definition, demand and delivery for development contexts (K4D Helpdesk Report). Institute of Development Studies
- Kain C, Koschmieder C, Matischek-Jauk M, Bergner S (2024) Mapping the landscape: a scoping review of 21st century skills literature in secondary education. *Teach Teach Educ* 151:104739. <https://doi.org/10.1016/j.tate.2024.104739>
- Karakus O, Howard-Jones PA, Jay T (2015) Primary and secondary school teachers' knowledge and misconceptions about the brain in Turkey. *Procedia Soc Behav Sci* 174:1933–1940. <https://doi.org/10.1016/j.sbspro.2015.01.858>
- Kendeou P, Walsh EK, Smith ER, O'Brien EJ (2014) Knowledge revision processes in refutation texts. *Discourse Process* 51(5–6):374–397. <https://doi.org/10.1080/0163853X.2014.913961>
- Kenrick DT, Griskevicius V, Neuberg SL, Schaller M (2010) Renovating the pyramid of needs: contemporary extensions built upon ancient foundations. *Perspect Psychol Sci* 5(3):292–314. <https://doi.org/10.1177/1745691610369469>
- Kereluik K, Mishra P, Fahnoe C, Terry L (2013) What knowledge is of most worth: teacher knowledge for 21st century learning. *J Digit Learn Teach Educ* 29(4):127–140. <https://doi.org/10.1080/21532974.2013.10784716>
- Kirschner PA (2017) Stop propagating the learning styles myth. *Comp Educ* 106:166–171. <https://doi.org/10.1016/j.compedu.2016.12.006>
- Khramova MV, Bukina TV, Smirnov NM, Kurkin SA, Hramov AE (2023) Prevalence of neuromyths among students and pre-service teachers. *Humanit Soc Sci Commun* 10(1). <https://doi.org/10.1057/s41599-023-02412-4>
- Kowalski P, Taylor AK (2009) The effect of refuting misconceptions in the introductory psychology class. *Teach Psychol* 36(3):153–159. <https://doi.org/10.1080/00986280902959986>
- Lacko D, Machackova H, Smahel D (2024) Does violence in video games impact aggression and empathy? A longitudinal study of Czech adolescents to differentiate within- and between-person effects. *Comp Hum Behav* 159:108341. <https://doi.org/10.1016/j.chb.2024.108341>
- Lewandowsky S, Ecker UK, Seifert CM, Schwarz N, Cook J (2012) Misinformation and its correction: continued influence and successful debiasing. *Psychol Sci Public Int* 13(3):106–131. <https://doi.org/10.1177/1529100612451018>
- Lithander MPG, Geraci L, Karaca M, Rydberg J (2021) Correcting neuromyths: a comparison of different types of refutations. *J Appl Res Mem Cogn* 10(4):577–588. <https://doi.org/10.1016/j.jarmac.2021.03.006>
- Lucas, B (2019) Why we need to stop talking about twenty-first century skills (Vol. 283, pp. 1–18). Centre for Strategic Education. <https://cse.digital/content/why-we-need-stop-talking-about-twenty-first-century-skills>
- Macdonald K, Germino L, Anderson A, Christodoulou J, McGrath LM (2017) Dispelling the myth: training in education or neuroscience decreases but does not eliminate beliefs in neuromyths. *Front Psychol* 8:1314. <https://doi.org/10.3389/fpsyg.2017.01314>
- Markey PM, Ferguson CJ, Hopkins LI (2020) Video game play myths and benefits. *Am J Play* 13(1):87–106. <https://files.eric.ed.gov/fulltext/EJ1304728.pdf>
- Menz C, Spinath B, Seifried E (2021) Misconceptions die hard: prevalence and reduction of wrong beliefs in topics from educational psychology among preservice teachers. *Eur J Psychol Educ* 36:477–494. <https://doi.org/10.1007/s10212-020-00474-5>
- Mishra P, Mehta R (2017) What we educators get wrong about 21st-century learning: results of a survey. *J Digit Learn Teach Educ* 33(1):6–19. <https://doi.org/10.1080/21532974.2016.1242392>
- Nancekivell SE, Shah P, Gelman SA (2020) Maybe they're born with it, or maybe it's experience: toward a deeper understanding of the learning style myth. *J Educ Psychol* 112(2):221–235. <https://doi.org/10.1037/edu0000366>
- Newton PM, Miah M (2017) Evidence-based higher education - Is the learning styles "myth" important? *Front Psychol* 8:444. <https://doi.org/10.3389/fpsyg.2017.00444>
- Newton PM, Salvi A (2020) How common is belief in the learning styles neuromyth, and does it matter? A pragmatic systematic review. *Front Educ* 5:602451. <https://doi.org/10.3389/feduc.2020.602451>
- OECD (2002) *Understanding the brain: towards a new learning science*. OECD Publishing. <https://doi.org/10.1787/9789264174986-en>
- OECD (2007) *Understanding the brain: the birth of a learning science*. OECD Publishing. <https://doi.org/10.1787/9789264029132-en>
- Papadatou-Pastou M, Touloumakos AK, Koutouveli C, Barrable A (2021) The learning styles neuromyth: when the same term means different things to different teachers. *Eur J Psychol Educ*. 36. <https://doi.org/10.1007/s10212-020-00485-2>
- Pashler H, McDaniel M, Rohrer D, Bjork R (2008) Learning styles: concepts and evidence. *Psychol Sci Public Int* 9(3):105–119. <https://doi.org/10.1111/j.1539-6053.2009.01038.x>
- Pasquinelli E (2012) Neuromyths: why do they exist and persist? *Mind Brain Educ* 6(2):89–96. <https://doi.org/10.1111/j.1751-228X.2012.01141.x>
- Posner GJ, Strike KA, Hewson PW, Gertzog WA (1982) Accommodation of a scientific conception: toward a theory of conceptual change. *Sci Educ* 66(2):211–227. <https://doi.org/10.1002/sce.3730660207>
- Przybylski AK, Weinstein N (2019) Violent video game engagement is not associated with adolescents' aggressive behaviour: Evidence from a registered report. *R Soc Open Sci* 6(2):171474. <https://doi.org/10.1098/rsos.171474>

- Rogers J, Cheung A (2020) Pre-service teacher education may perpetuate myths about teaching and learning. *J Educ Teach* 46(3):417–420. <https://doi.org/10.1080/02607476.2020.1766835>
- Schroeder NL, Kucera AC (2022) Refutation text facilitates learning: a meta-analysis of between-subjects experiments. *Educ Psychol Rev*. 34(2). <https://doi.org/10.1007/s10648-021-09656-z>
- Sinatra GM, Broughton SH (2011) Bridging reading comprehension and conceptual change in science education: the promise of refutation text. *Read Res Q* 46(4):374–393. <https://doi.org/10.1002/RRQ.005>
- Tight M (2021) Twenty-first century skills: meaning, usage and value. *Eur J High Educ* 11(2):160–174. <https://doi.org/10.1080/21568235.2020.1835517>
- Tippett CD (2010) Refutation text in science education: a review of two decades of research. *Int J Sci Math Educ* 8:951–970. <https://doi.org/10.1007/s10763-010-9203-x>
- Torrijos-Muelas M, González-Víllora S, Bodoque-Osma AR (2021) The persistence of neuromyths in the educational settings: a systematic review. *Front Psychol*. 11(January). <https://doi.org/10.3389/fpsyg.2020.591923>
- Tovazzi A, Giovannini S, Basso D (2020) A new method for evaluating knowledge, beliefs, and neuromyths about the mind and brain among Italian teachers. *Mind Brain Educ* 14(2):187–198. <https://doi.org/10.1111/mbe.12249>
- Treagust DF, Duit R (2008) Conceptual change: a discussion of theoretical, methodological and practical challenges for science education. *Cult Stud Sci Educ* 3(2):297–328. <https://doi.org/10.1007/s11422-008-9090-4>
- Tunga Y, Çağiltay K (2023) Myths or facts: prevalence and predictors of neuromyths among Turkish teachers. *Educ Sci* 48(216):229–246. <https://doi.org/10.15390/eb.2023.12089>
- Van Dijk W, Lane HB (2020) The brain and the US education system: perpetuation of neuromyths. *Exceptionality* 28(1):16–29. <https://doi.org/10.1080/09362835.2018.1480954>
- Vaughn AR, Johnson ML (2018) Communicating and enhancing teachers' attitudes and understanding of influenza using refutational text. *Vaccine* 36(48):7306–7315. <https://doi.org/10.1016/j.vaccine.2018.10.040>
- Vosniadou S (2013) Conceptual change in learning and instruction: the framework theory approach. In: Vosniadou S (ed) *International handbook of research on conceptual change* (2nd ed.). Routledge, pp 11–30
- Wahba MA, Bridwell LG (1976) Maslow reconsidered: a review of research on the need hierarchy theory. *Organ Behav Hum Perform* 15(2):212–240. [https://doi.org/10.1016/0030-5073\(76\)90038-6](https://doi.org/10.1016/0030-5073(76)90038-6)
- Waterhouse L (2006) Multiple intelligences, the Mozart effect, and emotional intelligence: a critical review. *Educ Psychol*. 41(4):207–225. https://doi.org/10.1207/s15326985ep4104_1

Author contributions

Y.T.-conceptualization, literature review, formulating research questions, writing and editing the manuscript; B.C.- Conceptualization, formulating research questions, literature review, data collection and analysis, writing and editing the manuscript; K.C.-conceptualization, data collection, critical review of the manuscript, and guidance of the research process.

Competing interests

The authors declare no competing interests.

Ethical approval

Approval was obtained from the ethics committee of the Middle East Technical University (Approval number 320-ODTU-2020, dated 13th Nov 2020). All procedures in this study were designed and implemented in line with the ethical standards of the Declaration of Helsinki. The scope of the approval covered all aspects of the study.

Informed consent

Prior to participation, all participants were informed about the purpose and procedures of the study. Written informed consent was obtained from all participants in April 2022, ensuring voluntary participation and confidentiality of responses. The study information and consent form were presented on the first page of the online questionnaire. Participants could choose to proceed by starting the questionnaire and had the option to withdraw at any time according to their preference.

Additional information

Supplementary information The online version contains supplementary material available at <https://doi.org/10.1057/s41599-025-05470-y>.

Correspondence and requests for materials should be addressed to Yeliz Tunga.

Reprints and permission information is available at <http://www.nature.com/reprints>

Publisher's note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.



Open Access This article is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License, which permits any non-commercial use, sharing, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if you modified the licensed material. You do not have permission under this licence to share adapted material derived from this article or parts of it. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by-nc-nd/4.0/>.

© The Author(s) 2025