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Exploring Decision-Making Competence in Sugar-Substitute Choices: A Cross-Disciplinary Investigation among Chemistry and Sports and Health Students

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Abstract: Interdisciplinary teaching approaches have gained significant importance in today's educational landscape. Among these approaches, decision-making competence plays a pivotal role by nurturing critical thinking and problem-solving skills. Focusing on the decision-making process regarding the sensibility of using sugar-substitutes, this study addresses three key questions. (1) Do chemistry and sports and health students differ in evaluation-competence? (2) What criteria do they use in evaluating the decision-making problem? (3) How do they use ChatGPT (OpenAI, San Francisco, CA, USA), an AI tool, in decision-making? Through surveys, the study revealed two evaluation-competence factors, identified decision-making criteria, and analyzed querying behavior using ChatGPT. The results revealed nuanced differences between the two student groups in the factors of evaluation-competence. While both groups showed improvements in recognizing moral dimensions and considering alternatives, chemistry students displayed enhanced abilities in establishing evaluation criteria and empathetic thinking. Furthermore, differences emerged in the criteria selected for decision-making and querying behavior, indicating varying engagement with ChatGPT. This study offers insights into enhancing interdisciplinary education and underscores the need for tailored interventions to address diverse student needs.

Keywords: interdisciplinary education; evaluation-competence; cross-curricular competencies; sugar-substitutes; ChatGPT interaction; sports; chemistry; health; teaching; artificial intelligence

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1. Introduction

The need for interdisciplinary teaching approaches has become increasingly evident in today's rapidly evolving educational landscape. Educators recognize that a single disciplinary framework is often insufficient to address complex and multi-factorial real-world problems [1,2]. As a result, there is a growing emphasis on integrating multiple academic disciplines to provide students with a more comprehensive and holistic understanding of the issues they will face in their personal and professional lives [3]. Interdisciplinary teaching empowers students to become active learners and problem solvers who can navigate complex challenges in an interconnected world and recognize the complexities and interdependencies of different subject areas [4]. This encourages students to think critically, analyze complex information from different perspectives, and develop creative solutions and valuable skills, such as communication, teamwork, and adaptability, that are essential for success in the 21st century [5,6].

It is crucial for prospective teachers to understand the importance of interdisciplinary teaching in preparing students for the challenges they will encounter in and out of the classroom [7–9]. As future educators, teachers must be well-versed in interdisciplinary teaching methods to effectively engage students and help them make meaningful connections across different subjects [10]. By incorporating interdisciplinary teaching strategies, teachers can create a rich learning environment that encourages collaboration, creativity, and innovation [11,12].

Evaluation and decision-making play a central role in interdisciplinary learning. Research has demonstrated that interdisciplinary instruction not only enhances students' critical thinking and problem-solving skills but also fosters a deeper understanding of complex concepts by providing multiple perspectives and approaches to learning [13]. Decision-making skills in the context of interdisciplinary issues require the ability to make justified and systematic decisions about different options for dealing with complex and flexible problem situations in order to be able to participate competently in interdisciplinary discourse in society [14]. Especially in our complex, digitalized world, the ability to adaptively learn new knowledge and critically evaluate it in interdisciplinary contexts is becoming increasingly important [15].

Furthermore, in an era characterized by an unprecedented abundance of information alongside the pervasive presence of misinformation and "fake news" [16], the capacity to critically evaluate information emerges as being increasingly indispensable for educational achievement and personal growth [17,18]. Within this milieu, decision-making competence assumes a paramount role in nurturing critical thinking and problem-solving abilities. It empowers students not merely to acquire information, but also to interrogate its credibility, relevance, and accuracy, to delve into complex issues, to consider diverse perspectives, and to derive autonomous conclusions [19–22]. Students equipped with the ability to scrutinize information critically are endowed with the capacity to make well-informed decisions and to engage actively and responsibly within society [23,24]. Therefore, imparting decision-making competence should be a central component of the school curriculum. Teachers should be encouraged to promote decision-making competence through interactive and discussion-based learning methods that stimulate students to question and reflect actively.

In the context of teaching decision-making in schools [25], particularly in subjects like chemistry, sports, or health, which are inherently interdisciplinary, interdisciplinary approaches can be particularly beneficial [3,26]. Incorporating these strategies encourages students to explore the interconnectedness of scientific concepts and apply knowledge to real-world scenarios, fostering critical thinking and informed decision-making [27,28]. Assessment literacy aids students in analyzing and evaluating information for solving interdisciplinary problems, empowering them to manage complexity and make better-informed decisions [29].

The ever-evolving professional landscape, marked by rapid digitalization and a growing emphasis on interdisciplinarity, necessitates a transformative approach to preparing students for future challenges [10,30,31]. This transformative educational approach is exemplified in the present study by the convergence of (a) chemistry and (b) sports and health students within an innovative, interdisciplinary framework. With this framework, we aim to unravel the complexities of decision-making processes among chemistry and sports and health students, focusing on their *evaluation-competence* in the context of sugar-substitutes. Evaluation-competence refers to the ability to critically assess, analyze, and make informed judgments or decisions based on evidence, criteria, and relevant context [14,32,33]. In the context of education, particularly in interdisciplinary fields like chemistry, sports, or health, evaluation-competence involves understanding and applying principles from multiple disciplines to evaluate the effectiveness, safety, ethical implications, and other relevant factors of substances or practices. It entails not only technical knowledge but also the capacity to weigh different perspectives, consider diverse stakeholders, and communicate findings effectively. This competence is crucial for navigating complex decision-making processes and addressing real-world challenges in various domains.

The topic was selected due to the pivotal role of sugar metabolism in sports and health sciences [34–37]. Moreover, the relevance of sugar and its substitutes is profound in both educational contexts, from secondary school to higher education levels, making it a pertinent area of investigation in chemistry education [38,39].

This explorative study examines whether chemistry and sports and health students differ in terms of the impact on the dimensions of decision-making competence of a treatment targeting the decision-making problem related to the sensibility of sugar-substitute use (RQ 1). Additionally, we delve into identifying the specific criteria utilized by these students in their decision-making process and determine whether there is a difference between the groups (RQ 2). This aspect of the research is crucial for understanding whether the criteria considered relevant vary significantly between the two groups, thereby offering insights into the diverse perspectives shaped by their respective academic disciplines.

As the world becomes increasingly connected through technology, the fusion of chemistry and sports and health education can benefit from innovative digital tools and AI-driven solutions [40–42]. The integration of AI, particularly in the form of chatbots like ChatGPT (OpenAI, San Francisco, CA, USA), can revolutionize the learning experience [43]. ChatGPT can be integrated to provide students with personalized learning experiences [44]. Based on the concept of the "more knowledgeable other" (MKO) from Vygotsky's sociocultural theory [45], this takes learners from the zone of the current to the zone of proximal development, where tasks cannot be accomplished alone but with the help of an expert [46]. MKOs do not have to take the form of a person but can also be aids, such as books, instructional videos, the Internet, or, as in our case, ChatGPT [47,48]. By leveraging natural language processing and contextual comprehension, ChatGPT facilitates engaging dialogs, offers informative responses, and delivers supplementary materials customized to the unique learning requirements of each student [49–52]. According to [47], ChatGPT can assist university students in the development of problem-solving skills and critical thinking. This integration enriches the educational experience, fostering a collaborative and interactive milieu where students can explore the convergence of chemistry and sports and health with real-time, AI-driven support. Students can cultivate a deeper grasp of the interconnectedness inherent in scientific disciplines while refining their decision-making competence [53–55] in a digitally immersive environment. This can not only bridge the gap between chemistry and sports and health but also embrace technology to enhance learning and engagement.

Investigating how students from different disciplines interact with and utilize this AI tool and if they differ will provide a deeper understanding of their engagement with technological solutions in problem-solving scenarios. Therefore, we will explore the potential benefits and challenges of integrating the artificial intelligence tool ChatGPT in interdisciplinary teaching, assessing whether there is a difference in the querying behavior of chemistry and sports and health students when using ChatGPT for solving decision-making problems (RQ 3).

2. Materials and Methods

This study employs a mixed-methods approach, combining qualitative analysis to evaluate the prompts utilized within ChatGPT and the criteria for the evaluation of the decision-making problem with quantitative surveys to assess decision-making competence among chemistry and sports and health students. The overall study workflow is illustrated in Figure 1 to provide a comprehensive overview. The subsequent sections will describe each phase in more detail. The test was performed with chemistry and sports and health students at different points in time. At the study's outset, a pre-test was conducted to gather demographic data, assess prior knowledge, and evaluate participants' competency in assessing information. Subsequently, the participants were provided with a thematic introduction to the issue that many ingredient lists lack detailed information about contained sugars (including sugar-substitutes), despite their diverse impacts on blood-sugar levels.

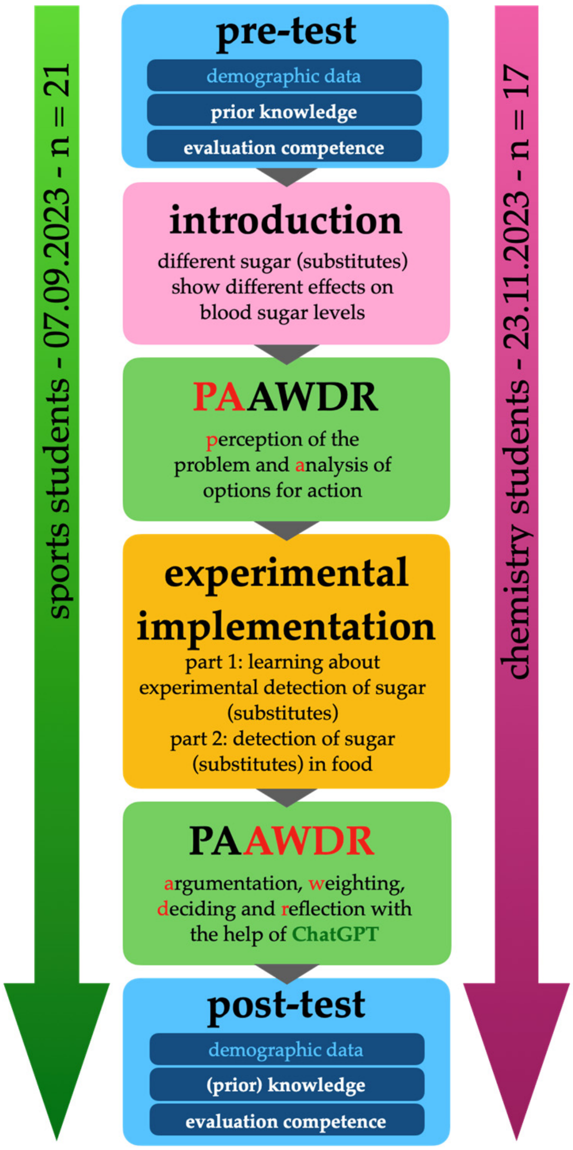

Figure 1. Workflow chart of the study.

Building on this problem, the first two steps of the PAAWDR model (see Figure 1 and Section 2.3 for the details) were addressed using a worksheet. To address the research question in a scientifically rigorous manner, an experimental approach was adopted, characterized by two stages: (1) first, familiarization with various methods for detecting sugars (and substitutes) followed by (2) the examination of food items. Following the experimental exploration of the problem domain, the final four stages of the PAAWDR model were completed with the assistance of ChatGPT (OpenAI, San Francisco, CA, USA). Subsequently, a post-test was administered to assess participants' subject knowledge and evaluate their competency in assessment, subject-matter expertise, and reflective thinking skills.

2.1. Subjects

Participants were recruited from regular classes within the sports and chemistry departments, directly inviting them to participate voluntarily. Furthermore, a mass email was distributed to the departments to encourage participation. The exclusion criterion was no full participation in all partial surveys.

The initial study involved students in sports and health sciences (21 students; age: 20–35 years; 15 males, 6 females, 0 diverse; number of semesters: 1–8 majoring in Sports Education (B.Ed. and M.Ed.), Sports Science and Health (B.Sc.), and Health (B.Ed. and

M.Ed.)). These three academic programs were grouped together as sports and health students for the present study due to a high degree of curriculum overlap, indicating similar basic knowledge and skills for the participants. Subsequently, a survey was conducted with chemistry students (17 students; age: 20–24 years; 7 males, 10 females, 0 diverse; number of semesters: 2–7 majoring in Chemistry (B.Ed. and M.Ed.)). The time gap between the two measurements was approximately 3 months, with careful attention to maintaining identical conditions on measurement days (same test administrators, same time, same day of the week, and identical room setups). All participants were thoroughly informed in advance and provided written informed consent for participation.

2.2. Description of the Experimental Setup

The experimental setup consisted of two parts: (1) testing five sugar solutions (glucose, fructose, saccharose, aspartame, and xylitol) on their components and (2) testing groceries for the sugar they contain. For testing which sugar was contained in the solution, established methods were used.

The tests for each sugar (substitution) were performed as follows:

- Glucose: GOD test [56,57] and Fehling sample [58];
- Fructose: Fehling sample [58] and Seliwanoff sample [59];
- Saccharose: Seliwanoff sample [59];
- Aspartame: Ninhydrin reagent [60];
- Xylitol: none of the abovementioned was positive.

2.3. PAAWDR Model

A decision was made to align with the PAAWDR model [61] to promote students' evaluative skills in an interdisciplinary context. This methodical approach aims to facilitate a shift in perspective for students by guiding them from their typically monoperspective view to a multiperspective examination of the controversial problem through the application of various criteria.

The PAAWDR model serves as a structuring aid for assessment processes, guiding students through the conscious navigation of individual steps in an assessment process and concluding with reflection. The model was used as a theoretical basis to structure the assessment process for the selected context. A worksheet was developed to make this process transparent for the students. In this worksheet, students are presented with a nutrition-related problem statement. Within an experimental setting and the integration of ChatGPT (see below), students autonomously navigate through the phases of the PAAWDR model to solve the problem statement.

Figure 2 visualizes the model, and the following phases can be delineated:

- Perception: Position yourself and make informed decisions (possibly indifferent). This step was performed before the first experiments to detect various sugars and sugar-substitutes;
- Analysis: Record potential courses of action or compromises and the information you need for assessment. What supports or opposes the decision? This step was performed before the experiments with the sugars to detect sugars and sugar-substitutes, included in various foods;
- Argumentation: Utilize ChatGPT to identify relevant evaluation criteria for the decision conflict. Compile arguments for and against the use of substitute materials. Evaluate these in terms of their factual statements, technical accuracy, and reliability. This step was performed after the chemical experiments to argue about the results and get further information about the underlying biological and chemical dynamics;
- Weighting: Weigh at least five criteria according to their relevance using (++ for high, + for moderate, − for low, − − for negligible) to get a comprehensive idea about factors to be considered for evaluation;

- Deciding: Make a reasoned decision based on your weighting (e.g., "The arguments... are in conflict. I consider... the most crucial argument, therefore..."). This process followed the weighting to evaluate the most crucial factors leading to a based decision;
- Reflection: Compare your initial positioning with the final decision. Are you satisfied with the decision-making process? (e.g., "I can better justify my own decision because...", "I can understand other positions better because...", and "My position has shifted towards..."). As the last step, the students had to reflect on their own actions and decisions.

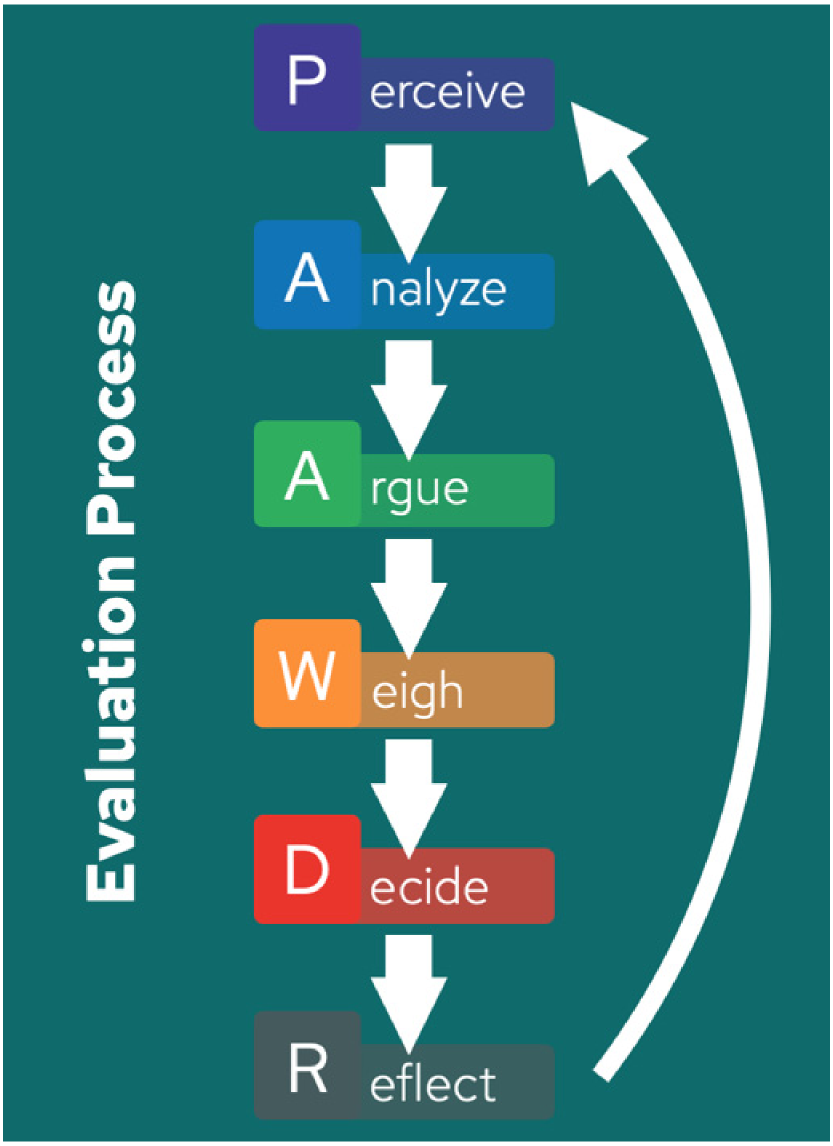

Figure 2. Stages of the PAAWDR model.

2.4. Application of ChatGPT

The students were allowed to use ChatGPT (version 3.5) on the tablets provided (Apple iPad 10th Generation, Apple Inc., Cupertino, CA, USA) during the working phase after experimenting to fill in any knowledge gaps. Specifically, the first two aspects of the PAAWDR model (perceive and analyze) were addressed using the students' existing knowledge without the assistance of ChatGPT. However, for the aspects of analyzing, weighing, deciding, and reflecting, the students were allowed to utilize input from ChatGPT. The chat protocols were manually copied into text files by the experimenters upon the return of the tablets for later analysis.

2.5. Measurement Evaluation-Competence

A questionnaire was developed to gauge the decision-making competence. The individual survey items are detailed in Table 1, featuring both the original German version and its corresponding English translation. Participants were provided with the questionnaire in paper–pencil format. Prior to analysis, the clarity of these items underwent rigorous scrutiny through repeated administration in student surveys, ensuring their comprehensibility. A six-point Likert scale, ranging from strongly disagree to strongly agree, was chosen for the questionnaire responses.

Table 1. Assignments of variables mapping evaluation-competence to factors sorted by descending-factor loading. Loadings below 0.4 are hidden for better clarity.

Label	Text	Factor 1	Factor 2
FA1.1	Once I have identified a course of action to solve a problem, I still consider whether there are other options. German: Wenn ich eine Handlungsmöglichkeit zur Lösung eines Problems identifiziert habe, überlege ich trotzdem weiter, ob es noch andere Optionen gibt.	0.90	
FA1.2	I am capable of deriving multiple courses of action for a given problem. German: Ich bin dazu in der Lage, bei einem Problem mehrere Handlungsmöglichkeiten abzuleiten.	0.80	
FA1.3	I can recognize moral issues and articulate them concretely. German: Ich kann moralische Probleme erkennen und sie konkret benennen.	0.70	
FA2.1	It is easy for me to establish criteria for evaluating from multiple perspectives. German: Mir fällt es leicht, mehrperspektivische Bewertungskriterien festzulegen.		0.84
FA2.2	I can empathize well with other people and their perspectives on various courses of action. German: Ich kann mich sehr gut in andere Menschen und deren Sicht auf verschiedene Handlungsmöglichkeiten hineinversetzen.		0.81
FA2.3	I find it easy to weigh and prioritize different arguments against each other. German: Mir fällt es leicht, verschiedene Argumente gegeneinander abzuwägen und zu gewichten.		0.76
	I weigh various courses of action against each other based on different criteria. German: Ich wäge verschiedene Handlungsmöglichkeiten auf Grundlage verschiedener Kriterien gegeneinander ab.	excluded	
	In my decisions, I always consider the implications for the future. German: Bei meinen Entscheidungen denke ich immer an die Auswirkungen in der Zukunft.	excluded	

The structure of the decision-making competence instrument underwent thorough examination via exploratory factor analysis. This analysis is pivotal, identifying underlying factors influencing decision-making competence and validating the questionnaire's structure. A principal component analysis with Varimax rotation was employed in this evaluation. Eigenvalues surpassing 1.0, scree plots, and content validation collectively guided the determination of a suitable factor solution. Items were systematically excluded in cases of ambiguous loading or the involvement in multiple factors by following expert assessments and a subsequent iteration of the factor analysis.

After the identification of each factor, the item values were aggregated using the sum, taking into account the loading direction, to derive a comprehensive factor value for subsequent calculations.

2.6. Further Calculations and Statistics

The inductive category formation for both the selected decision-making criteria and the querying behavior using ChatGPT was conducted by an external expert not affiliated with the study. Two additional experts, who were also not involved in the data collection, verified the categories. Any discrepancies in identified solutions were resolved through expert discussion, leading to a mutually agreed-upon resolution.

A mixed ANOVA was used to assess the potential differences between the chemistry and the sports and health students (treating the type of course as the between-subject factor of the course of study) across the measuring points in time (considered as the within-subject factor of time) for the factors found mapping the evaluation-competence (RQ 1). This analytical approach was selected, as it accounts for both the variation within individuals over time (within-subject variability) and the differences between individuals (between-subject variability). By considering both types of variability simultaneously, mixed ANOVA offers greater statistical power and efficiency compared to separate analyses of within-subject and between-subject factors [62]. In case of the violation of the sphericity requirement, a Greenhouse–Geisser correction of the degrees of freedom was carried out. Further assumptions (homogeneity of variance, normality of residuals, and no outliers) were checked and could be assumed.

For the statistical comparison of the categories mentioned for both the analysis of the criteria of the decision-making problem (RQ 2) as well as the ChatGPT querying behavior (RQ 3) between the chemistry and sports and health students, Fisher's exact test was used, as the sample-size requirements were not met for the Chi-square test. Fisher's exact test is a statistical method used for small sample sizes to assess the significance of associations between categorical variables in contingency tables. It calculates the probability of observed frequency arrangements, comparing them to the null hypothesis of independence [63]. In accordance with the exploratory orientation, following Armstrong (2014) [64], no correction of the error rate in the multiple comparisons was made for the post hoc tests.

Calculations were performed using SPSS (IBM, version 29, SPSS Inc., Chicago, IL, USA) and the Python library SciPy [65].

3. Results

3.1. Impact on Evaluation-Competence Factors

Both the Bartlett test (chi-square (15) = 66.89, $p < 0.001$) and the Kaiser–Meyer–Olkin measure of sampling adequacy (KMO = 0.63) indicate that the variables are suitable for factor analysis. Eigenvalues greater than 1.0, scree plots, and content validation suggest a two-factor solution, explaining 68.83% of the variance. Table 1 depicts the allocation of variables to the factors. Factor 1 is labeled as "Cognitive Versatility and Value Recognition", and factor 2 as "Empathetic Thinking and Consideration Competence".

Figure 3 visualizes the effects of time and course of study on the two identified factors. For factor 1, no interaction effect was observed between the time and course of study ($F(1, 36) = 0.01$, $p = 0.93$). However, according to Cohen (1988) [66], a strong main effect for the within-subject factor of time was detected ($F(1, 36) = 0.25$, $p < 0.004$, partial $\eta^2 = 0.20$, $f = 0.50$). Notably, there was a significant improvement in factor 1 evaluation-competence between the pre-test and post-test stages ($p < 0.004$; MDiff = 1.03, 95%-CI [0.34, 1.7]).

For factor 2, there is, according to Cohen (1988) [66], a strong significant interaction effect of time and course of study ($F(1, 36) = 12.46$, $p = 0.001$, partial $\eta^2 = 0.26$, $f = 0.59$). Chemistry students showed an improvement in factor 2 evaluation-competence after the treatment ($p = 0.02$; MDiff = 0.94, 95%-CI [0.18, 1.70]), whereas sports and health students showed a slide reduction in factor 2 evaluation-competence after the treatment ($p = 0.04$; MDiff = −0.57, 95%-CI [−0.04, −1.10]).

3.2. Criteria for the Decision-Making Problem

Table 2 shows the selected criteria, inclusive of the expert-based mapping of the criteria to thematic clusters (nutrition and health, taste and preferences, costs and economics, and food processing and safety). In Figure 4, separate differences between the frequency of occurrence of each category for chemistry and sports and health are presented. Significant differences in the frequency of the selected criteria for the assessment of the decision-making problem between the student groups were only found for costs and economics ($p = 0.03$). Chemistry students more often selected cost and economic criteria compared to sports and health students.

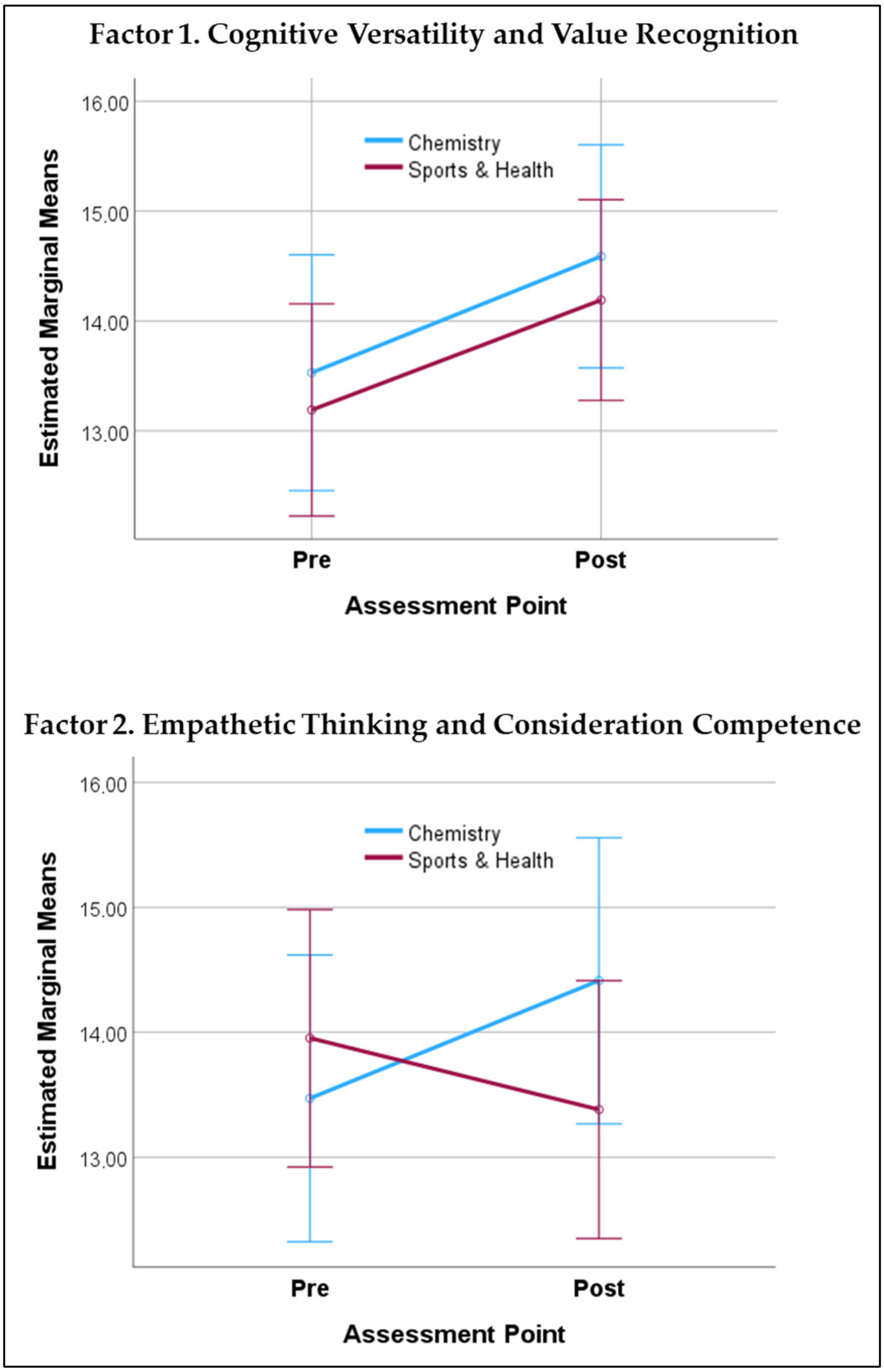

Figure 3. Effects of time of measurement and group on the two factors. Blue = chemistry, red = sports and health.

Table 2. Criteria for the evaluation of the decision-making problem inclusive of the expert-based mapping of the criteria to thematic clusters (column header).

Nutrition and Health		**Taste and Preferences**	**Costs and Economics**	**Food Processing and Safety**
Health, calorie reduction, diabetes management, suitable for dietary restrictions, digestive problems, risk of obesity, long-term effects, excessive consumption, nutrition, health concerns, side effects	Gut health, pregnant women, allergies, neurological effects, suitable for people with certain conditions, health goals and needs, blood-sugar control, tooth friendliness, blood-sugar levels, weight control	Taste, appetite stimulation, taste preferences, less sugar/sweetness habituation	Costs, economic impacts, market conditions, customer satisfaction	Processing, quality, safety, temperature stability, texture/consistency, consumer protection

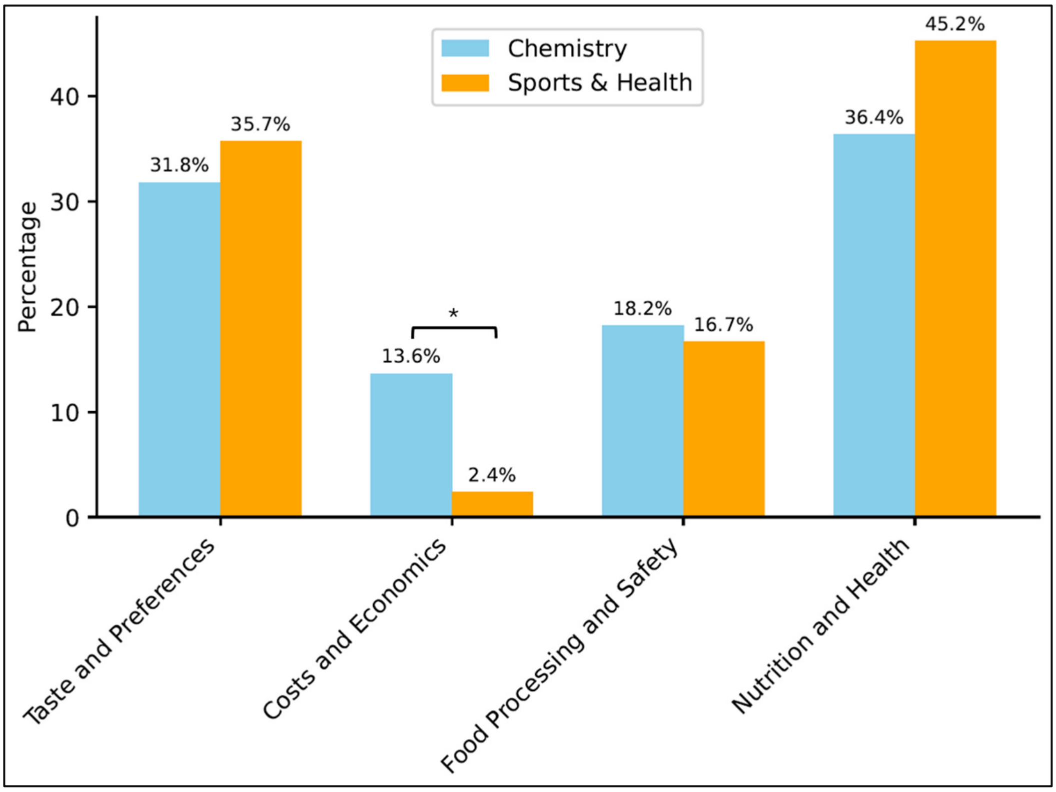

Figure 4. Percentage of occurrence of each category of the criteria for the evaluation of the decision-making problem separately for chemistry (blue bars) and sports and health students (orange bars). * $p < 0.05$.

3.3. Querying Behavior Using ChatGPT

The following categories for the querying behavior using ChatGPT were found.

- The *weighting query* is when ChatGPT was tasked with prioritizing criteria, advantages, and disadvantages based on their relevance.
- The *evaluation criteria inquiry* is when explicit inquiries were made to identify criteria for assessing the problem statement.
- *Studies and science* refers to explicit requests made for the substantiation of results through studies and scientific evidence.
- *Consumer perspective* is an analysis from the viewpoint of consumers or end-users, considering factors such as cost, applicability, and suitability for specific groups.

- *Continued work* is when the users did not settle for the output provided by ChatGPT alone. Instead, they continued to work on the output and posed follow-up questions based on the initial responses.
- *The pros and cons* were when specific queries were made regarding the advantages and disadvantages of sugar-substitutes and sugar.

Based on the occurrences of the categories identified for every subject, the querying behavior differences between the chemistry and sports and health students were analyzed and are presented in Figure 5. On a statistical basis, the student groups differ regarding the categories of *evaluation criteria inquiry* ($p = 0.01$) and *consumer perspective* ($p = 0.01$). Therefore, chemistry students more often asked ChatGPT to mention evaluation criteria and the consumer perspective than sports and health students.

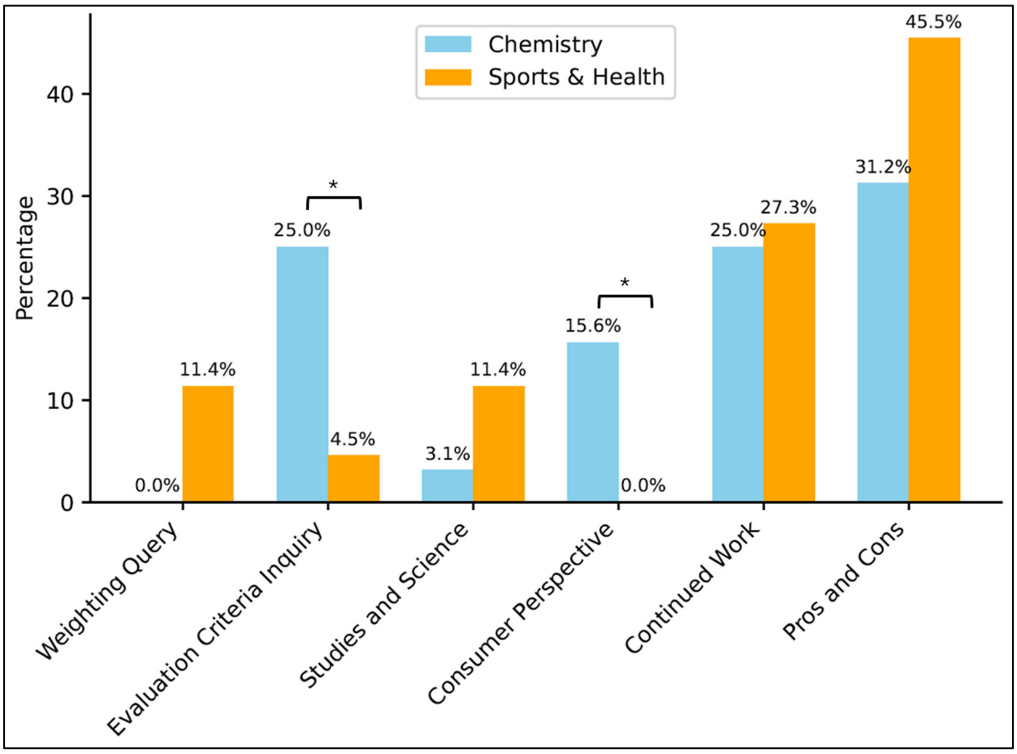

Figure 5. Percentage of occurrence of each category formed by the ChatGPT querying behavior separately for sports and health (orange bars) and chemistry students (blue bars). * $p < 0.05$.

4. Discussion

This investigation aimed to explore the differences in evaluation-competence among chemistry and sports and health students when confronted with a decision-making problem regarding the sensibility of using sugar-substitutes (RQ 1). Two distinct factors emerged, one of which is delineating the cognitive processes underlying evaluation-competence.

Factor 1, termed *cognitive versatility and value recognition*, encompasses a diverse array of skills. Individuals displaying this trait identify potential solutions and actively explore alternative options [67,68]. It describes a capacity for creative problem-solving and generating multiple courses of action. Additionally, it maps an awareness of moral considerations, articulating them clearly and recognizing the ethical dimensions inherent in decision-making. In essence, this factor underscores a comprehensive and adaptable approach to problem-solving, integrating critical thinking, creativity, and ethical considerations.

Factor 2, termed *empathetic thinking and consideration competence*, encompasses skills related to evaluating situations from varied perspectives [69]. Individuals with high factor values establish assessment criteria from diverse viewpoints and demonstrate strong empathetic abilities, enabling them to understand and connect with others' perspectives on different courses of action. Moreover, they show proficiency in weighing and prioritizing diverse arguments. This factor highlights a capacity for empathetic thinking, adeptness in considering various viewpoints, and the ability to make informed judgments by evaluating multiple arguments. This aspect provides a crucial foundation for interdisciplinary collaboration, as effective communication between disciplines transcends mere information exchange. Instead, it involves a reciprocal and nuanced understanding of each other's perspectives. Empathetic engagement with diverse disciplinary viewpoints entails immersing oneself in the emotions, interests, and viewpoints of others, thereby fostering deeper understanding and collaboration across disciplinary boundaries [70].

The emergence of these factors underscores the complexity of decision-making and the multifaceted nature of evaluation-competence [71]. This study revealed notable enhancements in subjective competency ratings for both chemistry and sports and health students for factor 1, which pertains to recognizing moral dimensions and considering alternatives [67,68]. However, in the case of factor 2, the treatment exhibited positive effects exclusively among chemistry students, manifesting as an improved subjective rating in establishing evaluation criteria, empathizing with others, and effectively weighing and prioritizing various arguments. The unexpected reduction in factor 2 among sports and health students may be attributed to the treatment's emphasis on problem complexity [72]. At this juncture, the education department effect, which describes students' thinking in accordance with the educational outcomes of their education departments has shown effects., e.g., on creative thinking [73], and could provide further explanation. Studies suggest that individuals with backgrounds in chemistry may possess analytical skills and problem-solving approaches that are advantageous for evaluating complex decision scenarios [74] and could navigate through the decision-making problem more adeptly, resulting in a positive outcome. Conversely, sports and health students may have felt overwhelmed by the intricate nature of the problem, possibly perceiving a deficiency in their chemical background knowledge. Consequently, the differences likely lead to lower values in factor 2 for the sports and health students, reflecting the varying problem-solving approaches and confidence levels.

The findings only revealed significant differences in the frequency of the selected criteria for assessment of the decision-making problem between the student groups for *costs and economics*, with chemistry students more often selecting cost and economic criteria compared to sports and health students (RQ 2). The small variances in the frequency of the selected criteria for assessing the decision-making problem across the student groups are relatively unexpected given the diverse backgrounds of the groups stemming from their respective courses, suggesting a potential range of perspectives on the decision problem. The use of ChatGPT in the intervention may explain this lack of divergence, as it introduces diverse viewpoints on the decision problem, potentially homogenizing the groups. This assertion finds support in the work of [75], who demonstrated that, in interdisciplinary learning environments, ChatGPT can serve as a valuable resource for bridging gaps in disciplinary knowledge. Hence, the employment of large language models (LLMs) emerges as a promising tool for mitigating these differences and fostering collaboration among students with diverse academic backgrounds in interdisciplinary settings.

Student groups differ in their querying behavior while using ChatGPT to solve decision-making problems regarding the categories of *evaluation criteria inquiry* and *consumer perspective* (RQ 3). Chemistry students more often asked ChatGPT to mention evaluation criteria and the consumer perspective than sports and health students. This could potentially be attributed to the fact that the sports and health students, in contrast to the chemistry students, had already learned about sugar in food and its effects on the body and health during their studies and were, therefore, able to draw on their wealth of knowledge, which also aligns with the education department effect [73].

In addition to the benefits of tools like ChatGPT outlined above, it is essential to highlight the challenges and risks, such as bias, misinformation, and reduced human interaction [76,77]. Concerns have also been raised regarding the potential adverse effects of readily available information on the ability to think critically and solve problems due to the model's facilitation of easy access to answers or information, which may exacerbate tendencies towards passivity and hinder learners' motivation to engage in independent inquiry and reach their own conclusions or solutions [47]. A significant challenge is that students could rely too heavily on this technology, which impairs critical thinking skills [44,78]. Despite the potential for these models to provide valuable assistance and personalized learning experiences, students must be careful not to over-rely on the system. Over-reliance on systems such as ChatGPT could lead to learners becoming passive consumers who simply accept the responses generated by the system without critically questioning or evaluating their accuracy or relevance [44]. This could lead to neglected critical-thinking skills, such as assessing the quality and reliability of sources, making informed judgments, and developing creative and original ideas. This makes the considered and responsible use of such AI-based tools all the more important [77]. This underscores the need for caution, particularly among chemistry students, who rely more on ChatGPT for finding evaluation criteria for the given decision-making process.

It has been shown that the erroneous answers and flawed explanations of ChatGPT in chemical subject matters may sometimes seem logically coherent and potentially persuasive, particularly to those who are less familiar with the subject matter [41]. Thereby, studies indicate that the accuracy of ChatGPT's responses to chemistry questions can vary widely and heavily depend on the specific prompts provided [79,80]. According to [81], aspects for the optimal use of ChatGPT to obtain high-quality results involve the following: providing clear prompts with context, refining iteratively, experimenting with parameters, using system prompts, correcting inaccuracies, exploring question structures, avoiding ambiguity, providing feedback, and being mindful of biases. By adhering to these principles, users can maximize ChatGPT's performance across various domains.

The results show that the students only partly followed these aspects. In the category of *continued work*, which is crucial for enhancing the quality of results using large language models (LLMs) as shown above, no significant differences were observed among the study courses. Only approximately 25% of the students engaged in continued work. The use of models in the academic setting is still relatively new, presenting extensive opportunities for improvement through competence building, as the full potential of LLMs has not yet been fully harnessed.

Overall, questions about supporting ChatGPT's statements with scientific results (the category *studies and science*) were rarely asked. Statistically, no clear distinction among the fields of study was observed, although the sports and health students were more descriptively inclined to seek a scientific foundation. This could be related to the fact that within the sports and health curriculum, more events are situated in both quantitative and qualitative research. In summary, it can be concluded that students seem to readily trust the AI's statements. This is in concordance with other studies that also report this finding [82,83]. Opportunities for instructional improvement lie in highlighting the fact that AI is fallible and carries risks, elucidating how such errors can be detected, and demonstrating strategies for their reduction.

Several limitations warrant consideration in interpreting the findings of this study. First, it is essential to acknowledge that evaluation-competence was assessed through self-rating rather than external assessment. Consequently, the subjective nature of self-rating introduces the possibility of bias, potentially skewing the assessment of participants' actual competence levels. This limitation aligns with findings from other research that emphasize discrepancies between self-rated competence and objective measures [84,85]. Second, this study represents exploratory work focusing on understanding the differences in evaluation-competence between chemistry and sports and health students. It is important to note the relatively small sample size, which calls for a cautious interpretation of the findings. Hence, the results should be approached with an acknowledgment of their preliminary nature.

While this research provides valuable insights into the nuanced differences between chemistry and sports and health students' approaches to decision-making processes, there are ample opportunities for further development beyond the presented conditions. A central limitation within the study is the lack of focus on the individual processes of the PAAWDR model. The largest gap can be seen in the structuring and building of arguments within the evaluation process. For this reason, the argumentation strategies of students must be better promoted in follow-up studies, and intelligent AI tools must be used. The first successful approaches already exist for this [86], which could be integrated into interventions in order to improve the results and reach new findings. It is important to acknowledge that the results should be seen as a starting point for further exploration and refinement. Future research endeavors should aim to delve deeper into understanding the mechanisms underlying evaluation-competence, potentially through external assessments rather than relying solely on self-ratings. Additionally, replicating these findings with larger and more diverse samples could enhance the generalizability and robustness of the conclusions drawn. Furthermore, conducting comparative analyses without the intervention of ChatGPT could provide valuable insights into the specific effects of its application on decision-making processes and evaluation-competence.

5. Conclusions

Expanding on the current results, it is evident that the differences in decision-making processes between chemistry and sports and health students have significant implications for interdisciplinary education. Understanding these differences is crucial for creating more effective educational strategies that cater to the diverse needs of student populations. Moreover, the integration of deep-learning techniques in analyzing students' written arguments offers a promising avenue for uncovering hidden patterns and improving the decision-making process [87]. Furthermore, the findings indicate that integrating theory-driven human interpretation with data-driven deep-learning techniques can provide a more comprehensive and accurate evaluation of students' argumentation skills in chemistry education. By combining the insights from the application of LLMs in chemistry, sports, and health with research on argumentation skills, this study highlights the potential for interdisciplinary learning to promote problem-solving, critical thinking, and decision-making competencies.

This research not only advances our understanding of decision-making processes among different student groups but also provides valuable insights into how decision-making competence can be improved in interdisciplinary learning environments. By identifying the factors that influence decision-making competence, the study lays the foundation for developing targeted interventions that can enhance the learning experience for students from varied disciplines, for example in the context of sustainability. In terms of enhancing interdisciplinary education, this research contributes to the enhancement of educational strategies by emphasizing the need for tailored interventions. The study highlights the importance of adapting educational approaches to address the specific differences between student populations in interdisciplinary learning settings. Educators and institutions can use the findings of this research to design more inclusive and effective educational practices that leverage students' strengths and cater to their diverse decision-making processes. Furthermore, the use of ChatGPT as an intervention tool sheds light on the potential effects of technology in shaping decision-making processes. Exploring the specific impacts of ChatGPT on students' decision-making could have broader implications for integrating technology into interdisciplinary education.

Moving forward, the practical applications of these findings can influence educational practices by promoting the development of tailored programs that consider the varying decision-making approaches of students across different disciplines. This research, therefore, provides the groundwork for the implementation of inclusive and effective interdisciplinary education practices that can benefit both students and educators. In summary, this research highlights the potential of interdisciplinary learning to promote problem-solving, critical thinking, and decision-making competencies, with a focus on argument analysis and evaluation skills in interdisciplinary topics.

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