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Argumentation and processing knowledge in open-ended assignment tasks: Challenges and accomplishments among pharmacy students

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Argumentation and processing knowledge in open-ended assignment tasks: Challenges and accomplishments among pharmacy students

Abstract

Students in higher education have been shown to have difficulties in developing their critical thinking skills, such as analysis and problem solving, reasoning and argumentation. Open-ended tasks offer opportunities for students to develop their own interpretations of various sources, to critically analyse domain-specific knowledge and utilize that knowledge in their argumentation. This study focuses on the ability of new Master's students (n=37) to utilize pharmaceutical knowledge from different sources in producing written arguments and counter-arguments in the context of open-ended assignment task. The data were analysed by qualitative content analysis. The results showed that there was substantial variation in how students analysed and processed pharmaceutical knowledge as well as how they utilized that knowledge in their argumentation. While some students were able to provide comprehensive analysis of the different sources, others superficially analysed and processed the sources and struggled to generate convincing arguments. Students' written responses were typically one-sided: only a few students provided counter-arguments associated with the pharmaceutical problem-solving situation presented in the task. Understanding the nature of the challenges in argumentation and knowledge processing encountered by pharmacy students can help pharmacy educators to modify their pedagogical practices to better support students' learning.

Practitioner Notes

1. University students even in Master program level may have challenges related to argumentation and processing knowledge
2. The challenges in argumentation and processing knowledge should be taken into account and should be enhanced and practiced from the beginning of the studies.
3. Critical thinking and argumentation should be integrated into the intended learning outcomes, learning and teaching activities, the contents of the courses, and assessment.

Keywords

critical thinking, argumentation, knowledge processing, analysis, reasoning, pharmacy, higher education

Introduction

Previous studies indicate that critical thinking is pivotal in order to learn field-specific skills and knowledge (Arum & Roksa, 2011; Hyytinen et al., 2019; Tuononen & Parpala, 2021), to aim at high-quality learning for understanding (Tuononen et al., 2019a), as well as to develop expertise in one's own field (Tuononen et al., 2017; Tuononen et al., 2019b). Critical thinking is a purposeful self-regulatory judgement about what to believe and what to do in a certain situation (Halpern, 2014; Hyytinen & Toom, 2019). It is a combination of complex cognitive skills such as problem solving, analysis and evaluation, and argumentation, but it also involves the disposition to use these skills. There is evidence that many higher education students have difficulties in critical thinking, more precisely in assessing the reliability and relevance of information, in recognizing biases and reaching a conclusion, and in generating convincing arguments (Arum & Roksa, 2011; Badcock et al., 2010; Evens et al., 2013; Hyytinen et al., 2015; Hyytinen et al., 2018; Nissinen et al., 2021).

Skills in producing arguments are an integral part of critical thinking (Kuhn, 2019). It is also related to reasoning and decision-making skills. Argumentation refers to the process of providing claims, challenging them, and backing them with reasons (Gambrill, 2019; Hyytinen et al., 2017). Pharmacy students should learn both domain-specific content knowledge as well as skills to use content knowledge during their studies. These skills are also essential later in working life as pharmacy professionals (Allen & Bond, 2001; Cisneros, 2009; Cone et al., 2016; Kidd & Latif, 2003; Miller, 2003; Miller, 2004; Nornoo et al., 2017; Phillips et al., 2004). One core skill for pharmacists is the ability to generate arguments and counter-arguments. Pharmacists need profound argumentation skills when working as pharmacy professionals in a multiprofessional health-care team and in patient counselling situations (Phillips et al., 2004). In the pharmaceutical industry, moreover, the increasingly interdisciplinary nature of pharmaceutical product development and manufacture has addressed the need to contribute not only to the domain-specific knowledge of pharmacy students, but to enhance the development of reasoning and decision-making skills during pharmacy education (LIAT-Ph Consortium, 2014). Despite the importance of skills in making arguments, this aspect has received little attention within research on pharmacy education.

This study approaches these concerns by presenting an open-ended task to assess pharmacy students' understanding of pharmaceutical knowledge and their ability to process that knowledge and use it in their written argumentation. Previous research has shown that the first year of study forms a crucial foundation for academic achievement in subsequent studies and in degree completion (e.g., Haarala-Muhonen et al., 2017). More precisely, critical thinking is found to be an important factor for academic achievement and adaptation to higher education (e.g. Allen & Bond, 2001; Arum & Roksa, 2011; Badcock et al., 2010; Miller, 2003; van der Zanden et al., 2019). In order to better understand students' various needs, to add to our pedagogical understanding, and to provide study programmes with tools to support students' transition to Master's studies, the present study sets out to explore the ability of 1st-year Master's students to utilize pharmaceutical knowledge from different sources in producing arguments and counter-arguments.

Critical thinking is essential in the field of pharmacy

Pharmacy students should develop an adequate knowledge base related to relevant natural science phenomena as well as the skills to evaluate and utilize pharmaceutical knowledge critically during their studies. They should also be able to evaluate the information critically, make reasoned decisions based on the available information, and communicate it in order to be able to perform successfully as pharmacy experts in working life. Nevertheless, a recent study among pharmacy students (Inacio et al., 2017) showed severe problems in pharmacy students' understanding of basic

knowledge, such as antibiotic resistance mechanisms. Furthermore, pharmacy students tend to adopt surface-level processing in learning (Nieminen, et al., 2004; Varunki et al., 2017), which means that they do not emphasize knowledge processing and construction much, and instead tend to have a fragmented knowledge about the subject matter. This, in turn, may lead to low-level learning and problems in knowledge application. This is problematic because students should become experts who are able to construct and process knowledge in order to be able to apply that knowledge effectively to actual problems in real-life situations (Boshuizen & Schmidt, 2008).

Pharmacy professionals need a repertoire of critical thinking skills that will enable them to acquire, evaluate and synthesize knowledge and use that knowledge in reasoning, argumentation, and in patient counselling (Miller, 2003; Oyler & Romanelli, 2014). Since much of professional practice is problem-solving, students need to develop analytical skills to make decisions in both familiar and unfamiliar circumstances. Critical thinking fosters a questioning attitude among professionals and is a prerequisite skill in making arguments and counter-arguments (Oyler & Romanelli, 2014). Argumentation is thus a necessary skill for a pharmacy graduate because pharmacists need to question claims and make professional and expert decisions. They also need to evaluate and analyse knowledge from several sources and utilize that knowledge when resolving patients' medication problems and assessing treatment outcomes (Abrami et al., 2008; Oderda et al., 2010; Persky, Medina & Castleberry, 2019). Earlier research has demonstrated that critical thinking skills are predictive of student performance in clerkships and pharmacy practice courses (Allen & Bond, 2001), and critical thinking is also positively related to students' study success (Miller, 2003; see also Arum & Roksa, 2011; Badcock et al., 2010; van der Zanden et al., 2019).

Previous studies on pharmacy students' critical thinking skills have been mostly quantitative. Additionally, self-report surveys or standardized multiple-choice tests have been the main approaches to assessing critical thinking (e.g., Allen & Bond, 2001; Cisneros, 2009; Cone et al., 2016; Miller, 2003; Austin et al., 2008). However, current research on critical thinking has questioned the validity of self-reports or multiple-choice tests (e.g. Hyytinen et al., 2015; Kleemola et al., 2021; Shavelson, 2010; Shavelson et al., 2019; Zlatkin-Troitschanskaia et al., 2015), because this complex phenomenon is extremely difficult to capture with these measurements. To take an example, self-reports are seen to be problematic in critical thinking assessment as students' perceptions of their critical thinking may differ from their actual performance (Bowman, 2010; Hyytinen & Toom, 2019). The challenge of multiple-choice tests is that guessing or eliminating incorrect options is always possible without a profound understanding of the actual topic. Multiple-choice tests do not provide information on the thought processes through which the students reach their answers, nor their ability to build arguments (Hyytinen et al., 2015; Kleemola et al., 2021). Nonetheless, general critical thinking tests require no discipline-specific knowledge, that is, they do not specifically assess students' ability to apply their critical thinking skills within pharmacy contexts (Miller, 2003; Oyler & Romanelli, 2014).

Argumentation and knowledge-processing

Argumentation is a central part of critical thinking (Halpern, 2014; Kuhn, 2019). In argumentation, higher education students need to have the ability to think critically about beliefs and claims (Gambrill, 2019; Hyytinen et al., 2019). Argumentation plays a central role in everyday decision-making and reasoning. Consideration of different possibilities require making arguments for and against various views in the light of reasons (Gambrill, 2019). Argumentation is also considered a core activity of science (Keinonen & Kärkkäinen, 2010).

An argument intends to convince others that a claim or statement is valid or it aims to refute counterstatement(s) (Gambrill, 2019; Toulmin, 1958; Walton, 1995). It consists of, at least, a claim and reason(s) that support or oppose this claim (Hyytinen et al., 2017; Keinonen & Kärkkäinen,

2010). An argument may also include warrants, either implied or stated explicitly, that link the reasons to the claim (Gambrill, 2019; Toulmin, 1958). To produce convincing arguments a student needs to be able to process (i.e., assess, evaluate, synthesize and interpret) relevant information that is associated with a situation, and apply that information to find reasons that support or oppose the perspective taken by the student (Hyytinen et al., 2017).

Arguments always arise in a certain context that reflects the norms, values, procedures and types of evidence that are considered acceptable in that context (Gambrill, 2019). Although an argument can be considered an individual activity through thinking, it is deeply connected to the social elements of the academic culture (Hyytinen et al., 2017; Keinonen & Kärkkäinen, 2010). It follows that argumentation involves domain-specific knowledge, including both content knowledge and procedural knowledge (i.e. knowing how to apply content knowledge; Hyytinen et al., 2019; Gambrill, 2019). It has been suggested that arguments fail if a claim or conclusion is not balanced between the reasons. Fallacies (i.e. incorrect arguments) refer to errors in reasoning, for example when a conclusion is stated, but the rationales given do not support that conclusion (Gambrill 2019; Walton, 1995). In unclear argumentation, substantial claims or reasons that support the conclusion are missing, thereby leaving the argument obscure or lacking in logic (Hyytinen et al., 2017).

Previous studies have shown that higher education students have several problems in producing arguments and utilizing evidence-based knowledge from different sources in their argumentation (Arum & Roksa, 2011; Badcock et al., 2010; Hyytinen et al., 2017; Hyytinen et al., 2018; Keinonen & Kärkkäinen, 2010; Kleemola et al., 2021). It has been shown that many students are able to use evidence to generate claims but fail to construct rationales for or against the claims (Hyytinen et al., 2017; Hyytinen et al., 2018). In addition, there is evidence that science students tend to use personal feelings rather than evidence-based scientific knowledge in their argumentation (Keinonen & Kärkkäinen, 2010). However, earlier research on argumentation has often focused on the ability of students to assess arguments rather than the students' ability to produce their own arguments (Rapanta, et al., 2013).

To draw more valid inferences about pharmacy students' ability to produce arguments and counter-arguments, it is necessary to use tasks that tap these skills and simulate authentic problem-solving situations (Ercikan & Oliveri, 2016; Hyytinen et al., 2019; Shavelson, 2010). Surprisingly, to our knowledge, qualitative research on pharmacy Master's students' knowledge-processing and argumentation skills plus the associations between them does not yet exist. As the first year forms a crucial foundation for study progress and adaptation to subsequent studies more knowledge is needed about argumentation and knowledge processing.

Aims of this study

The aim of this study is to explore 1st-year Master's level pharmacy students' ability to analyse and process source materials of a given pharmaceutical topic and use that knowledge to produce arguments and counter-arguments. We focus on what kind of problems, if any, can be found in argumentation.

More specifically, our research questions are:

1) How do students process and use the source materials given in an open-ended task?
2) What are the characteristics of students' argumentation?
3) What kind of arguments do students provide in their written responses?
4) How are the characteristics of argumentation associated with the processing of source materials

Materials and methods

Description of context: pharmacy education in Finland

First-year Master's-level pharmacy students were studied in a research-intensive university. In Finland, university-level pharmacy studies comprise a three-year degree programme for a Bachelor of Science in Pharmacy (180 credits), followed by a two-year degree programme for a Master of Science in Pharmacy (120 credits) (Hirvonen et al., 2019; Sivén et al., 2020). The learning outcomes of both these degrees consist of domain-specific and generic skills outcomes (see the listed outcomes in Authors 2017). The objectives of education leading to a Bachelor or Master of Science (in Pharmacy) degree are to produce experts in pharmaceutical work in all branches of healthcare and provide the knowledge and skills needed to maintain and improve their expertise. Directive 2005/36/EC outlines the knowledge to be acquired through the education leading to the Master of Science (in Pharmacy) degree.

At the University of Helsinki, a curriculum reform was implemented in the academic year 2017-2018. The learning outcomes and teaching practices for the Degree Programme in Pharmacy had been revised to include both subject-related learning outcomes, and generic skills that are recognized as an important and integral part of professional expertise (Katajavuori et al., 2017). The teaching and evaluation methods within the Bachelor's degree include lectures, group work and assignments, independent assignments, laboratory courses and calculation practices, essays, and multiple-choice question-based exams. In turn, the Master's-level teaching involves methods such as problem-based learning, project work in groups and written research plans and essays with the aim of deep understanding in learning and fostering critical thinking and analysis. The Faculty cooperates with the University Career Services to foster the students' working life skills. The students in this study are about to start their first-year Master's-level studies, where the focus shifts to a deeper understanding of pharmaceutical sciences.

Participants

The participants were 37 Master's-level pharmacy students (26 females and 11 males). The students' ages varied from 21 to 47, the mean age being 26 years. Although women were overrepresented in the sample, the distribution was representative of the university population in Finland. At the University of Helsinki, 66% of the Master's-level students are women (see more https://www.helsinki.fi/en/university/the-university-of-helsinki-in-brief/the-university-of-helsinki-in-numbers), the respective ratio being 72% in the Faculty of Pharmacy. The students had a homogeneous educational background: all had completed the Bachelor of Pharmacy and they were at the same phase of their studies, that is, in the beginning of their Master's studies (see above for a description of their previous studies). All participants had previous experience on working in a community or hospital pharmacy, some (n=8) had also worked elsewhere (the pharmaceutical industry, wholesales, university).

Data collection

The data were collected during the students' first study week as part of their orientation studies. The purpose was to collect data about incoming students' argumentation skills. All new Master's students were invited to participate in the study in 2018 and 2019, and 40% (n=20) of the cohort in 2018 and 31% (n=17) in 2019 volunteered. The students gave their written consent for participation, and they were informed that consenting or refraining from consenting would not affect their status or subsequent grades in any way. The task was approved as part of their compulsory portfolio work process, and the students who participated got a mark for their portfolio. The anonymity of the

participants was ensured in the research process. This study did not require a Finnish ethics review (cf. Finnish National Broad on Research Integrity, 2019).

Data were collected applying an open-ended task (the Figure 1) in which students were asked to read and analyse four pharmaceutical documents dealing with the problem in question (antibiotic resistance) and to write arguments and counter-arguments for and against this problem using information from the source materials. The task included instructions, reading materials about a pharmaceutical problem, and three open-ended questions for students to address in their written response. Students were instructed to use the reading materials provided in preparing their response to the questions. However, the task was open-ended, so it required students to develop their own interpretations and make choices about the use of sources. In the data collection situation, the students had 90 minutes to complete the task.

The open-ended task

Students were given four documents dealing with antibiotic resistance.

Document 1: An article in a professional journal
Document 2: An abstract of a systematic research article
Document 3: A review in a scientific journal
Document 4. A textbook chapter

Questions for students to evaluate based on these documents:

1. *"Antibiotic resistance needs to be systematically regulated"*

Are you for or against this claim? Evaluate the strengths and limitations of this claim based on the documents you read. Explain how you reached your conclusion.

2. *"Antibiotic resistance as a problem is exaggerated, the use of antibiotics is already successfully implemented"*

Are you for or against this claim? Evaluate the strengths and limitations of this claim based on the documents you read. Explain how you reached your conclusion.

3. *"What are good practices considering antibiotic resistance?"*

Present your own recommendations for good practices. Justify your answers on the basis of the content and reliability of the documents you read.

Figure 1

A summary of the open-ended task.

The task was built upon real documents, such as an article in a professional journal, a research abstract, a review in a scientific journal, and a textbook chapter. The task was designed so that the documents contained the necessary information to complete the task. The documents were chosen to be at a sufficient level of difficulty that a student who had completed Bachelor's-level studies had enough previous knowledge to manage the task. The task also included contradictory information, meaning that some was relevant, whereas some was irrelevant to the questions presented in the task.

Data processing and analysis

The data were analysed by qualitative content analysis combining data-driven and theory-driven approaches (Elo et al., 2014). It is important to note that each students' written response to the three

questions presented in the task were analysed as a whole. In the first phase, all the authors read through the students' written responses several times independently to get an idea of all the texts. After this, the authors negotiated together about the coding scheme. The second phase was coding. This phase was guided by previous research, as the coding of data involved (1) analysis and processing of source materials (Hyytinen et al., 2015; Hyytinen et al., 2018) and (2) argumentation (Gambrill, 2019; Walton, 1995). The coding related to the analysis and processing of source materials focused on how the students identified, interpreted, analysed, synthesized and evaluated the materials in their written response. The coding of argumentation concentrated on reasons and explanations how students supported or opposed an idea, claim or conclusion in their written responses. These different qualities were searched for and coded systematically within each response. During the analysis process, the responses were carefully compared to the source materials. The data were analysed first by all the authors independently, and after this the coding was checked, compared and negotiated until consensus was reached with all the authors.

In the third phase, the authors grouped codes into categories. The categories were then refined, labelled and cross-checked in relation to the entire data set. Altogether, three categories for analysis and processing of source materials were identified in the data (for a more detailed description of the categories, see the Results section). Coding related to argumentation was organized into five categories of arguments.

During the first three phases, we found that categories varied amongst the students. This allowed us to classify each student's written response into one of the three qualitatively different text groups. In this fourth phase of analysis, the groups were then further distinguished by analysing the differences and similarities between them, in such a way that each group included a particular combination of analysis and processing of source materials and argumentation that was sufficiently distinct from the other groups. This classification into groups was conducted first by the authors independently, and after this, a final categorization was negotiated together with all of the authors. During the last phase, we also generated a final description and interpretation. In the first three phases, the unit of analysis was the individual student's written response to the open-ended task, while in the fourth phase the text groups were the units of analysis. All the data extracts were translated from Finnish into English.

Results

Characteristics of the analysis and processing of source materials

We identified three categories of analysis and processing of source materials which we labelled *superficial*, *moderate* and *thorough processing*. Superficial processing refers to a situation in which students demonstrated minimal or no analysis in their responses. That is, students did not show any serious attempt to analyse, interpret, synthesize or evaluate the information from the source materials, and disregarded or misinterpreted information. In moderate processing students provided analysis that addressed a few ideas presented in the source materials, made minor misinterpretations, and made hardly any claims about the quality or reliability of the information. This suggested partial comprehension of the materials. Thorough processing refers to situations in which students identified the major ideas presented in the materials in their written responses. These students were able to provide a thorough and accurate analysis and they evaluated the relevance of information in a manner that demonstrated comprehension and understanding of the source materials. Some of them also comprehensively elaborated the reliability of the information presented.

Characteristics of the argumentation

Students' written arguments (i.e. how students provided the reasons and explanations to support or oppose claims or conclusions) varied. We identified five main categories of arguments from the students' responses. *Incorrect argument* referred to a situation in which students drew a claim, conclusion or recommendations, but the rationales or explanations given did not support this claim or conclusion. As an example, a student justified the conclusion by making overstated and hasty interpretations or generalizations. In *Unclear argument,* a student provided a claim, conclusion, or recommendation, but did not provide reasons, evidence or explanations to support it. Alternatively, a student provided a rationale, but did not clearly state what the rationale was for. Unclear argumentation also refers to a situation in which a student provided a rationale, but it was based entirely on the student's own opinion rather than a solid argument based on a careful analysis of the materials provided, thereby leaving the argument weak. *List of isolated facts* referred to a situation in which a student provided a claim or conclusion, but the rationale consisted of a list of disconnected facts, i.e. students offered disconnected or random facts, and connected these to each other without proper justification. *Convincing argument* meant that a student presented rationales and valid evidence that supported the conclusion, i.e. students were able to justify their conclusions or statements using reliable and valid evidence from the materials avoiding problematic, overstated and inaccurate interpretations based on the analysis of the materials provided. In *counter-argument*, a student presented valid counter-evidence for or against a particular conclusion, claim or statement using information from the sources.

The associations with argumentation and processing of source materials

The categories of analysis and processing of source materials and argumentation and the ways in which these categories were associated with each other differed among participants. Analysis further revealed that the responses differed how the relevance of the information to the given pharmaceutical problem was elaborated. Based on these differences, it was possible to divide each students' written response into one of these three text groups. These groups were *1) Hasty responses, 2) Uneven responses, and 3) Elaborated responses* (see Table 1). Next, we present these groups in more detail.

About a third (n=9) of the students' responses were classified in the *Hasty responses* group (Table 2). Students' responses in this group were not based on a thorough analysis of the documents. The responses were short in comparison to the other two groups. The student responses in this group provided minimal analyses of the documents. The students briefly addressed only one idea from one or two documents and repeated the information as it was given in the source documents. Students did not consider the relevance of the information to the problem, nor source reliability in their responses. Although students in this group might provide claims, conclusion or recommendations, they did not develop convincing arguments. Argumentation was typically unclear and/or incorrect, or they made overstated arguments. Common to all the responses in this group, they were one-sided in nature and based on isolated facts or ideas from the documents.

Table 1

A summary of variation identified in students' responses to the open-ended task (n=37).

Group	Relevance to the problem	Processing	Argumentation
1 Hasty responses (n=9)	Response is weakly based on documents. Relevance of the information to the problem is not considered.	Minimal or superficial processing and analysis, analysis is inaccurate, misinterprets information. Presents and repeats scattered information from the documents.	Making unclear or overstated arguments, e.g. the rationales are based on the students' own opinions, or a single isolated fact is presented as a rationale
2 Uneven responses (n=18)	Response is based on documents provided, relevance of the information is recognized. Reference is given.	Uneven in quality: suggesting partial comprehension of the documents. May repeat the information, may misinterpret the information. A response may be based on a single document. May attempt to address contradictory information.	Uneven argumentation: provides unclear or overstated arguments, presents isolated facts as rationales. May provide some valid arguments and counter-arguments.
3 Elaborated responses (n=10)	Response is based on relevant and reliable documents. Relevance of the documents is evaluated. Reference is given.	Combining and synthesising information from several documents. Demonstrates versatile and thorough processing and elaboration of information. Pros and cons are discussed. May refute contradictory evidence.	Presents convincing arguments. Reasons and rationales are based on a comprehensive analysis of the relevant sources. May present counter-arguments.

Table 2

An extract of a typical response of the hasty responses group

Data extract	Coded for
Claim/question: *"Antibiotic resistance needs to be systematically regulated"* A: "Intervening in a systematic manner is, however, difficult. It would have been done already if it was easy. To humankind it is unsustainable that the development of new antimicrobials is unprofitable and yet at the same time the negligent use of existing medicines is economically profitable." (Student 13, 2019)	Superficial processing of source material Response is weakly based on documents Overstated arguments are made Provides personal opinions rather than information from the documents No references given

Almost half (n=18) of the students' responses were classified in the *Uneven responses* group (see Table 3). In this group, most students based their arguments on only a few documents and ideas provided in the task (n=14) and excluded the rest. They did not provide a comprehensive analysis of all documents in their response. Some of them misinterpreted the information provided. Although students in this group recognized the relevance of the information to the pharmaceutical problem-solving situation presented in the task, they did not explicitly elaborate source reliability. Citations

were not always given either, although they were requested in the assignment. Students were able to provide clear statements about their opinions, but the argumentations varied. All five categories of argumentation were identified in students' responses: incorrect argument, unclear argumentation, list of isolated facts, convincing argument, and counter-argument. Some students in this group presented isolated facts as rationales (n=4) or provided unclear or overstated arguments in their responses (n=3). Some students (n=4) were able to present a counter-argument or refute contradictory evidence in their response.

Table 3

An extract of a typical response of the Uneven responses group

Data extract	Coded for
Q. *"Antibiotic resistance as a problem is exaggerated, the use of antibiotics is already successfully implemented"*	
A: "As a problem antibiotic resistance could well be excessive, as we already have a lot of means to influence the generation of resistances. As a problem antibiotic resistance is, however, severe as the more multiresistant bacteria are formed, the more difficult it is to treat the diseases. … On the basis of all the documents, antibiotic resistance will be a significant threat in the future. … The manufacture of antibiotics has slowed down and new antibiotics are harder to come by than previously. If new antibiotics were found all the time, humankind would not have this problem at all." (Student 14, 2019)	Uneven quality in processing the data Presents partial comprehension of the documents Relevance of the information is recognized Refers to the documents, but the source is not specified Provides opinions Unclear argumentation Presents isolated facts as rationales Provides some valid arguments

A quarter (n=10) of the students' responses belonged to the *Elaborated responses group* (Table 4). These students presented comprehensive and thorough analyses of all the relevant information based on the documents, and the relevance of the documents to the pharmaceutical problem was also evaluated. The majority of the students in this group clearly cited the sources of their information: only two of them did not cite the source materials in their response. Furthermore, students in this group presented convincing arguments. Half of the students in this group (n=5) presented counter-arguments or refuted contradictory information in their responses. Many students did not, however, comprehensively evaluate source reliability (n=6).

Table 4

An extract of a typical response of the Elaborated responses group

Data extract	Coded for
Q: *"Antibiotic resistance as a problem is exaggerated, the use of antibiotics is already successfully implemented"*	
A: "None of the given documents denies that antibiotic resistance would be a real threat or states that we should not interfere with the way things are. The differences in the documents apply to the suitable and necessary means to interfere in the problem. I would consider the most reliable source material the review article by authors Karman and Virta, which justify the measures with reliable-sounding reference materials. The authors present several references, and the source material consists of newly published scientific articles and research reports. …. Not a single document argues that antibiotic resistance is exaggerated as a problem, so I disagree with the statement given." (Student 15, 2019)	Demonstrates thorough processing and elaboration of information Combining and synthesizing information from several documents Response is based on relevant and reliable documents Relevance of the documents is evaluated Reference is given Presents mainly convincing arguments with evidence that supports the conclusion.

Discussion and conclusions

This study set out to explore how 1st -year Master's students process and use the source material in a given pharmaceutical open-ended task, what is characteristic to their argumentation and what kind of arguments they provide and finally, how the argumentation is associated with the processing of source material.

Firstly, the results of this study revealed that even though the 1st-year Master's students shared a homogeneous educational background there was substantial variation among the students how they analysed and processed the domain-specific knowledge and utilized that knowledge in generating written arguments. This is in line with the findings of earlier studies (cf. Arum & Roksa, 2011; Badcock et al., 2011; Evens et al., 2013; Nissinen et al., 2021). Secondly, we found that most of the students had difficulties in providing comprehensive analyses in their response, and this led to fragmented written responses. Some students repeated the information presented in the source materials or their responses were based solely on a single document. Some students also misinterpreted the information. These findings indicate that many students' knowledge processing and the use of source materials remained inadequate. Earlier studies have also shown that pharmacy students tend to adopt surface-level processing in learning (Nieminen et al., 2004; Varunki et al. 2017). At the same time, many students also had problems in developing convincing arguments concerning the pharmaceutical problem-solving situation presented in the task. Providing unclear or overstated arguments or presenting isolated facts as rationales were common problems.

The third aim was to explore how students' argumentation is associated with the use of source materials. Consistent with the literature (Hyytinen et al., 2017; Hyytinen et al., 2018), the results of

this study showed that the characteristics of argumentation were associated with the processing of the available source materials. Students who provided minimal or partial comprehension of the documents more often had trouble with argumentation when compared with students in the elaborated response text group. Interestingly, the results also demonstrated that the students' written responses were often one-sided, meaning that only a minority of the students provided counter-arguments in their responses. This was prevalent in all groups. Only a few students comprehensively evaluated the reliability of the given information. Additionally, the findings of the present study are in line with earlier studies, which have shown that even if students are able to use evidence to generate claims, they can fail to construct rationales for or against the claims (e.g., Hyytinen et al., 2017; Hyytinen et al., 2018).

This study has educational significance in identifying challenges related to argumentation and processing knowledge in open-ended assignment tasks encountered by 1st-year Master's pharmacy students. These challenges are important to take into account because they may have negative far-reaching consequences for studies and later for transition to the working life (cf. Arum & Roksa, 2011; Haarala-Muhonen et al., 2017; van der Zanden et al., 2019). Mastering critical thinking and argumentation enables students to apply their field-specific knowledge to a variety of situations both during their studies and later in the world of work (e.g., Hyytinen et al., 2019; Tuononen & Parpala, 2021; Tuononen et al., 2019b).

In order to ensure the development of critical thinking during university studies, knowledge processing and argumentation skills need to be practised. In addition, the acquisition of skills need to be supported in a variety of ways throughout pharmacy education (Arum & Roksa, 2011; Hyytinen et al., 2019; Oyler & Romanelli, 2014). Curricula need to be carefully and systematically designed to teach critical thinking and argumentation (Cone et al., 2016; Persky et al., 2019). These skills should be integrated into the intended learning outcomes, learning and teaching activities, the contents of the courses, and assessment (Hyytinen et al., 2019). It is also important to promote students' awareness of their skills, for instance, by engaging in different tasks or sharing with others (Tuononen et al., 2017; Tuononen et al., 2019b). Such reflections help students to understand their own skills and current abilities, and thus support their learning processes.

However, further research is needed on whether the development of pharmacy education and curriculum planning could improve critical thinking and argumentation skills in a meaningful way (Miller, 2003). In such evaluations, assessment tasks that focus on students' abilities in authentic problem-solving situations, mimicking a real-life situation, are needed (Ercikan & Oliveri, 2016; Hyytinen & Toom, 2019; Shavelson et al. 2018; Shavelson et al. 2019; Zlatkin-Troitschanskaia et al. 2015). The open-ended task presented here would serve as one assessment tool in such studies. This would provide more nuanced information on the development of critical thinking throughout the degree programme curricula and thus be valuable in fostering pharmacy students' learning.

Limitations of the study

The major limitation of this study was the small number of the participants, with the risk of bias in the data. Only 35% of the cohort took the open-ended task, which might indicate that only the most motivated students participated in the study. The task completion was solely based on students' voluntary activity. The task was approved as part of their compulsory portfolio work process with no grade being given. Therefore, the effort the student put into the task might have been different than if the task had been graded or compulsory. Further, time limitations, the student's personal situation and peer pressure might have accounted for the outcome of the task. Moreover, the results were based on an analysis of the students' written responses, and thus we do not know what the students were thinking about the task and why they made the choices they did. Understanding how students think and reason would, however, be important from the perspective of the learning process.

For these reasons, further studies on the current topic are needed. In order to investigate the development of critical thinking, there is a need for a longitudinal study in which the same pharmacy students are followed from the initial to the final stage of their study path.

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