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ARTICLE

Preservice Biology Teachers' Beliefs About Evidence-Based Medicine and Alternative Medicine

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Abstract
Health-related discussions in society and the media—specifically during the COVID-19 pandemic—showed that individuals are confronted with Alternative Medicine and Evidence-Based Medicine. When making reflective decisions about these treatments, both knowledge and beliefs are important. Previous research with preservice biology teachers has shown that they commonly use Alternative Medicine, although they have little knowledge about it. To date, systematic studies on preservice biology teachers' beliefs about Alternative Medicine and Evidence-Based Medicine are lacking. Based on the Theory of Planned Behavior, the present study elicited German ($N=40$) preservice biology teachers' beliefs about these treatments via an open-ended questionnaire. Behavioral, normative, and control beliefs were categorized using qualitative content analysis. The results showed that the participants mentioned the efficacy, scientificity, and safety of treatments as important beliefs. For Alternative Medicine, beliefs were related to scientific evidence for its efficacy, naturalness and mild effects. These beliefs indicate that some preservice biology teachers do not have a clear understanding of Evidence-Based Medicine and Alternative Medicine, which can influence their decision-making. The results highlight the need to incorporate Alternative Medicine and Evidence-Based Medicine into health-related decision-making within biology education and biology teacher education and provide a basis for further research.

1 Introduction

The COVID-19 pandemic led to more public discussions about health issues and the nature, outcomes, and social consequences of medical treatments (Burwell et al., 2023; Nan & Thompson, 2021). During the pandemic, it became evident that individuals are confronted with scientific and pseudoscientific perspectives of medical treatments, including Evidence-Based Medicine (EBM) and various forms of Alternative Medicine (AM)

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(Chavda et al., 2022). The choice between these socially and health-relevant positions highlights the need for reflective and informed decision-making about health issues (Bromme et al., 2015; Roache, 2014; Sørensen et al., 2012) and especially in the field of EBM and AM (Gruner, 2000; Schmidt, 2021). It is thus also particularly important to prepare preservice biology teachers to promote critical decision-making and opinion-forming about AM and EBM as part of their education since they will be teaching health literacy as prospective teachers. This is also an opportunity for future science teachers to reflect on the Nature of Science (NOS) (Allchin, 2013; Buber and Coban, 2022; Erduran & Dagher, 2014; Lederman et al., 2002; Urhahne et al., 2011).

To implement AM and EBM into teacher training courses, it is important to tie in with preservice biology teachers' knowledge (Arnold, 2018; Bromme et al., 2015; Keselman et al., 2004) and beliefs (Fishbein & Ajzen, 2010; Valcke et al., 2010) about AM and EBM. From extant research, preservice biology teachers have misconceptions about AM and EBM due to their lack of knowledge about AM and EBM (Hamdorf, 2018). Additionally, Han-Tosunoglu and Ozer (2022) reported that health-related decision-making is not only based upon one's knowledge, but also upon one's beliefs, which can be moral, emotive and intuitive (see also Fishbein & Ajzen, 2010). To date, systematic studies that elicit preservice biology teachers' beliefs about AM and EBM are lacking. This emphasizes the need to examine preservice biology teachers' beliefs about AM and EBM (Schmidt, 2021).

2 Theoretical Background

2.1 Evidence-Based Medicine and Alternative Medicine

EBM is defined as a scientific practice with conscientious, explicit, and judicious use of current and leading scientific evidence from systematic research related to making decisions about the care of patients (Sackett et al., 1996). On the other hand, definitions of AM, also termed pseudo-medicine, which may be a derogatory term, vary greatly. AM is a broad domain that includes resources and practices that aim to improve health, including the prevention, diagnosis, and treatment of physical and mental diseases. It is mainly used outside of orthodox health care and holistically by meeting the demands that are not satisfied by conventional medicine or diversifying conventional medicine (Ernst, 2004). AM is mainly based upon the knowledge, practices, and skills derived from (mainly non-scientific) experiences, philosophies, and theories (Falkenberg et al., 2012; Wieland et al., 2011). The use of AM with EBM is referred to as Complementary Alternative Medicine (CAM). The field of AM and CAM comprises various procedures and therapies. A list of some AM treatments is presented in the work of Ernst (2004), while Chavda et al. (2022) compiled a list of alternative medical treatments for COVID-19. Well-known AM therapies include homeopathy, naturopathy, herbal medicine, Traditional Chinese Medicine (TCM), chiropractic adjustments, and acupuncture (Ernst, 2000; Frass et al., 2012). Numerous studies have surveyed the rate of AM use (Beer et al., 2016; Eardley et al., 2012; Frass et al., 2012), but they have shown differing results. The lack of a standardized definition for AM has been cited as a potential reason for these differences. Nevertheless, this has made it challenging to compare the results of studies on the use of paramedical treatment (Eardley et al., 2012; Frass et al., 2012; Zutavern et al., 2007). According to a report by the World Health Organization (WHO, 2019), AM treatment methods are very widespread internationally, but people give various reasons for using it, including

dissatisfaction with EBM (McFadden et al., 2010; Siahpush, 1999), faith in natural remedies (Siapush, 1999), a holistic view of health (Mc Fadden et al., 2010; Robinson & Cooper., 2007; Siahpush, 1999), and chronic diseases (Berna et al., 2019). Studies have also indicated that people who have a strong belief in AM are more skeptical about EBM and are more likely to refuse vaccinations (Attwell et al., 2018; Dotter et al., 2023).

In discussions about EBM and AM, characteristics like experience, knowledge acquisition, effectiveness, professionalization, and accessibility are often used in reference to both treatments. However, these characteristics often have different meanings for each treatment form (Teichfischer & Münstedt, 2011; Fig. 1). In EBM, for instance, experience is gained systematically by using criteria and scientific methods as a benchmark for obtaining and evaluating data. Key features of systematic experience generation in clinical trials are, for example, blinding and randomized controlled trials (Karanicolas et al., 2010; Worrall, 2002). AM experiences, on the other hand, are often grounded in history, culture, and tradition. Supporters of AM attribute their empirical values to the successful application of treatment procedures over many generations (Petri et al., 2015). Some AM treatments already indicate this historical or cultural background or worldview in their names (e.g., anthroposophy, TCM). Furthermore, the term knowledge acquisition in EBM is associated with generalizable results, whereas in AM, it is often related to individuals. Studies on EBM are also designed by considering several terms and conditions (e.g., a large study sample) to ensure that the study results are reproducible. Accordingly, an EBM treatment should work for all people, regardless of which physician administers it and which patient receives it (WHO, 2005). On the other hand, AM focusses on individualized and holistic treatments, often using a smaller study sample (Teichfischer, 2012). Furthermore, practitioners of AM often refer to knowledge authorities or miracle healers, who declare themselves to be healers with special abilities that only they possess (Teichfischer & Münstedt, 2011). There have been numerous reports in the literature about individuals with special healing powers (Herrlinger, 2023; Langford, 2021), such as charismatic healers (Katja, 2021), gurus

Fig. 1 Characteristics of Evidence-Based Medicine and Alternative Medicine and their expression tendencies. Blue symbolizes the scientific characteristics and green the pseudoscientific characteristics of EBM and AM, which represent the endpoints of the continuum. The color gradient visualizes the continuum on which AM and EBM procedures can be arranged in terms of their scientificity and pseudo-scientificity

(Lucia, 2021), Rabbinic authorities in reproductive medicine (Ivry & Teman, 2021), medical missionaries, and witch doctors (Midena, 2021). One such self-proclaimed miracle healer is Josip Grbavac (known as "Braco"), who claims to be able to cure diseased people with his gaze (Kamp, 2023). Further research findings on Shamanic healing among various ethnic groups have indicated the supposed supernatural powers of healers (Krippner, 2012; Sidky, 2009; Singh, 1999; Winkelman, 1990). Nevertheless, these differences in the meanings of experience and knowledge acquisition between AM and EBM influence the effectiveness of each treatment form. That is, while EBM has a specific effect that is scientifically proven, the effectiveness of AM is usually not. Instead, science explains the effects of AM as placebo, spontaneous, or self-healing (Barry, 2006; Ernst, 2009; Hyland, 2005; Teichfischer, 2012). In addition, differences in the professionalization of physicians and representatives of AM and EBM and their structural anchoring within the health care system can be observed. EBM physician training is academic and offered at universities. It is also regulated by strict admission procedures, curricula, assessment, quality assurance systems, and laws (World Federation for Medical Education, 2020; WHO, 2005). Considering national policy, state-level laws, or regulations for AM, there are regional differences. According to a WHO (2019) report, Africa and South-East Asia have the highest percentage (> 80%) of WHO member states with national or state-level laws and regulations governing AM, while only 43% of WHO member states within the Americas have such laws and regulations. Additionally, fewer than 50% of WHO member states in the Western Pacific region are under 50% and 40% of WHO member states in the European region have national or state-level laws or regulations governing AM (World Health Organization, 2019).

The relationships described above show why EBM is considered as scientific and AM as pseudoscientific. However, based on the demarcation problem (see also Erduran, 1995), a clear separation between AM and EBM is not always possible (Bunge, 2011; Ernst, 2019; Matthews, 2021). For example, scientific methods of gaining knowledge are also used in some AM procedures (e.g., chemical analyses in phytotherapy; Colalto, 2018). In EBM, the standards of scientific work cannot always be met, such as when testing drugs for very rare diseases on a small sample (Mann, 2003). Consequently, the characteristic of "experience" is therefore not to be understood as a clear-cut distinction in "systematic" and "traditional," but rather as a continuum between these endpoints, whereon procedures of AM and EBM can be arranged. However, EBM therapies show a stronger tendency toward systematic experiences, while AM procedures show a stronger tendency toward traditional experiences. The same is true for knowledge acquisition, effectiveness, professionalization, and accessibility (Schmidt, 2021). These described relationships are illustrated in Fig. 1 and described in Table 1.

The widely spread perception that AM is more natural, gentle, and mild and has fewer side effects (Ernst & Hung, 2011), while EBM uses chemical or artificial ingredients that lead to severe side effects, is not a distinguishing criterion for AM and EBM (Ernst, 2019). For example, the plants, used in phytotherapeutic AM that are often considered "natural," contain chemical molecules (Ernst, 2019; Teichfischer, 2012). Moreover, plants or their constituents are used not only in AM but also in EBM (Firenzuoli & Gori, 2007). AM preparations are also not always mild and free of side effects, since in AM in some cases toxic plants—such as *Aconitum napellus* and *Atropa belladonna*—are used, which can lead to poisoning (Akbar, 2020). The above-mentioned demarcation problem and the spread misconceptions about AM and EBM emphasize the importance of a reflective and informed decision-making about these treatments in biology education.

Table 1 Characteristics of Evidence-Based Medicine and Alternative Medicine in terms of their expression as endpoints of a continuum

Characteristic	Evidence-Based Medicine	Alternative Medicine
Experience	Gained systematically by using criteria and scientific methods (e.g., blinding and randomized controlled trials)	Grounded in history, culture, and tradition; gained through the application of the treatment over many generations
Knowledge acquisition	Generalizable due to large study samples and reproduceable study results	Focused on individual participants by considering holistic treatment approaches
Effectiveness	Specific effects are scientifically proven	Unspecific effects; effectiveness is explained as a placebo, spontaneous, or self-healing effect
Professionalization/accessibility	Training of staff is academically regulated by strict curricula, assessment, and quality assurance systems and laws	Regional differences in policies, state-level laws, and regulations

2.2 Evidence-Based Medicine and Alternative Medicine in Biology Education

Biology education plays a central role in the teaching of health literacy (Sørensen et al., 2012), a field in which decision-making about AM and EBM is necessary (see also Matthews, 2021; Moreno-Castro et al., 2019). An examination of curricula for biology education in Germany (Kultusministerkonferenz, 2004, 2020) showed that it is not mandatory to address AM and EBM therein, although these curricula contain explanations that can be used as a basis for discussing AM and EBM. Nevertheless, the responsible handling of one's own health and health literacy is an important educational contribution of biology (Kultusministerkonferenz, 2020). At the level of competencies, for instance, there are points of contact between the competencies of decision-making and knowledge acquisition. As part of the promotion of the decision-making competency, students should be taught how to assess issues from multiple perspectives, form opinions based on criteria, make informed decisions, and reflect on their decision-making processes and the consequences thereof in social and everyday decision-making situations. This also includes the evaluation of sources for their origin and interests, the demarcation of a distinction between descriptive and normative statements, and the evaluation of the possibilities and limitations of biological perspectives (Kultusministerkonferenz, 2004, 2020; Neumann et al., 2010). In the educational standards for biology at the lower secondary level, the description and evaluation of findings and methods in medicine are explicitly mentioned as part of the promotion of assessment skills (Kultusministerkonferenz, 2004). Furthermore, the competency of knowledge acquisition offers a starting point for dealing with AM and EBM with the processes of interpreting and reflecting on knowledge processes and results, as well as characterizing and reflecting on features of scientific statements and methods (Kultusministerkonferenz, 2004, 2020; Neumann et al., 2010). There are also links at the content level: The educational standards for the lower secondary level state that the basic biological understanding acquired should allow for the assessment of biological applications in medicine. For the upper secondary level, an examination of genetic diseases using the example of cancer and its treatment, gene therapy procedures, and personalized medicine is mandatory. Since a discussion of AM and EBM is not mandatory in biology curricula, regardless of the numerous points of reference that can be used as starting points, it is at the discretion of the teachers whether and how they address AM and EBM in the classroom. However, Schmidt (2021) pointed out that there is a lack of appropriate AM and EBM teaching materials and concepts at present.

An examination of the curricula for biology or science education in the USA (National Research Council, 2012), Australia (Australian Curriculum Assessment and Reporting Authority, 2023) and Great Britain (Department for Education, 2015) showed that there is no explicit discussion of AM and EBM therein. Nevertheless, there are numerous points of reference highlighting the curricular importance of AM and EBM in biology or science classes, such as NOS (e.g., National Research Council, 2012), para- and pseudoscience (e.g., NSW Education Standards Authority, 2023), and decision-making processes (e.g., Department for Education, 2015). For example, the high school science curriculum of the Australian state of New South Wales has pseudoscience as an explicit topic. By fostering learners' analytical and problem-solving skills, they will be able to make evidence-based analyses and decisions. Furthermore, there is an explicit discussion of the demarcation between science and pseudoscience using examples is explicitly stated (NSW Education Standards Authority, 2023). The National Curriculum of

England mentions in that students key stage four should be taught about "the process of discovery and development of new medicines" and develop scientific thinking for i.e., "making decisions based on the evaluation of evidence and arguments" (Department for Education, 2015). Further, NOS (Allchin, 2013; Erduran & Dagher, 2014; Lederman et al., 2002) is discussed in the American Next Generation Science Standards (National Research Council, 2012), with reference to scientific investigations, laws, theories, and mechanisms. For example, utilizing case studies is suggested for deepening students' understanding of NOS by discussing "the importance of evidence with scientific arguments" in middle and high school (National Research Council, 2012).

In addition to the curricular requirements, biology teachers and their knowledge and beliefs about AM and EBM are important when dealing with AM and EBM in biology classes. To date, medical staff and patients' knowledge and beliefs about EBM and AM have been assessed in numerous surveys (e.g., Arthur et al., 2012; Bishop et al., 2007; Brewer et al., 2019; Furnham & Forey, 1994). In the field of science education, studies have elicited knowledge and beliefs about pseudoscience among science students, preservice teachers, and in-service teachers. Several international studies have also found that these populations believe in pseudoscience and trust in scientifically false beliefs (e.g., Fuertes-Prieto et al., 2020; Keranto, 2001; Öztuna Kaplan, 2014; Surmeli & Saka, 2011). For example, in a study conducted by Losh and Nzekwe (2011), preservice teachers indicated that they believed in psychics, reincarnation, and ghosts, while Wilson (2018) found that American university students strongly believe in AM, superstition, spiritualism and witchcraft. Further, Fernández-Carro et al. (2023) asked Spanish preservice teachers about their beliefs in pseudoscience and superstitions, comparing their results with those of other members of their age group. Their results showed that preservice teachers believe more strongly in superstitions and less in pseudoscientific practices like homeopathy and acupuncture than the general population, but they still believe the most strongly in these. In a study conducted in Germany (Hamdorf, 2018), preservice biology teachers were asked about their awareness of various AM treatments. Herbal medicine was cited as the best-known AM, while acupuncture and homeopathy were also mentioned highly popular. Students listed osteopathy and Ayurveda medicine as other well-known procedures, while Reiki and anthroposophical medicine were indicated as less well-known AM treatment forms. The participants reported frequent usage of homeopathy, while about 50% of the study sample used herbal medicine occasionally. Concerning their intended future use, more than half (58%) of the preservice biology teachers could imagine using AM in the future. A particularly high level of agreement for future use was recorded for herbal medicine (73%) and acupuncture (58%). The study results also showed that preservice biology teachers' knowledge about AM was lacking and included misconceptions. For example, half of the participants agreed with the false statement that homeopathy is purely herbal. In addition, the predominant opinion among participants was that herbal medicines are more natural and gentler and have fewer side effects than other therapies, while EBM treatments are chemical and artificial (Hamdorf, 2018). Education students' lack of knowledge about AM was also supported by the findings of Moreno-Castro et al. (2019).

2.3 Two-Eyed Seeing

A holistic way of dealing with AM and EBM issues can be a Western philosophical version of two-eyed seeing (TES), which has recently been formulated to frame questions about

health and environmental education within science education (Zeyer et al., 2023). It was coined by Mi'kmaw elders Albert and Murdena Marshall from the Eskasoni First Nation in Nova Scotia, Canada, and inspired by Sellars' (1962) concept of viewing the world through two distinct yet complementary perspectives: the scientific eye (a third-person perspective) and the holistic eye (a first-person perspective). The TES approach emphasizes the synthesis of these dual perspectives, referred to as the *scientific image* and the *manifest image,* respectively. The scientific image is focused on quantifiable, objective phenomena typically analyzed through reductionist principles at a fundamental, often atomic or subatomic, level. Contrastingly, the manifest image considers the personal, normative, and social dimensions of human life, viewing sentient people and their interactions as fundamental components of reality (Esfeld, 2020).

The TES framework can provide a compelling and nuanced method to analyze the relationship between people's beliefs about EBM and AM in a way that respects but does not conflate them. By using both the scientific eye, which focuses on the systematic methods and replicable results of EBM, and the holistic eye, which emphasizes the experiential and traditional knowledge that underpins AM, this approach promotes a more comprehensive understanding of medical practice. It enables a dialogue, at eye level, wherein the strengths of one approach can be used to overcome the shortcomings of the other, facilitating a more comprehensive approach to patient care that respects both scientific rigor and individual patient values and cultural backgrounds. TES thus highlights the importance of a balanced view that respects and utilizes the diversity inherent in medical approaches.

2.4 Beliefs and the Theory of Planned Behavior

Research on teachers' professional development has shown that not only their knowledge but also their beliefs are important for teaching science (Ferreira et al., 2016; Jones & Park, 2023; Moreira-dos-Santos & El-Hani, 2017; Southerland et al., 2001). Teachers hold a complex system of beliefs that can impact their teaching methods and their perception of the subjects (Bryan, 2012). Brock and Park (2022) found that beliefs are especially important when teaching NOS (Allchin, 2013; Erduran & Dagher, 2014; Lederman et al., 2002). According to the Theory of Planned Behavior (Fishbein & Ajzen, 2010), beliefs are the foundation from which behavior can be explained because they influence attitudes, subjective norms, perceived behavior control factors, and the intention, which are the determinants of behavior. Fishbein and Ajzen (1975) defined beliefs as the subjective probability of an object or behavior having a certain attribute. Beliefs about a behavior are formed by association with different characteristics, qualities, and attributes. During their lives, people's experiences lead them to form different beliefs via direct observation, the acceptance of information from sources like friends, family, and the media or self-generation through interference processes (Ajzen, 2005; Fishbein & Ajzen, 2010). The process of belief formation can be explained as individuals' preexisting evaluations of attributes that become linked to an object or behavior (Fishbein & Ajzen, 2010). Similar to the core beliefs (Hautzinger, 2008), the beliefs mentioned in the Theory of Planned Behavior are foundational to explaining and predicting behavior. Accordingly, people's behavior is determined by three types of beliefs: behavioral, normative, and control beliefs. Definitions of these constructs are provided in Table 2.

Behavioral beliefs link behavior to a specific outcome or attribute (e.g., the cost incurred by performing the behavior). A person's evaluation of the outcome determines whether their attitude toward the behavior will be favorable or unfavorable. For example,

Table 2 Definitions of behavioral, normative, and control beliefs

Construct	Definition
Behavioral belief	A behavioral belief is the subjective probability that performing a behavior will lead to a specific outcome
Normative belief	A normative belief is the subjective probability that particular people or groups will prescribe or proscribe the performance of a behavior
Control belief	A control belief is the subjective probability that factors will facilitate or impede the performance of a behavior

See Fishbein and Ajzen (2010)

a person who believes that performing a given behavior will result in mostly positive outcomes will have a positive attitude toward the behavior. Normative beliefs are linked to subjective norms by considering specific individuals or groups who approve or disapprove of a given behavior and thus engage or do not engage therein. Therefore, people who believe that most individuals with whom they are motivated to comply think that they should perform the given behavior will experience social pressure to do so. Control beliefs are considerations of the presence or absence of factors that facilitate or impede the performance of a given behavior. In part, these beliefs may be based on experiences with the behavior, and they may be influenced by observing others performing the behavior or other factors that increase or reduce the perceived difficulty of performing the behavior. Consequently, the more required resources and opportunities individuals think they possess, and the fewer obstacles they anticipate, the greater their perceived control over the behavior would be. Control beliefs thus determine people's perception of the extent to which they can perform a behavior (Ajzen, 2005).

Beliefs can be influenced by factors like age, gender, and cultural background. They can also be mutually dependent (Ajzen, 2005). Although beliefs can be inaccurate, biased, wishful, or irrational, people consider them to be valid and consequently act upon them (Furnham & Lovett, 2001). People usually have several beliefs about an object or behavior, but Fishbein and Ajzen (2010) stated that only a few beliefs (five to nine) determine a person's attitude at any given moment. These are termed *salient beliefs* and are similar to core beliefs (Hautzinger, 2008) since they can be activated spontaneously and subconsciously. Core beliefs are fundamental and deeply rooted in the human mind, so they are usually not spoken aloud, not even to oneself (Hautzinger, 2008; James & Barton, 2004). Given sufficient motivation and time, individuals can retrieve many normative, control, and behavioral beliefs from memory. Beliefs can also change over time by expanding, strengthening, or weakening preexisting beliefs, and new beliefs can emerge or existing ones can be discarded (Fishbein & Ajzen, 2010). However, similar to core beliefs (Hautzinger, 2008), behavioral, normative, and control beliefs do not undergo rapid changes. Ajzen (2011) pointed out that lasting changes in beliefs strongly depend on the individual's mental engagement in an intervention process. In real-life settings, this prerequisite is often difficult to meet and can be considered the reason why some interventions fail.

Research has successfully elicited and adapted beliefs to explain health-related behavior and decision-making processes referring to health-related issues (e.g., Arnold, 2018; Bauer et al., 2018; Heuckmann et al., 2020; Ng, 2022; Schmidt, 2021). However,

to date, systematic studies that elicit biology students' beliefs about EBM and AM are lacking (Schmidt, 2021). We aimed to fill this gap with our investigation.

2.5 Research Aim

To set a baseline for fostering teachers' professional development within health literacy and scientific competence in the fields of EBM and AM, the aim of this study was to elicit preservice biology teachers' behavioral, control, and normative beliefs about EBM and AM.

3 Methods

3.1 Procedure and Material

To begin with, a pilot study was conducted to test the comprehensibility and coherence of the questions included in our questionnaire. After revising the questionnaire based on the results of the pilot study, participants' beliefs were elicited using a paper-and-pen qualitative questionnaire. The questionnaire included an introduction, in which the terms AM and EBM were briefly defined. To clarify what AM is, homeopathy was used as an example treatment, since this therapy is popular among preservice biology teachers (see also Hamdorf, 2018). In addition, the desired behavior to which the beliefs refer was defined in terms of four elements (Fishbein & Ajzen, 2010): target (recovery or improvement of one's health status), action (use of AM or EBM), context (when ill), and time (within the next 12 months). The questions were formulated based on Fishbein and Ajzen's (2010) operationalization. Therefore, the following items were used to elicit behavioral, normative, and control beliefs (for each medical treatment separately):

- Behavioral beliefs: What do you see as the advantages for using AM/EBM? What do you see as the disadvantages of using AM/EBM?
- Normative beliefs: Please list the individuals or groups who would approve of or think you should use AM/EBM. Please list the individuals or groups who would disapprove of or think you should not use AM/EBM.
- Control beliefs: Please list any factors or circumstances that would make it easy for you or enable you to use AM/EBM. Please list any factors or circumstances that would make it difficult for you or prevent you from using AM/EBM.

Beliefs were surveyed with one positive and negative question each and the participants were allowed to give multiple responses for each question. Data were collected from December 2022 to February 2023. Responses were independently translated, reviewed, and adjudicated.

3.2 Participants

A total of N = 40 preservice biology teachers in their first year of study at a German university participated in the study. All of them were in their first study semester of

biology education. Data were collected from students at a university in a medium-sized city in central Hesse, and most of the students came from the Hesse region. The sample was chosen because of its dual function: On the one hand, participants were expected to hold beliefs that originated from their own health and biology education, as they have only recently left school, wherein they studied advanced science courses during their A-levels that adhered to the curricular standards mentioned in "Evidence-Based Medicine and Alternative Medicine in Biology Education" above (Kultusministerkonferenz, 2004, 2020). On the other hand, we could elicit their beliefs as future biology teachers in a professional development program that will lead them to teaching decision-making competencies related to health issues themselves.

3.3 Data Analysis

To analyze participants' beliefs about AM and EBM, categories were developed inductively. Based on the classification method formulated by Fishbein and Ajzen (2010), beliefs were grouped into a category based on the similarity of their outcomes. Answers within a category were subcategorized when their outcomes were not identical. For instance, "is covered by health insurance" was subcategorized as "economic accessibility," while "not getting an appointment with the doctor" was subcategorized as "structural accessibility," but both these subcategories belonged to the category of "accessibility." Answers that differed only semantically, were considered equivalent and were grouped together in the same category. If participants gave several answers for one question, each belief was categorized or subcategorized separately. Since the beliefs were surveyed with one positive and one negative question each (e.g., "Please list any factors that would make it easier for you/prevent you from using…"), the categories and subcategories contained both negative and positive expressions (e.g., "often long waiting times at doctors" and "quickly(er) get appointments with doctors"). Various researchers coded the responses. First, we categorized the answers independently. Then, categories and subcategories were compared, and disagreements were discussed until an agreement was reached.

4 Results

In total, six behavioral belief, eight normative belief, and five control belief categories were identified for EBM. For AM, five behavioral belief, eight normative belief, and seven control belief categories were identified. The categories and subcategories for behavioral, control, and normative beliefs about EBM and AM are described in Tables 3, 4 and 5. Regarding each treatment form, both common and uncommon categories and subcategories were formed. An overview of these, with their anchor items, can be found in the appendix (Tables 6, 7 and 8). Some selected results are described below. Anchors for the (sub)categories are given in parentheses.

4.1 Behavioral Beliefs About Evidence-Based Medicine and Alternative Medicine

Behavioral beliefs about EBM and AM (Table 3) were classified into the overlapping categories of "effectiveness of treatment," "science-based treatment," "safety of

treatment," and "accessibility." Therefore, preservice biology teachers believed that if they used AM or EBM, the treatments would be effective, science-based, safe, and accessible. Notably, some differences in subcategories were found. Regarding the category of "effectiveness of treatment," "placebo effect" was mentioned only for AM. For the category of "safety of treatment," the subcategories of "safe/harmless through studies" ("proven safety through studies," ID 2, Table 6) and "experiences" ("no practical skills," ID 27, Table 6) were only cited for EBM, while "mildness" ("gentle for the body," ID 26, Table 6) was exclusively mentioned for AM. Although preservice biology teachers cited the subcategories of "artificiality" and "naturalness" for both EBM and AM, there were differences in their expressions. Considering the subcategory of "artificiality," the participants mentioned "chemicals" (ID 17, Table 6) for EBM, while the following were cited for AM: "no chemicals" (ID 3, Table 6), "not so much additional chemistry in the body" (ID 29, Table 6), and "no chemical drugs" (ID 20, Table 6). For EBM, the subcategory of "naturalness" was linked with negative formulations: "Medicine is not something our body is familiar with in its natural course" (ID 21, Table 6), and "self-healing power is reduced" (ID 43, Table 6). Behavioral beliefs about AM were also expressed positively for the mentioned subcategory: "with nature is healed (good for me)" (ID 3, Table 6), "natural treatment" (ID 20, Table 6), "natural healing without chemical plastic remedies" (ID 27, Table 6), "natural healing process" (ID 26, Table 6). For the subcategory of "side effects," awareness of side effects was indicated for EBM ("side effects, which can be a danger, are widely known and studied," ID 23; "possible dependencies," ID 12, Table 6), whereas for AM, there was only a risk of side effects ("risk of side effects," ID 10, Table 6). Considering the category of "economic accessibility," health insurance was mentioned for both treatments forms, but with differences in expressions: "Health insurance does not pay" (ID 26) for AM (Table 6); "is covered by health insurance" (ID 33) for EBM (Table 6). Furthermore, preservice biology teachers associates the economic accessibility of EBM with the "greed of doctors" (ID 26, Table 6) and financial interests ("surgeries instead of physiotherapy so that investors of clinics pull the money out of my pocket," ID 11, Table 6). In addition to these common categories of behavioral beliefs about EBM, some beliefs were categorized as "animal suffering" and "pluralism" ("other healing/treatment methods are often excluded," ID 32, Table 6), whereas those about AM were categorized as "holism" ("not only single symptoms are considered but whole well-being," ID 7, Table 6). Some subcategories were expressed both positively and negatively. For instance, for the AM subcategory "effective/fast treatment," the responses "Faster/healthier/better healing" (ID 8) and "no real effectiveness" (ID 24) were mentioned (Table 6). "Placebo works wonders in my opinion" (ID 35) and "possible only placebo effect" (ID 4) were cited for the AM subcategory of "placebo effect," and the responses "scientifically proven" (ID 17) and "unproven effectiveness" (ID 24) were recorded for the AM subcategory of "proven effect" (Table 6).

4.2 Normative Beliefs About Evidence-Based Medicine and Alternative Medicine

The overlapping categories of normative beliefs about EBM and AM (Table 4) were "family," "peers," "professionals," "patients," "opponents of science," "practitioners of Alternative Medicine," and "spiritual groups of people." Beliefs in the category of "professionals" were subcategorized as "medical professionals" ("doctors," ID 9; "medical

Table 3 Behavioral beliefs about using medicine: categories, subcategories, descriptions, and expressions for Evidence-Based and Alternative Medicine ($n = 40$)

Category	Description	Subcategory	Description	Evidence-Based Medicine	Alternative Medicine
Effectiveness of treatment	If a medicine is used, the treatment will be effective	Effective/fast treatment	If a medicine is used, the treatment will have a (fast) effect	x	x
		Exact/accurate treatment	If a medicine is used, the treatment will have an exact effect	x	x
		Placebo effect	If a medicine is used, it will have a placebo effect		x
Science-based treatment	If a medicine is used, the treatment will be science-based	Proven effect	If a medicine is used, the effect of the treatment will be scientifically proven	x	x
		Application of scientific methods	If a medicine is used, the treatment will be tested through scientific methods	x	x
		Innovation of treatment	If a medicine is used, the treatment will be characterized by innovative elements		x
Safety of the treatment	If a medicine is used, the treatment will be safe	Safe/harmless through studies	If a medicine is used, the safety of the treatment will be attested by studies	x	
		Side effects	If a medicine is used, the treatment will have side effects	x	x
		Uncertainty	If a medicine is used, the treatment will involve uncertainties	x	x
		Experiences	If a medicine is used, the practitioner will have experience therewith	x	
		Artificiality	If a medicine is used, it will be characterized by or contain artificial elements	x	x
		Naturalness	If a medicine is used, it will be characterized by or contain natural elements	x	x
		Mildness	If a medicine is used, the treatment will be mild		x

Table 3 (continued)

Category	Description	Subcategory	Description	Evidence-Based Medicine	Alternative Medicine
Accessibility	If a medicine is used, the treatment will be bound by economic, structural, personal, and/or informational conditions	Economic accessibility	If a medicine is used, the treatment will be bound by financial conditions	x	x
		Structural accessibility	If a medicine is used, the treatment will be bound by facilities, systems, and services	x	x
Pluralism	If a medicine is used, it will be characterized by different forms of treatment (pluralism)	Alternative treatment	If a medicine is used, alternative treatment forms will be considered	x	
Holism	If a medicine is used, the treatment will consider the whole person				x
Animal suffering	If a medicine is used, it will cause animal suffering			x	

Table 4 Normative beliefs about using medicine: categories, subcategories, descriptions, and expressions for Evidence-Based and Alternative Medicine ($n = 40$)

Category	Description	Subcategory	Description	Evidence-Based Medicine	Alternative Medicine
Family	The use of a medicine is influenced by the family			x	x
Peers	The use of a medicine is influenced by peers			x	x
Professionals	The use of a medicine is influenced by members of a profession or people with expertise in a specific field	Medical professionals	The use of a medicine is influenced by medical professionals	x	x
		People familiar with science	The use of a medicine is influenced by people who are familiar with science	x	x
Patients	The use of a medicine is influenced by patients	Ill people	The use of a medicine is influenced by the person being ill	x	x
		Seriously ill people	The use of a medicine is influenced by the person being seriously ill	x	
		Slightly ill people	The use of a medicine is influenced by the person being slightly ill	x	x
Opponents of science	The use of a medicine is influenced by opponents of science			x	x
Spiritual groups and people	The use of a medicine is determined by spiritual groups and people			x	x
Health institutions	The use of a medicine is influenced by health institutions			x	
Practitioners of Alternative Medicine	The use of a medicine is influenced by practitioners of Alternative Medicine			x	x
Supporters of Alternative Medicine	The use of a medicine is influenced by supporters of Alternative Medicine				x

Table 4 (continued)

Category	Description	Subcategory	Description	Evidence-Based Medicine	Alternative Medicine
Other groups and people	The use of a medicine is influenced by other groups and people	Elderly people	The use of a medicine is influenced by elderly people		x
		Educated people	The use of a medicine is influenced by people with a higher educational level		x
		Opponents of science	The use of a medicine is influenced by people who support science		x

staff," ID 10, Table 7) and "people familiar with science" ("natural scientists," ID 15; "professors," ID 34, Table 7). Beliefs in the category of "patients" were subcategorized as "ill people" ("people with diseases," ID 4, Table 7), "seriously ill people" ("anyone who is seriously ill," ID 11, Table 7), and "slightly ill people" ("patients with mild diseases," ID 29, Table 7). Overall, preservice biology teachers believed that their use of medical treatments was influenced by what other people and groups said about those treatments. Categories that applied exclusively to AM included "other groups and people" (subcategories: "elderly people," "educated people," and "supporters of science," Table 4) and "supporters of alternative medicine" ("fans of homeopathy," ID 29, Table 7), while the subcategory of "health institutions" ("health-insurance company," ID 28, Table 7) is only mentioned for EBM. (For additional anchor quotes, see Table 7).

4.3 Control Beliefs About Evidence-Based Medicine and Alternative Medicine

The control belief categories of "science-based treatment," "effectiveness of treatment," "accessibility," and "safety" were applicable for both EBM and AM (Table 5). Differences were found among their subcategories, though. For example, the subcategory of "placebo effect" ("often only placebo; not reliable, psychological component too serious," ID 29, Table 8) under the category of "effectiveness of treatment" was only mentioned as a control belief for AM. The category of "safety" had various subcategories, including "risk" for EBM and "side effects" and "uncertainty" for AM. The expressions of these subcategories were negatively formulated for both EBM ("too much risk [risky surgery]," ID 6; "expected severe side effects," ID 25, Table 8) and AM ("otherwise I have to expect great suffering/death," ID 34; "negative experiences/results that did not have desired effects," ID 5, Table 8). The categories of "social environment" ("positive experiences from my social environment," ID 6; "acquaintances have had bad experiences," ID 6) and "culture" ("with own culture connected possibilities of alternative medicine," ID 28) were found only for AM (Table 8). Within some (sub)categories were answers that contained both a negative and a positive expression. For instance, for the EBM subcategory of "proven effect," the responses "clear study situation, which proves effect" (ID 16), and "no clear study situation" (ID 18) were given (Table 8). This was also observed in the category of "structural accessibility" for EBM ("often long waiting times at doctors," ID 32; "quickly(er) get appointments with doctors," ID 33; "fast inaccurate treatment," ID 30, Table 8) and "personal accessibility" ("good consultation with the doctor," ID 6; "distrust of treatment method," ID 25, Table 8). For AM negative and positive expressions of the responses were found in the category of "social environment" ("positive experiences from my social environment," ID 6; "acquaintances have had bad experiences," ID 6, both Table 8). Different expressions of the responses were also be elicited for the subcategories of "application of scientific methods" ("studies," ID 35; "no research," ID 3), "proven effect" ("scientific proofs," ID 8; "scientific controversy," ID 15), and "informational accessibility" ("info about different healing possibilities," ID 7; "poor information," ID 19, Table 8).

Table 5 Control beliefs about using medicine: categories, subcategories, descriptions, and expressions for Evidence-Based and Alternative Medicine ($n = 40$)

Category	Description	Subcategory	Description	Evidence-Based Medicine	Alternative Medicine
Science-based treatment	The scientificity of a treatment influences its use	Application of scientific methods	The application of scientific methods in formulating a medicine influences its use	x	x
		Proven effect	The proof of its efficacy influences the use of a medicine	x	x
Effectiveness of treatment	The effectiveness of a medical treatment influences its use	Effective treatment	The effectiveness of a treatment influences its use	x	x
		Placebo	The placebo effect of the medical treatment influences its use		x
Type of disease	The type of disease influences the use of a medicine	Serious disease	The use of a medicine is influenced by its use for treating serious diseases	x	x
		Diseases	The use of a medicine is influenced by its use for treating diseases	x	
Accessibility	Economic, structural, personal, and/or informational conditions influence the use of a medicine	Economic accessibility	Finances influence the use of a medicine	x	x
		Personal accessibility	A personal contact or communication between patient and doctor influences the use of a medicine	x	
		Structural accessibility	Access to facilities, systems, and services influences the use of a medicine	x	x
		Informational accessibility	Access to information about the treatment influences its use	x	x
Safety of treatment	The safety of a treatment influences its use	Risk	Risks influence the use of a medicine	x	
		Side effects	Side effects influence the use of a medicine		x
		Uncertainty	Uncertainty influences the use of a medicine		x

Table 5 (continued)

Category	Description	Subcategory	Description	Evidence-Based Medicine	Alternative Medicine
Social environment	People being in intermediate social and physical settings influences the use of a medicine				x
Culture	The user's culture influences their use of a medicine				x

5 Discussion and Conclusion

5.1 General Discussion

Overall, the number of categories and subcategories showed that preservice biology teachers have numerous and multifaceted beliefs about AM and EBM, supporting the findings of Hamdorf (2018) and Teichfischer and Münstedt (2011). Especially, the categories of "effectiveness of treatment," "science-based treatment," "safety of treatment," and "accessibility" showed great differentiation for behavioral and control beliefs about AM and EBM. For normative beliefs, the categories of "professionals" and "patients" are specified in subcategories for both AM and EBM. This differentiation could indicate that these beliefs of preservice biology teachers are more complex and stronger, so they are considered when making decisions about using AM and EBM. A comparison of categories and subcategories between EBM and AM illustrated that there was some overlap between the two treatment approaches. For example, the categories of "effectiveness of treatment," "science-based treatment," "safety of treatment," and "accessibility" were mentioned for both EBM and AM. However, differences were observed in the characteristics and expressions of the categories or subcategories, supporting the explanations of Teichfischer and Münstedt (2011) and the correlations illustrated in Fig. 1. For example, for the behavioral and control belief category of "effectiveness of treatment," an efficient and fast effect was reported for EBM (e.g., "fast help," ID 26; "efficient," ID 26, Table 6), whereas for AM, the placebo effect was cited (e.g., "possibly only placebo effect," ID 4, Table 6; "often only placebo; not reliable, psychological component too serious," ID 29, Table 6).

The elicited behavioral, normative, and control beliefs provided insights into preservice biology teachers' understanding of EBM. The results indicated that some students understand EBM, an understanding characterized by systematic increases in experience and evidence-based effectiveness (see also Fig. 1). For example, in the "effectiveness of treatment" category, both behavioral and control beliefs about EBM were mentioned, namely that EBM is fast, accurate, and effective, with a good chance of a cure (Tables 3 and 5). Proven effects (e.g., "clear study situation, which proves effect," ID 16, Table 8) and the use of scientific methods ("based on rational scientific research," ID 24, Table 6) were also mentioned as subcategories of "science-based treatment." However, it was unclear to what extent the effectiveness of EBM was understood to be specific and generalizable (Ernst, 2009) and through which scientific methods medical knowledge was gained (Karanicolas et al., 2010; Worral, 2002). The latter is particularly important for preservice biology teachers because it connects directly with NOS (Allchin, 2013; Erduran & Dagher, 2014; Lederman et al., 2002). For the EBM behavioral belief of "safety of treatment," studies were cited as a basis for the safety of treatment procedures ("proven safety through studies," ID 2, Table 6), which is reached through knowledge about side effects ("side effects, which can be a danger, are widely known and studied," ID 23, Table 6). However, the other behavioral and control beliefs from the category of "safety of treatment" indicated that for preservice biology teachers, the use of EBM is associated with uncertainty, possible dependencies, and risks (Tables 3 and 5). This supports the findings of Ernst (2019). In addition, we found that preservice biology teachers hold the behavioral beliefs that chemical ingredients are used in EBM and that these treatments are unnatural ("medicine is not something our body is familiar with in its natural course," ID 21, Table 6). Similar findings were reported by Ernst (2019) and Teichfischer and Münstedt (2011). These results indicated that preservice biology teachers' understanding of EBM is insufficiently

differentiated, a result that can be compared to Hamdorf's (2018) findings about preservice biology teachers' knowledge about AM. The category of "accessibility" showed the importance of the economic, personal, structural, and informational availability of EBM for students (see also WHO, 2005). Concerning the availability and regulation, preservice biology teachers were found to hold both positive beliefs ("good consultation with the doctor," ID 6; "financial support," ID 12, Table 8) and negative beliefs ("too expensive drugs," ID 25, "often long waiting times at doctors," ID 32, Table 8; "greed often he doctors," ID 26, Table 6). In terms of informational availability, students complained about the lack of information about EBM ("no sufficient information," ID 5, Table 8). This could indicate a general lack of knowledge about EBM among biology education students (see also Hamdorf, 2018).

The elicited beliefs also provided insights into preservice biology teachers' understanding of AM. Regarding the effectiveness of AM, some participants mentioned behavioral beliefs that AM treatments have no effect or are not reliable ("no real effectiveness," ID 9; "often not reliable," ID 7, Table 6). Some participants believed that AM efficiency can be explained by the placebo effect ("placebo works wonders in my opinion," ID 35; "possibly only placebo effect," ID 4, Table 6), or it being holistic ("not only single symptoms are considered but whole well-being," ID 7, Table 6). These beliefs underpin the understanding of AM as based on an individualized effectiveness (see also Barry, 2006; Hyland, 2005; Teichfischer, 2012; Fig. 1), although the preservice biology teachers did not explicitly state that the effect of AM is non-specific. Further, some of the participants stated that AM treatments result in faster, healthier, and better healing ("faster/healthier/better healing," ID 8, Table 6). On the one hand, this statement, which is generalized, could indicate a lack of knowledge about AM, as described by Hamdorf (2018). On the other hand, this statement could also be interpreted as an expression of individual experience. In terms of gaining knowledge about and experience with AM, some preservice biology teachers were found to hold behavioral and control beliefs in the category "science-based treatment" that indicated their understanding of AM as a discipline that does not meet the standards of scientific work (see also Ernst et al., 2004), as shown in the subcategories of "unproven effectiveness" (ID 24, Table 6), "scientific studies are missing" (ID 5, Table 6), and "no research" (ID 3, Table 8). Simultaneously, behavioral and control beliefs were found that suggested a lack of understanding about AM in terms of knowledge acquisition ("scientifically proven," ID 17, Table 6). In addition, knowledge about and experiences with AM were influenced by personal perceptions or experiences of individuals ("when I notice success when using them," ID 23, Table 8; "positive experiences from my social environment," ID 6, Table 8) and cultural factors ("with own culture connected possibilities of alternative medicine," ID 28, Table 8). These beliefs point to an understanding of AM, as described by Barry (2006) , Hyland (2005). Petri et al. (2015), and Teichfischer (2012) (see also Fig. 1). Regarding AM, behavioral and control beliefs about "safety of treatment," references to naturalness, artificiality, side effects, and mildness were found (comparable to EBM). However, these had different characteristics than for EBM. That is, preservice biology teachers were found to hold that behavioral beliefs that AM treatments are natural ("with nature is healed—good for me," ID 3), not artificial ("no chemicals," ID 3), and mild ("gentle for the body," ID 26, all Table 6). These beliefs support the findings of Ernst and Hung (2011) and Hamdorf (2018), who pointed out that, although they are known to be widely held beliefs about AM, they are not general characteristics of AM. Consequently, this may indicate that biology education students lack a reflective understanding of naturalness and artificiality in relation to EBM and AM. Regarding side effects, participants held beliefs that indicated that they were aware of the risks of using AM, as indicated by

the subcategories of "risk of side effects" (ID 10, Table 6) and "otherwise I have to expect great suffering/death" (ID 34, Table 8). For behavioral and control beliefs about the availability of AM, the results showed that economic and structural availability is important for the use of AM and that these are not uniformly regulated (e.g., "health insurance does not pay," ID 26, Table 6; "health insurance pays," ID 26, Table 8). This supports the findings of the WHO (2019) (see also Fig. 1). Similar to EBM, preservice teachers believed that they lack information about AM ("poor information," ID 19, Table 8), suggesting that they lack knowledge of both AM and EBM (see also Hamdorf, 2018).

The elicited normative beliefs showed that the students' use of EBM and AM is influenced by numerous individuals and groups of people. Notably, only some individuals or groups mentioned had medical and health expertise, namely "professionals" and "health institutions," as well as "practitioners of alternative medicine" with medical training. Further, for both EBM and AM, preservice biology teachers identified "opponents of science" as a group of people who influenced their use of medical treatments, which could be explained by the copiousness of pseudoscientific perspectives in the media during the COVID-19 pandemic (see also Chavda et al., 2022). The influence of "spiritual groups and people" on the use of AM could be due to AM treatment procedures often having historical, cultural, and traditional backgrounds (Petri et al., 2015; see also Fig. 1). Finally, the participants being first-year students could explain the influence of "family" and "peers" (Table 4).

This study on preservice biology teachers' beliefs about AM and EBM had some limitations. Since the survey was conducted in German, there may have been inaccuracies in the English translation that could have had linguistic and cultural influences. Furthermore, the survey asked about participants' beliefs about AM and EBM in general, which could have included diverse forms of treatment (see also Ernst, 2004). Accordingly, the surveyed beliefs of participants may not apply equally to all treatment forms but may either refer to individual therapies or beliefs about the overarching constructs of AM and EBM. Future studies can thus focus on prominent treatment procedures (e.g., phytotherapy in AM, see also Hamdorf, 2018). Another limitation was the brief answers of the participants (e.g., "faster/healthier/better healing," ID 8, Table 6). Some answers also lacked explanations. The assignment of these statements to a category was thus subject to our interpretation. For future studies, it would be beneficial to ask for greater explanations of the answers (e.g., through interviews).

Despite the limitations, this study had important implications and conclusions that can be used to promote informed decision-making about AM and EBM among preservice biology teachers. The diversity of beliefs elicited illustrated that participants held numerous beliefs about two treatment approaches and that these beliefs were relevant to them, even though discussions about AM and EBM are not included in school curriculum guidelines (e.g., Kultusministerkonferenz, 2020). The beliefs elicited in this study also showed that preservice biology teachers, who are exposed to NOS (Allchin, 2013; Erduran & Dagher, 2014; Lederman et al., 2002) and human biology as part of their studies, did not have a clear understanding of AM and EBM and their connection. This may influence their decision-making about EBM and AM since these decisions are not critically reflected upon, which highlights the desirability of explicit discussions about EBM and AM in biology education—particularly in the context of health literacy (Sørensen et al., 2012), NOS reflection (Abd-El-Khalick & Lederman, 2023; Allchin, 2013; Erduran & Dagher, 2014; Lederman et al., 2002) and decision-making (see also Matthews, 2021; Moreno-Castro et al., 2019) in biology education.

Conversely, our findings underlined the underestimated role of medicine in biology education and science education in general, a point that was highlighted in Science|Environment|Health, a new science pedagogy that aims to promote the mutual benefits of these three areas of education (Keselman et al., 2018; Zeyer & Dillon, 2014).

Pre-service biology teachers are an important target group for these efforts, as they will be science-literate professionals who will promote health literacy (Sørensen et al., 2012) and reflective decision-making about health-related issues for future citizens (Schmidt & Minkin, 2024; Zeyer, 2012). The results of the present study thus demonstrated the need and provided an important basis for further quantitative, qualitative, and longitudinal research on decision-making processes about AM and EBM and their influencing factors nationally and internationally.

5.2 Application of the Two-Eyed Seeing Approach to Evidence-Based Medicine and Alternative Medicine

In the subsection "Two-Eyed Seeing," we suggested that a Western variant of TES, inspired by Sellars (1962), might provide a framework for analyzing the relationship between EBM and AM in a way that respects but does not conflate them. In this concluding section, we outline how this approach might help to clarify the results presented in Tables 3, 4 and 5. The following considerations cannot be fully substantiated by the data presented and the conclusions drawn require further empirical validation.

Tables 3, 4 and 5 present various beliefs that seem to be held about both AM and EBM. However, by examining these beliefs through the lens of TES, it becomes clear that while the surface of beliefs about EBM and AM may appear similar, the foundational reasoning and ontological commitments underpinning those beliefs align with either the scientific or manifest image. Specifically, EBM operates within the domain of the scientific image, prioritizing objective, measurable, and generalizable knowledge. Contrastingly, AM is often more aligned with the manifest image, emphasizing the subjective, normative, and personal dimensions of human health. In this way, seemingly identical belief categories may contain different content. Here, the TES approach highlighted how the manifest and scientific images provide different rationales for beliefs in the context about EBM and AM. For example, for EBM, the belief about "effectiveness of treatment" is based primarily on empirical evidence, such as clinical trials, statistical significance, and reproducibility. Effectiveness is thus seen as measurable and quantifiable. For AM, effectiveness is often based on personal testimonies, traditional uses, and holistic effects on wellbeing that are not be easily measured but are personally felt and experienced. A proven effect of EBM means an outcome that has been validated by rigorous scientific methods and peer-reviewed research that has established a cause-and-effect relationship within controlled environments, while a proven effect of AM may be based on historical validation and long-term use across generations, emphasizing continuity and tradition over controlled experimentation. The belief in the "application of scientific methods" for EBM involves the use of standardized, systematic methods like randomized controlled trials and blinding tests to ensure objectivity and minimize bias in EBM. For AM, the use of "scientific methods" is less formal and includes anecdotal evidence and individual case studies that are consistent with holistic and integrative approaches to health. In addition, EBM involves discussions about side effects in the context of documented clinical research, detailing probabilities and severities based on extensive studies. Side effects of AM, on the other hand, may be discussed in terms of personal experience or traditional warnings, lacking the same quantitative precision but incorporating personal and community wisdom. For EBM, uncertainty is often quantified statistically, indicating the limits of current knowledge and the likelihood of outcomes, while uncertainty for AM may be accepted as part of the natural variability of individual responses to treatment, reflecting a more personal and experiential

understanding. Furthermore, the subcategories of "artificiality" and "naturalness" for EBM refer to the synthetic or natural origin of treatment substances, often focusing on molecular composition and the presence of human-made chemicals. For AM, artificiality and naturalness refer to a deeper philosophy of living in harmony with nature, using treatments that are perceived as less intrusive and more aligned with natural processes. For EBM, structural accessibility is often about the physical availability of health services, hospitals, and clinics equipped with the necessary technology and staff. For AM, on the other hand, structural accessibility may involve the community-based distribution of knowledge and services, informal networks of practitioners, and home-based remedies that emphasize personal relationships and community trust.

Some of the beliefs presented in Tables 3, 4 and 5 may be attributable to either EBM or AM exclusively because they were mistakenly viewed only through the lens of the "scientific eye" or the "holistic eye," without considering any potential overlaps or mutual benefits. For example, attributing innovation only to EBM may reflect a scientific view that emphasizes technological and pharmacological advances. However, AM is also evolving, with new holistic practices and the integration of traditional remedies with modern health care becoming increasingly popular, suggesting that innovation is not exclusive to conventional medicine. The belief that AM treatments are inherently milder can be attributed to the holistic perspective that sees natural remedies as less aggressive compared to synthetic drugs. However, this overlooks the fact that EBM also aims to reduce side effects and that many modern medicines are designed to be as gentle as possible while still being effective. Associating cultural relevance exclusively with AM also ignores the cultural impact and origins of many conventional practices within EBM. Specifically, many modern medical practices originated in specific cultural or historical contexts and may thus reflect the values and beliefs of those origins. Attributing side effects and uncertainty only to EBM may reflect a scientific perspective focused on the risks and unknowns of chemically synthesized treatments.However, AM also carries risks of side effects, interactions, and less predictable outcomes due to the variable nature of herbal compounds and other natural products.

5.3 Conclusion

Examining beliefs about AM and EBM in science education revealed significant opportunities for improving educational practice. Educators are encouraged to adopt a balanced perspective that recognizes the advantages and disadvantages of both AM and EBM, thus preparing students to critically evaluate different medical treatments and philosophies. By adopting a TES approach that integrates "scientific" and "holistic" perspectives, science education can foster a more comprehensive understanding of health and medicine. This method can not only broaden students' perspectives but can also promote critical thinking and decision-making skills that are crucial in a world where medical decisions are becoming increasingly complex. Furthermore, discussing the intersections and differences between AM and EBM can help to demystify misconceptions and stimulate a more informed, inclusive dialogue about health practices in future generations.

Our initial observations suggest that there is a substantial need for further investigation, particularly through qualitative research approaches like case studies and discourse analysis, that can provide deeper insights into the complexities and nuances underlying the thematization of AM and EBM in science education.

Appendix

Table 6 Behavioral beliefs about Evidence-Based Medicine and Alternative Medicine: categories, subcategories, and anchor quotes ($n = 40$)

Category	Subcategory	Anchor quotes for EBM	Anchor quotes for AM
Effectiveness of treatment	Effective/fast treatment	"fast help" (ID 26), "efficient" (ID 26), "high probability of desired effect" (ID 34)	"faster/healthier/better healing" (ID 8), "no real effectiveness" (ID 9), "disease can be cured" (ID 6)
	Exact/accurate treatment	"best variant to fight against diseases" (ID 21)	"often not reliable" (ID 7)
	Placebo effect		"placebo works wonders in my opinion" (ID 35), "possibly only placebo effect" (ID 4)
Science-based treatment	Proven effect	"scientifically proven chances of recovery" (ID 39)	"scientifically proven" (ID 17), "unproven effectiveness" (ID 24)
	Application of scientific methods	"based on rational scientific research" (ID 24)	"scientific studies are missing" (ID 5)
	Innovation of treatment		"new research results could be found" (ID 13), "discovering something with positive benefit from which one does not expect it" (ID 19)

Table 6 (continued)

Category	Subcategory	Anchor quotes for EBM	Anchor quotes for AM
Safety of the treatment	Safe/harmless through studies	"proven safety through studies" (ID 2)	
	Side effects	"side effects, which can be a danger, are widely known and studied" (ID 23), "possible dependencies" (ID 12)	"risk of side effects" (ID 10)
	Uncertainty	"uncertainty." (ID 3)	"depending on the disease alternative medicine is probably not sufficient" (ID 6)
	Experiences	"no practical skills" (ID 27)	
	Artificiality	"chemicals" (ID 17)	"no chemicals" (ID 3), "not so much additional chemistry in the body" (ID 29), "no chemical drugs" (ID 20)
	Naturalness	"medicine is not something our body is familiar with in its natural course" (ID 21), "self-healing power is reduced" (ID 43)	"herbal medicines are 'healthier'" (ID 1), "with nature is healed (good for me)" (ID 3), "natural treatment" (ID 20), "natural healing without chemical/plastic remedies" (ID 27), "natural healing process" (ID 26)
	Mildness		"gentle for the body" (ID 26)
Accessibility	Economic accessibility	"greed of the doctors" (ID 26), "surgeries instead of physiotherapy so that investors of clinics pull the money out of my pocket" (ID 11), "is covered by health insurance" (ID 33)	"health insurance does not pay" (ID 26)
	Structural accessibility	"long waiting times" (ID 33), "not getting an appointment with the doctor (problem mass patient)" (ID 6)	"in emergencies quick access without patenting phase to consider" (ID 9)

Table 6 (continued)

Category	Subcategory	Anchor quotes for EBM	Anchor quotes for AM
Pluralism	Alternative treatment	"other healing/treatment methods are often excluded" (ID 32)	
Holism			"not only single symptoms are considered but whole well-being" (ID 7)
Animal suffering		"animal suffering" (ID 4)	

Table 7 Normative beliefs for using Evidence-Based Medicine and Alternative Medicine: categories, subcategories, and anchor quotes ($n=40$)

Category	Subcategory	Anchor quotes for EBM	Anchor quotes for AM
Family		"my parents" (ID 2), "my siblings" (ID 2)	"mother" (ID 31)
Peers		"Friends" (ID 2), "acquaintances" (ID 20)	"friends" (ID 20)
Professionals	Medical professionals	"doctors" (ID 9), "medical staff" (ID 10)	"physicians" (ID 8)
	People familiar with science	"students" (ID 33), "natural scientists" (ID 15), "professors" (ID 34)	"scientists" (ID 15)
Patients	Ill people	"people with diseases" (ID 4), diseased" (ID 35)	"people with allergies" (ID 4)
	Seriously ill people	"anyone who is seriously ill" (ID 11)	
	Slightly ill people	"people with well treatable diseases" (ID 25)	"patients with mild diseases" (ID 29)
Opponents of science		"lateral thinkers" (ID 20,25), "people who fundamentally do not trust science" (ID 29)	"vaccination opponents" (ID 22)
Spiritual groups and people		"spiritual people" (ID 10), "certain religions" (ID 10)	"spiritual people" (ID 10,35), "religious" (ID 39)
Health institutions		"drug industry" (ID 26), "health insurance company" (ID 28)	
Practitioners of Alternative Medicine		"homoeopaths" (ID 21,34,39)	"homoeopaths" (ID 18)
Supporters of Alternative Medicine			"fans of homoeopathy" (ID 29)
Other groups and people	Elderly people		"people of the older generation" (ID 35)
	Educated people		"more educated peers" (ID 19)
	Supporters of science		"people who firmly believe in science" (ID 22)

Table 8 Control beliefs for using Evidence-Based Medicine and Alternative Medicine: categories, subcategories, and anchor quotes ($n=40$)

Category	Subcategory	Anchor quotes for EBM	Anchor quotes for AM
Science-based treatment	Application of scientific methods	"competent medical advice based on science or studies with appropriate research available" (ID 30), "studies" (ID 10), "research" (ID 10)	"studies" (ID 35,40), "no research" (ID 3), "studies that demonstrate efficacy" (ID 25), "already proven treatments that had positive effects" (ID 5)
	Proven effect	"clear study situation, which proves effect" (ID 16), "no clear study situation" (ID 18)	"scientific proofs" (ID 8), "scientific controversy" (ID 15)
Effectiveness of treatment	Effective treatment	"good healing chances" (ID 6), "successful treatment in others" (ID 15), "seeing success with others" (ID 23)	"when I notice success when using them" (ID 23), "positive effects" (ID 25), "effect becomes noticeable" (ID 31)
	Placebo effect		"often only placebo → not reliable, psychological component too serious" (ID 29)
Type of disease	Serious disease	"severe diseases" (ID 31)	"the severity + seriousness of the disease" (ID 24)
	Diseases	"depending on the disease" (ID 34)	
Accessibility	Economic accessibility	"health insurance" (ID 10), "financial support" (ID 12), "too expensive drugs" (ID 25), "inflation" (ID 9)	"health insurance pays" (ID 26), "costs" (ID 8)
	Personal accessibility	"good consultation with the doctor" (ID 6), "consultation by doctor" (ID 18), "distrust of treatment method" (ID 25)	
	Structural accessibility	"often long waiting times at doctors" (ID 32), "fast inaccurate treatment" (ID 30), "quickly(er) get appointments with doctors" (ID 33)	"no prescription necessary" (ID 24)
	Informational accessibility	"no sufficient information" (ID 5), "negative headlines" (ID 15), "negative press" (ID 19)	"info about different healing possibilities" (ID 7), "poor information" (ID 19), "information material" (ID 10), "professional magazines/websites" (ID 4), "more transparency" (ID 33)

Table 8 (continued)

Category	Subcategory	Anchor quotes for EBM	Anchor quotes for AM
Safety	Risk	"too much risk (risky surgery)" (ID 6), "expected severe side effects" (ID 25)	
	Side effects		"otherwise I have to expect great suffering/death" (ID 34), "negative experiences/results that did not have desired effects" (ID 5)
	Uncertainty		"lack of certainty due to little research" (ID 32)
Social environment			"positive experiences from my social environment" (ID 6), "acquaintances have had bad experiences" (ID 6)
Culture			"with own culture connected possibilities of alternative medicine" (ID 28)

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Declarations

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