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Analysis of activities included in Saudi Arabian chemistry textbooks for the inclusion of argumentation-driven inquiry skills

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ABSTRACT

This research aimed to determine the extent to which twelfth-grade chemistry textbooks and workbooks included argumentation-driven inquiry skills in their activities. For this purpose, all activities found in the twelfth grade chemistry textbooks and workbooks were analyzed using an analysis rubric. Results indicate that the inclusion of the argumentation-driven inquiry skills in the analyzed chemistry activities generally fell within argumentation-driven inquiry levels one and two. This type of inclusion favors teacher-centered learning and teaching rather than student-centered learning and teaching. Therefore, the authors recommend that these textbooks and workbooks be revised to ensure that the argumentation-driven inquiry skills that are included are directed toward student-centered learning and teaching as required by levels four and three.

1. Introduction

Argumentation and inquiry are closely linked, in that the skills and experiences necessary to both are nearly identical. To understand science meaningfully, students must be qualified in both argumentation and inquiry. Scientific argumentation is described as a process, which encompasses several skills, such as identifying evidence, mental ability to recognize counter-arguments and the ability to reasonably rebut them (Songsil et al., 2019), while scientific inquiry was described as the processes of discovery which encompass several abilities such as questioning, collecting evidences, explaining, communication (Bybee, 2000). On the one hand, argumentation will equip students with the ability to defend their data, claims, and ideas and immunize them against stray thoughts (Songsil et al., 2019) and provide students with the ability to use logic to solve socio-cognitive conflicts. On the other hand, inquiry will equip students with the ability to pose questions, plan and conduct experiments, control variables, and reach conclusions. Additionally, argumentation and inquiry enable learners to organize their thoughts, present their results, and support their procedures (Songsil et al., 2019).

Due to the ability of argumentation to strengthen scientific inquiry and literacy skills (Erduran et al., 2015; Wilson-Lopez et al., 2018) and promote the fluent use of scientific language in the classroom (McDonald, 2016), science education must employ scientific argumentation in science and chemistry teaching and learning. This association between argumentation and inquiry enables students to use scientific argumentation to achieve authentic knowledge of the nature of science (van Emeren et al., 2014; Ryu and Sandoval, 2012).

To improve the quality of scientific argumentation in science classes, student-teacher interactions should be assured in the science curricula and implemented during teaching. Probosari et al. (2016) suggested that teachers can develop scientific argumentation through the five levels of argumentation; "1) Level 1, argumentation which contrasts between two different claims, 2) Level 2, argument which contrasts between a claim from another claim which includes data, warrants or backings but rebuttals; 3) Level 3, argument which contrasts among a set of claims or counter-claims which include data, warrants, or backings with weak rebuttals; 4) Level 4, representing argument with clear claims and rebuttals, which include a number of claims and counter-claims; and 5) Level 5, representing argument with more than one rebuttal. ". (p. 2). A closer definition to our aim was provided by Eemeren et al. (1996), who said “Argumentation is a verbal and social activity of reason aimed at increasing (or decreasing) the acceptability of a controversial standpoint for the listener or reader, by putting forward a constellation of propositions intended to justify (or refute) the standpoint before a rational judge” (p. 5). In this regard Schwarz (2009) indicated that argumentation could improve student knowledge and develop their understanding of the concepts. An older study by Toulmin (1958) asserted that an argument is arranged by the following elements, which are also included in the essential features of scientific inquiry: "1) claims, 2) data, 3)

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warrants to tie claims and data together, 4) backings to support warrants, 5) rebuttals to refute data, facts, or logics used, and 6) qualifiers to show the quality of the obtained conclusion" (p. 112).

All those definitions of argumentation suggested that it is important to students' learning of sciences, especially when it is associated with inquiry. The instrument includes elements that are included in the aforementioned definitions in addition to the definitions of the scientific inquiry to be presented later on. On the other hand, numerous studies (e.g. Dunne et al., 2013; Hodson 2003; Millar et al. 1998; National Research Council (NRC) 1996; Tamir 1991, Tamir et al., 1998; Wang et al. 2014) have contended that scientific inquiry bolsters science education. The National Science Education Standards related to inquiry (National Research Council (NRC, 1996) and the Next Generation Science Standards (NGSS) (NGSS Lead States, 2013) asserted that all K-12 students should develop the necessary abilities to perform inquiry as well as develop an understanding of the meaning of scientific inquiry, which can be fulfilled by including the following five essential inquiry components in science curriculum materials: 1) Learners are engaged by scientifically oriented questions. 2) They give priority to evidence when responding to questions. 3) They formulate explanations based on evidence. 4) They evaluate their explanations against scientific understanding. 5) They communicate and justify their explanations.

Scientific inquiry is interrelated with argumentation (Haug 2014; Sampson et al., 2013), in which students must meet the new standard of science and scientific inquiry by acquiring knowledge about the nature of scientific argumentation. Hammer et al. (2008) described scientific argumentation skills as "mechanistic reasoning, pursuing coherence in ideas, participating in scientific argumentation, supporting claims with evidence, formulating sensible hypotheses and attending to confounding causal factors" (p. 138). On the other hand, Rudolph (2005) indicated that scientific inquiries can vary in accordance with the phenomenon being investigated. However, science teachers frequently complain about the limited time for teaching science concepts, which hinders them from using argumentation-driven inquiry in their classroom practices (Erenler & Cetin, 2019; Seah, 2016). We argue that by including argumentation-driven inquiry in science or chemistry textbooks, this problem could be partially solved. Thus, authors of science textbooks should decrease the theoretical content and replace it with scientific processes and scientific activities; science teachers should shift from teaching students to acquire scientific knowledge to teaching for the purpose of developing scientific literacy.

Chemistry textbooks in the gulf countries serve as the major source of scientific information. In Saudi Arabia, for example, teachers depend on textbooks and guidebooks as sources for science instruction. Consequently, Saudi Arabian students depend on textbooks and workbooks as their main sources for learning science (Aldahmash et al., 2016; Dreyfus, 1992). Therefore, science educators in Saudi Arabia must determine the degree to which science textbooks support students' development of argument-driven inquiry skills as specified in the National Science Education Standards (NSES) (National Research Council (NRC, 2000), as well as in the Next Generation Science Standards (NGSS) (NGSS Lead States, 2013).

Many researchers have explored the inquiry levels in science curricula or science textbooks (Aldahmash et al., 2016; Forbes, 2013; Herron, 1971; Koksal & Berberoglu, 2014; Madden & Wiebe, 2013). Tamir and Pilar-Garcia (1992) analyzed practical activities included in seventh to twelfth-grade science textbooks in Catalonia in terms of the level of hands-on inquiry tasks. They found that science activities incorporating rigorous inquiry levels were smaller than those for similar grade textbooks in the United Kingdom and the United States. In addition, Chiappetta and Fillman (2007) compared biology textbooks for the United States published in 2007 to those published in 1998 and found that the textbooks improved in terms of the balance of presenting biology with respect to the four areas of science literacy, which considers scientific inquiry as one of the key components. Park et al. (2009) compared earth science textbooks in the United States and Korea and found that the Korean science textbooks included a greater number of inquiry activities than the United States' science textbooks, concluding that earth science activities in Korean textbooks may develop students' scientific reasoning skills more fully than would the United States' science textbooks. In contrast, Kahveci (2010) found that Turkish middle school science and high school chemistry textbooks poorly incorporated inquiry-based learning and teaching. Dunne et al. (2013) proved that even if the analyzed textbooks support inquiry-based science education, the success of these textbooks in developing students' inquiry depends on the teachers' understanding of the Inquiry-Based Science Education (IBSE) and hence their ability to teach using this strategy. Wilson-Lopez and Garlick (2017) conducted a content analysis of 69 middle school students' writing samples that argued on behalf of their proposed engineering design solutions. Common patterns were identified across their writing and have been used to propose categories for a rubric that accounts for different dimensions of argumentation specific to engineering.

However, scarcity of studies that investigates science or chemistry textbooks for the inclusion of argumentation or inquiry, especially in the gulf region, has led us to propose this study. That is because scientific argumentation activities enhance scientific content knowledge and help students engage in crucial scientific practices (Grooms et al. 2015). In addition, argumentation was the main focus of standards movements such as Common Core State Standards and Next Generation Science Standards (NGSS, Lead States, 2012). These standards affirm that teachers have to be prepared to engage their students in argumentation practices during science instruction in order to support the development of science proficiency.

Argument-driven inquiry is an instructional model that may enable teachers to design laboratory activities that help students perform scientific argumentation without losing focus on core ideas and cross-disciplinary science concepts (Erduran et al., 2019; Guluzar (2019; Inthaud & Bongkotphet, & Chindaruksa, 2019). In addition, it has been indicated that this instructional strategy can improve the key aspects of scientific proficiency and the essential practices of science included in the NGSS framework (Sampson et al., 2009, 2011). According to the Argumentation Derive Inquiry (ADI) model, students should engage in the following classroom activities:

data collection and analysis, argument generation, group argumentation, scientific writing, and double-blind peer review processes.

Science activities, which are built on argumentation driven-inquiry can foster the development of students' knowledge and skills needed for a meaningful understanding of science concepts. Therefore, in this study, we deducted our instrument from both standards documents hoping to shed the light on shortcomings in the existing science curriculum research by investigating the extent to which current Saudi Arabian chemistry textbooks include argumentation-driven inquiry as well as their potential to help students develop science argumentation and inquiry skills.

1.1. Purpose of the study

This study aimed to investigate both the extent and level of the inclusion of argumentation-driven inquiry in chemistry textbooks and workbooks for the academic year 2019-2020 as specified in the National Science Standards (2000) and the Next Generation Science Standards (NGSS, Lead States, 2012). Thus, the research questions and sub-questions that guided the study were as follows:

1.1.1. Main question

To what extent do chemistry textbooks and workbooks include scientific argumentation-driven inquiry in their activities?

Table 1
Skills of Argumentation Driven Inquiry (Aldahmash et al., 2016; Demircioglu, & Ucar, 2015; Hasnunidah et al., 2015).

Skills	Variations			
	Learner-directed		Teacher-directed	
	4	3	2	1
1. Questions. Content engages learners in scientifically oriented questions. Example:	Content directs learners to pose questions Example:	Content directs learners to select among questions, pose new questions Example:	Content directs learners to sharpen or clarify question provided by teacher, materials, or another source Example:	Content engages learners in question provided by teacher, materials, or another source Example:
2. Evidence: Data and patterns. Content encourages learners to give priority to evidence in responding to questions. Example:	Content directs learners to determine what constitutes evidence and collect it Example:	Learners are directed to collect certain data Example:	Learners are given data and asked to analyze Example:	Learners are given data and told how to analyze Example:
3. Students' explanations. Content asks learners to formulate explanations from evidence. Example:	Content directs learners to formulate explanations after summarizing evidence Example:	Learners are guided in process of formulating explanations from evidence Example:	Learners are given possible ways to use evidence to formulate explanations Example:	Learners are provided with evidence Example:
4. Scientific theories or models. Content asks learners to connect explanations to scientific knowledge. Example:	Content encourages learners to independently examine other resources and form the links to explanations Example:	Learners directed toward areas and sources of scientific knowledge Example:	Learners are given all procedures for possible connections Example:	Learners are given the procedures and the possible connections Example:
5. Argumentation, communication, and justification. Content encourages learners to communicate and justify explanations. Example:	Content directs learners to form reasonable and logical arguments to communicate and justify explanations Example:	Learners coached in development of communication and justification of explanations Example:	Learners are provided with broad guidelines to sharpen communication and justification of explanations Example:	Learners are given steps and procedures for the communication and justification of explanations Example:
6. Analysis. Content encourages learners to analyze evidence. Example:	Content gives the learners the chance to analyze evidence Example:	Content provides learners with some tips required to analyze evidence Example:	Content provides learners with the steps required to analyze evidence Example:	Content provides learners with the procedures and the analysis of evidence Example:
7. Connection. Content engages learners to connect explanations to scientific knowledge. Example:	Content engages learners the chance to connect explanations to scientific knowledge Example:	Content provides learners with some tips to connect explanations to scientific knowledge Example:	Content provides learners with the steps required to connect explanations to scientific knowledge Example:	Content provides learners with the procedures and the connection between explanations and scientific knowledge Example:
8. Reflection. Content engages learners to reflect on the inquiry process and their learning. Example:	Content gives learners the chance to reflect on the inquiry process and their learning Example:	Content provides learners with some tips to reflect on the inquiry process and their learning Example:	Content provides learners with the steps required to reflect on the inquiry process and their learning Example:	Content provides learners with the procedures and the reflection on the inquiry process and their learning Example:

1.1.2. *Sub-questions*

- At what levels do the included argumentation-driven inquiry skills in student's chemistry textbooks and workbooks activities appear?
- How do the determined levels of included argumentation-driven inquiry skills in chemistry textbooks and workbooks align with the NGSS recommendations for inquiry?

2. Research method

This study employs content analysis (White and Marsh, 2006) as its primary research methodology. During content analysis, researchers discussed data sources as well as the analytical framework used to explore the representation of the argumentation-driven inquiry in chemistry textbooks.

2.1. *Sample: materials analyzed*

Researchers selected twelfth-grade chemistry textbooks and workbooks from Saudi Arabian high schools in order to analyze the extent to which the activities incorporated argumentation-driven inquiry, and the level of that inquiry. We decided to analyze these books because they are taught at the final year of the secondary stage, which prepare students to the university level. This selection was based on the importance of the twelfth year as a transition year to the university level. The analyzed chemistry textbooks included two student textbooks and two workbooks. Each semester, students use one textbook and one workbook. The twelfth-grade Chemistry textbook for the first semester is 216 pages long and has five main chapters including introduction, general aims, topics, content, and assessment objectives. The twelfth-grade Chemistry workbook for the first semester is 79 pages long and includes lab safety, instruments, and ten experiments. In addition, Chemistry textbook for the second semester is 248 pages long and has five main chapters including introduction, general aims, topics, content, and assessment objectives. The Chemistry workbook for the second semester is 65 pages long and includes lab safety, instruments, and twelve experiments. Forty-four textbook activities and twenty-two workbook activities were analyzed for a total of sixty-six practical activities. The textbook activities included three types: 'launch activities' at the beginning of each chapter, 'lab experiments' in each lesson, and 'experiment.' All activities in the workbooks are called 'experiment.' It should be noted that the textbooks and the workbooks are or should be connected to each other. The workbooks activities should lead students to the discovery of concepts that are presented in the textbooks. This would result in student to act as scientists, which may enable them to carry out scientists' roles in the future.

2.2. *Analysis instrument*

Because the conceptual framework represents the most critical aspect of the documented information analysis, studies implement a variety of conceptual frameworks for conducting textbook analysis

(Aldahmash et al., 2016; Chiappetta & Fillman, 2007; Dunne et al., 2013; Kahveci, 2010; Vesterinen et al., 2013). Different frameworks exist; some of them outline the inclusion of subject matter content, some analyze the difficulties or the readability of the content, and others target the epistemological orientation of the text (Chiappetta & Fillman, 2007).

This study focused on the analysis of twelfth-grade chemistry textbooks and workbooks for the inclusion of argumentation-driven inquiry as indicated in the analysis instrument, which includes the following eight parts (Aldahmash et al., 2016; Demircioglu, & Ucar, 2015; Hasnunidah et al., 2015; National Research Council (NRC, 2000; and NGSS Lead States, 2013):

- Category 1: Questions. Content engages learners in scientifically oriented questions.
- Category 2: Evidence (Data and patterns). Content encourages learners to give priority to evidence in responding to questions.
- Category 3: Students' explanations. Content engages learners to formulate explanations from evidence.
- Category 4: Scientific theories or models. Content engages learners to connect explanations to scientific knowledge.
- Category 5: Argumentation, communication, and justification. Content encourages learners to communicate and justify explanations.
- Category 6: Analysis. Content encourages learners to analyze evidence.
- Category 7: Connection. Content engages learners to connect explanations to scientific knowledge.
- Category 8: Reflection. Content engages learners to reflect on the argumentation and inquiry process and their learning.

There are four levels for each skill category, progressing from teacher-centered (level one) to student-centered (level four), which represent the scientific argumentation-driven inquiry levels. The national science standards (National Research Council (NRC, 2000) and NGSS (NGSS Lead States, 2013) emphasize that chemistry curricula should include all levels of these features. Therefore, the rubric incorporates 8 main skills and 32 sub-skills, indicating the level to which argumentation-driven inquiry is included.

2.2.1. Validity of the analysis

Prior to the content analysis, we used the rubric (Table1) to analyze a pilot sample of the chemistry activities to determining the various levels of inquiry- driven argumentation. This pilot study was necessary for tuning the rating rubric to make any necessary revisions prior to its final use, to ensure that the rubric measures the intended content (Creswell and Miller 2000. The items on this rubric (Next Generation Science Standards, NGSS Lead States, 2013; National Research Council (NRC, 2000) were translated into Arabic because the textbooks were written in Arabic language. Back translations of the instrument and the rubric were done, and the two versions were submitted to six experts in chemistry education to ensure the validity of the translation and ensure that the rubric is understandable and usable. Some revisions were made in light of the experts' feedback.

The final version of the analysis rubric included the following:

1) Roles for describing content types that include one of the argumentation-driven inquiry skills.
2) The argumentation-driven inquiry skills and their levels in the chemistry textbooks and workbooks.
3) Roles for ensuring that the units of analysis include the argumentation-driven inquiry skills.
4) Instructions for using essential argumentation-driven inquiry skills hierarchy table.
5) Data collection table.

Table 2
Inter-Code Reliability Between Chemistry Textbook Raters.

Skills of argumentation driven inquiry	kappa	Sig
1. *Questions.* Content engages learners in scientifically oriented questions.	0.828	0.000
2. *Evidence: Data and patterns.* Content engages learners to gives priority to evidence in responding to questions.	0.630	0.000
3. *Students' explanations.* Content engages learners to formulate explanations from evidence.	0.624	0.000
4. *Scientific theories or models.* Content engages learners to connect explanations to scientific knowledge.	0.687	0.000
5. *Argumentation, communication, and justification.* Content encourages learners to communicate and justifies explanations.	0.922	0.000
6. *Analyze*: Content encourages learners to analyze evidence.	0.756	0.000
7. *Connect*: Content engages learners to connect explanations to scientific knowledge	0.845	0.000
8. *Reflect*: Content engages learners reflect on the argumentation and inquiry process and their learning	0.841	0.000

2.3. Procedures of the content analysis

In this analysis we compared the two types of textbooks (textbooks and workbooks) and assigned numbers to the types of books as follows: textbooks (1) and workbooks (2). Then, we emphasized the analysis units involved in both textbooks and workbooks. We also coded each section within the activities into instructions, aims, questions, procedures, diagrams, figures, and tables according to the appropriate argumentation-driven inquiry skills statement in the analytical framework. We gave more than one mark when the statement included more than one skill. For each of the argumentation-driven inquiry skills, the marked points were counted and divided by the total number of argumentation-driven inquiry skills identified in each part as well as the total within the book in order to calculate the percentages of inclusion in each textbook.

2.4. Determining the levels of argumentation driven inquiry skills

The Analytic Rubric was developed and used to analyze four books. The instrument indicates the essential features of argumentation-driven inquiry as well as the indications of the variations of these features according to the levels of each skill, which are described below.

At level 1, questions, procedures, and solutions are clearly stated as part of the practical activity. Students are given everything. At level 2, the activity delivers the predetermined problem to students and asks them to clarify and sharpen it. The activities also offer data for students to use and guide them to possible ways to draw evidence and select one of the reasonable conclusions. It provides them with strategies to make an argument. At level 3, the activities provide the student with many options to prepare questions or to pose new questions. Then students are required to collect certain data from a variety of resources, and the students are responsible for reporting their data. Finally, in level 4, activities encourage students to practice the highest level of inquiry by granting them the freedom to practice all steps scientists perform, such as formulating their own problems, posing questions, designing procedures, formulating the evidence that supports their arguments, and drawing reasonable conclusions.

In this analysis, we excluded parts of the books that did not include practical activities, as the activities served as the unit of analysis. Each of the argumentation-driven inquiry tasks was coded by the unit of the lesson (i.e., one complete lesson including scientifically oriented question, scientific explanation, etc.). Then, the frequencies and percentages of each of the features related to the number of activities were calculated.

2.5. Reliability of the content analysis

Two of the authors, who are specialists in chemistry education,

Table 3
Frequencies, Means, and Percentages for Inclusion of Argumentation Driven Inquiry for both types of textbooks.

Feature of inquiry	Freq. (f%)				Mean	SD	%	Level
	1	2	3	4				
Skill 1: Questions. Content engages learners in scientifically oriented questions.	45 (68.2 %)	7(10.6 %)	12(18.2 %)	2(3.0 %)	1.56	.897	39.00	1
Skill 2: Evidence: Data and patterns. Content encourages learners to give priority to evidence in responding to questions.	28 (42.4 %)	29(43.9 %)	9(13.6 %)	0 (0%)	1.71	.696	42.75	1
Skill 3: Students' explanations. Content asks learners to formulate explanations from evidence.	17 (25.8 %)	16(24.2 %)	31(47.0 %)	2(3.0 %)	2.27	.887	56.75	2
Skill 4: Scientific theories or models. Content encourages learners to connect explanations to scientific knowledge.	33 (50.0 %)	18(27.3 %)	9(13.6 %)	6(9.1 %)	1.82	.991	45.50	2
Skill 5: Argumentation, communication, and justification. Content encourages learners to communicate and justify explanations.	35 (53.0 %)	13(19.7 %)	15(22.7 %)	3(4.5 %)	1.79	.953	44.75	2
Skill 6: 6. Analysis. Content encourages learners to analyze evidence.	30 (45.5 %)	22(33.3 %)	9(13.6 %)	5(7.6 %)	1.83	938	45.75	2
Skill 7: Connect: Content engages learners to connect explanations to scientific knowledge	35 (53.0 %)	4(6.1 %)	21(31.8 %)	6(9.1 %)	1.97	1.118	49.25	2
Skill 8: Reflect: Content engages learners to reflect on the inquiry process and their learning	25 (37.9 %)	8(12.1 %)	29(43.9 %)	4(6.1 %)	2.18	1.021	54.50	2

Level 1= the skill is included but is strongly directed toward teacher-centered learning and teaching.
Level 2= the skill is included but is directed toward teacher-centered learning and teaching.
Level 3= the skill is included and is moderately directed toward student-centered learning and teaching.
Level 4= the skill is included but is strongly directed toward student-centered learning and teaching.

analyzed sample activities of twelfth-grade chemistry textbooks and workbooks. Each of the raters coded the sample units of analysis to indicate which aspect of the skills of argumentation-driven inquiry they included. The degree of agreement (the reliability) was calculated using the kappa formula (Cohen, 1990). According to Rubinstein and Brown (1984), kappa values ranging between 0.40 and 0.75 are acceptable. Values in Table 2 show excellent inter-rater agreement for all eight selections from the present study's chemistry textbooks and workbooks.

Table 2 illustrates that the kappa values ranged between (0.624) and (0.922), which indicates a higher than acceptable degree of agreement between the two raters when analyzing chemistry textbooks and workbooks for their levels of argumentation-driven inquiry skills.

To be able to explain the results, it is important to calculate the mean as well as the weighted percentages. The arithmetic mean of item responses is the most important measure of central tendency. It is computed using the mean, which is calculated as follows:

Arithmetic mean of the responses to the item with 4 levels = {(4 * corresponding iteration) + (3 * corresponding iteration) + (2 * corresponding iteration) + (1 * corresponding iteration)} / (4 + 3 + 2 + 1). Then, the value of the calculated arithmetic mean is explained based on the number of levels in the rubric.

- The range is calculated, where 4−1 = 3.
- The length of the category is calculated by dividing the range by the number of categories (options): 3/4 = 0.75.
- The mean for each level of the rubric is determined as follows: Level 1 is from 1 to 1.75, level 2 is from 1.76 to 2.51, level 3 is from 2.52 to 3.08, and level 4 is from 3.28 to 4.

3. Results and discussions

In this section, the general data for the inclusion of argumentation-driven inquiry skills in twelfth-grade chemistry activities found in students' textbooks and workbooks are presented. Those data include frequencies and percentages for each level of inclusion, as well as the mean and the percentages for each of the eight skills.

Table 3 contains descriptive data that show the extent to which argumentation-driven inquiry skills are included in the activities found in twelfth-grade chemistry textbooks and workbooks altogether. The frequencies and percentages show that five of the argument-driven inquiry skills included in these chemistry textbooks, namely, skill1, skill 2, skill4, skill5, and skill 6 occur at levels one and two. Although frequencies and percentages show that categories (3), (7), and (8) inclined toward level 3, the calculated mean and the percentages show that the inclusion of all skills fall in level one or two. For example, skills 1 (Questions. Content engages learners in scientifically oriented questions.) and 2 (Evidence: Data and patterns. Content encourages learners to give priority to evidence when responding to questions) appear at level one, while the inclusion of skills 3–8 appeared at level two. In short, it seems that none of the skills reached the third or fourth levels of inclusion, which are necessary for learning sciences as inquiry. This is supported by other results, which indicated that none of activities could promote argumentation-driven inquiry skills among high school students. According to National Education Science standards, National Research Council (NRC, 1996; 2000; NRC, 2012), and the Next Generation Science Standards (NGSS, Lead States, 2013), students at this grade level should engage in argumentation driven inquiry during learning of sciences. This means that the majority of included argumentation-driven inquiry skills should be occurring at level four rather than level one and two. Students at grade twelve are preparing for university, where they are expected to practice free inquiry science activities. These students should be able to pose their own questions, determine what constitutes evidence and collect it, formulate explanations after summarizing evidence, communicate and justify explanations, analyze evidence, connect explanations to scientific knowledge, and reflect on the inquiry process and their learning. We concluded that these textbooks and workbooks do not grant students the opportunity to practice the level of free inquiry and argumentation needed for university science education as specified by level 4. Therefore, these textbooks need to be revised such that they enable students to master university-level science education as well as prepare for their future scientific lives.

Table 4
Frequencies, Weighted Averages and Weighted Percentages of Inclusion of each level of Argumentation Driven Inquiry in the Textbook and the Workbooks.

Book type	Actual number of activities (66)	Level	Frequencies (and %)								
			Skill 1	Skill 2	Skill 3	Skill 4	Skill 5	Skill 6	Skill 7	Skill 8	Total
Textbooks	44	1	30	22	11	24	24	19	25	16	171
		2	5	20	10	14	8	15	2	6	80
		3	8	2	21	3	11	5	12	19	81
		4	1	0	2	3	1	5	4	3	19
	Mean		1.55	1.55	2.32	1.66	1.73	1.91	1.84	2.20	1.85
	%		38.8	38.8	58.0	41.5	43.3	47.8	46.0	55.0	46.3
	Level		1	1	2	1	1	2	2	2	2
Workbooks	22	1	15	6	6	9	11	11	10	9	77
		2	2	9	6	4	5	7	1	2	36
		3	4	7	10	6	4	4	9	10	54
		4	1	0	0	3	2	0	2	1	9
	Mean		1.59	2.05	2.18	2.14	1.86	1.68	2.14	2.14	1.97
	%		39.8	51.3	54.5	53.5	25.5	42.0	53.5	53.3	49.3
	Level		1	2	2	2	2	1	2	2	2

Table 4 includes the frequencies, means and percentages of inclusion of each level of argumentation-driven inquiry skills in both students' textbooks and experiment guides for high school chemistry. Data show that level one of including argumentation-driven inquiry skills in both textbooks and workbooks occurs more frequently than the other levels. It is apparent from the values of the means and percentages that greater number of activities included argumentation-driven inquiry skills at the first level and the second level than levels four and three. Level 4 occurs least frequently. This could reveal that both the textbooks and the workbooks lack the sufficient ability to give students the opportunity to engage in free argumentation-driven inquiry as required by level 4 or level three. As a result, both textbooks and workbooks should be subjected to major revision to ensure that all argumentation driven inquiry skills are included in a reasonable manner that provide students with the ability to acquire and practice free inquiry and argumentation skills.

4. Conclusion and implications

This research aimed to determine the extent to which twelfth-grade 'Saudi Arabian chemistry textbooks and workbooks included argumentation-driven inquiry skills in their activities. Results indicate that more included argumentation-driven inquiry skills in the activities of the twelfth-grade chemistry textbooks and workbooks generally appear at inquiry level one and two This means that this inclusion is directed toward teacher-centered learning and teaching. It was found that none of activities could promote argumentation-driven inquiry skills among high school students. Results also indicate that both chemistry textbooks and workbooks in Saudi Arabia included argumentation-driven inquiry skills in the same manner, which is most often at level one and two. Therefore, it is recommended that these textbooks and workbooks undergo revisions to ensure that included argumentation-driven skills favor student-centered learning and teaching. Proper inclusion of argumentation and inquiry skills would enable learners to acquire scientific ways of thinking and practicing. In addition, inquiry driven argumentation activities would foster the development of knowledge and skills needed to form meaningful understandings of science concepts. They would also equip learners with the abilities to refine information they receive or confront during their interaction with their peers or with social media. Similar studies should be performed targeting physics, biology, and other science related courses. Further studies should investigate the impact on students' critical thinking skills when argumentation-driven inquiry is properly implemented into the curriculum. Further study also should be done to explore the type of activities that could most promote argumentation-driven inquiry skills among high school students.

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Declaration of Competing Interest

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