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Study of Chemical Multirepresentation on Chemical Bonding Material in Independent Curriculum Chemistry Textbooks

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A B S T R A C T

Textbooks are one of the teaching materials that have an important role in understanding student representation. A meaningful approach can provide understanding to students by using images or visuals to illustrate different levels of representation in chemical phenomena contained in textbooks. One of the chemical materials that requires the role of chemical representation to provide a more realistic visualization for students about abstract chemical concepts is chemical bonding material. The concept in chemical phenomena that emphasizes three levels of chemical representation can provide a complete understanding if it is able to link the three levels of representation. The representations presented in the textbooks that were analyzed generally came from websites that were not scientifically trusted. This study aims to analyze the multi-representation of independent curriculum chemistry textbooks on chemical bonding material using five criteria developed by Gkitzia et al. (2011). The data sources in this study were six chemistry textbooks for the Independent Curriculum for SMA/MA which were compared with standard books. The results of this study indicate that the six textbooks generally have the following types of representation: (C1) multiple typology, but no mixed representation, (C2) explicit typology, (C3) fully related and related typology, (C4) typology of the existence of appropriate information, and (C5) fairly related typology.

1. Introduction

Teaching materials are all forms of teaching resources that contain learning messages both specific and general in nature that can be utilized for learning purposes. Teaching materials play an important role in supporting the learning process so that students can understand the basic concepts of the material being taught. One of the teaching materials used in schools is textbooks Magdalena et al., (2020). In addition, the use of textbooks also helps students to develop reading skills and understand written information. This can be supported by research conducted by Tolingguhu et al., (2024) which states that the use of textbooks as a learning resource helps students understand the concepts in the material presented.

Iswanto et al. (2018) also stated that textbook-based learning significantly improved student learning outcomes.

According to Gilbert & Treagust, (2009) textbooks as the main teaching material need to contain multirepresentations in explaining the chemical phenomena around them. This is in accordance with research conducted by Upahi & Ramnarain, (2023) in learning chemistry textbooks that are suitable for use are textbooks that contain multirepresentation of chemistry, because the use of images or visuals in textbooks to describe chemical phenomena at different levels of chemical representation will be a meaningful approach and make it easier for students to understand a concept. Therefore, the presence of textbooks is crucial for successful learning (Blongkod et al., 2022).

Chemical bonding material is material that has abstract concepts. The abstract concept of chemical bonds is characterized by learning difficulties in the concept of chemical bonds and the extent of concept errors. Problems in learning chemistry are not only due to abstract concepts but often learning focuses on the symbolic level but little emphasis on the submicro and macroscopic levels (Gabel, 1993). Based on research conducted by Yustin & Wiyarsi, (2019) in the learning process students are not accustomed to linking chemistry with the context of life around them so that students also make many mistakes in identifying what is needed from the problem.

Learners often fail to understand chemical concepts because they only memorize chemical definitions and concentrate on solving mathematical problems. They also often use chemical terms without understanding the concept well at three levels of chemical representation (Suparwati, 2022). According to Gilbert & Treagust, (2009) the three levels of chemical representation is an understanding of how the relationship of properties and meanings of macro, submicro and symbolic. Chemical concepts can be studied at three levels of representation namely macroscopic, microscopic and symbolic.

From the search that the researchers have done, six independent curriculum chemistry textbooks used by SMA/MA were found. However, after observing the six textbooks, it was seen that the sources of images contained in the textbooks were generally sourced from websites or platforms that provide stock photos, videos, audio and editorial content. This shows that most of the representations are only taken from websites or sites that cannot be trusted, or not from books and scientific journals that have met scientific principles that have a high level of accuracy and validation so that, multirepresentation analysis is needed in textbooks to see whether the representations presented are correct or not considering that the representation must be conceptually correct so that this research is important to do.

This research has been conducted by Hasanah et al., (2024) however, the book used in this study is a general chemistry textbook. Furthermore, this research has also been conducted by Lutviana et al., (2019) however, the book used in this study is still a 2013 curriculum chemistry textbook. At this time the curriculum

used by schools is the Merdeka Curriculum. However, there is no similar study on the analysis of chemical multirepresentations in the Merdeka Curriculum chemistry textbook, especially on chemical bonding material, which aims to review the extent to which the textbook meets the criteria for chemical representations that support the learning process. Therefore, this analysis is expected to provide recommendations for the development of textbooks that contain chemical representations and become a reference for teachers in using textbooks with appropriate representations, so that learning chemical bonding material can run optimally.

2. Methodology

This type of research is descriptive research using content analysis. The data sources in this study are six chemistry textbooks of the independent curriculum of SMA/MA which are generally used by schools in Padang City. The subjects in this study consisted of two people, namely one chemistry lecturer at FMIPA, Padang State University and the researcher himself.

The procedure in this study involved three stages, namely: (1) selection and sampling, the first step of this research is to observe six chemistry textbooks of the independent curriculum of SMA/MA used by schools to be sampled; (2) coding and analysis, the analysis conducted on multirepresentation of chemistry in six textbooks using an instrument developed by Gkitzia et al. (2011). This stage involved two people consisting of one lecturer and the main researcher. This process aims to review the extent to which the textbooks meet the five criteria of chemical representation; (3) summarizing the results of the analysis, the results of the analysis of the two textbooks are compared with the standard book, namely Jespersen's book, (2014) with the title Chemisrty: The Molecular Nature of Matter and Change.

This comparison aims to review the extent to which the representations presented in the six Merdeka Curriculum chemistry textbooks meet the chemical representations in standard chemistry textbooks. The research instrument used in this study was the chemical multirepresentation criteria and typology analysis sheet developed by Gkitzia et al. (2011). The data analysis technique in this study used Miles and Huberman's qualitative data analysis technique which consists of three streams, namely data reduction, data display, and conclusion drawing (Sugiyono, 2013). The following is a table of criteria and typology of chemistry multirepresentation by Gkitzia et al. (2011).

The chemical multirepresentation criteria and their typologies are described as follows: Criterion (C1): Types of representations. This criterion aims to analyze and identify what types of representations are presented and emphasized in the textbook. This criterion has six typologies including: (i) macroscopic, (ii) sub-microscopic, (iii) symbolic, (iv) multiple, (v) hybrid, and (vi) mixed. A representation can be classified as multiple when it describes a chemical phenomenon using two or three levels of representation, while hybrid when it

combines two or three levels of representation to form a reorientation that complements each other and a representation can also be classified as mixed when one of the three levels of representation and another type of representation are analogous together.

Table 1. Criteria and Typology of Chemical Multirepresentation

Criteria		Tipology	
C1	Representation type	i.	Macroscopic
		ii.	Sub-microscopic
		iii.	Symbolic
		iv.	Multiple
		v.	*Hybrid*
		vi.	Mixed
C2	Interpretation of image surface features	i.	Explicit
		ii.	Implicit
		iii.	Ambiguous
C3	Image to text connection	i.	Fully connected and bonded
		ii.	Partially connected and related
		iii.	Partially related and unrelated
		iv.	Not related
C4	Existence and nature of picture captions	i.	Presence of appropriate captions (explicit, clear, concise, comprehensive, autonomous)
		ii.	The existence of a statement with the problem
		iii.	No image caption
C5	The level of connectedness between representations consisting of multiple representations (C5)	i.	Quite related
		ii.	Not sufficiently related
		iii.	Not relevant

Criterion (C2): Interpretation of surface features. This criterion aims to analyze the extent to which the interpretation of surface features (elements that make up the representation) is clearly labeled or indicated. This criterion consists of three typologies including: (i) explicit, (ii) implicit and (iii) ambiguous. Explicit typology is when a surface feature of a representation is clearly labeled or indicated. If a surface feature or element of a representation is not clearly labeled or indicated then this representation is grouped with implicit codes, and for representations that do not indicate or label surface features at all then they are grouped with ambiguous codes.

Criterion (C3): the relationship of the image to the content of the text. This criterion aims to analyze the relationship between the representation and the text presented in the textbook and see if there is a direct relationship from the text to the representation. This criterion consists of five typologies including: (i) fully related and related, (ii) fully related and unrelated, (iii) partially related and unrelated, (iv) partially related and unrelated, (v) unrelated. A representation is categorized as fully related when it describes the exact content of the text. A representation is grouped under partially related when it depicts a subject similar to the text but not exactly the same or not completely. Conversely, a representation is coded as unrelated when it is not related to the text content.

Then, a representation was coded as related or unrelated, when the text referred to the representation using a direct link or not, i.e. with or phrases such as, "can be observed in Figure".

Criterion (C4): The existence and nature of image captions. This criterion aims to review the captions of the representations presented in the textbook. The captions contained in the representations are very important, as they can clarify the content and message of the representations. This criterion consists of three typologies including: (i) presence of appropriate captions (explicit, clear, concise, comprehensive, autonomous), (ii) presence of captions with problems, and (iii) no captions.

Criterion (C5): The relationship between components consisting of several representations. This criterion can only be used to analyze C1 criteria with multiple typologies. This criterion aims to see the relationship between representations that are clearly shown. This criterion consists of three typologies including: (i) sufficiently related, (ii) not sufficiently related, and (iii) not related. Representations are grouped in the moderately related typology when the relationship between representations is clearly shown using symbols such as arrows. If the representations are only described as parallel or parallel without using symbols then the representations are grouped in the not related enough typology, while if the representations are not clearly connected then the representations are grouped in the not related typology.

3. Result and Discussion

Research Results

The results of this multirepresentation analysis are presented in the form of a table containing representation criteria, typology and the number of representations of each typology contained in six chemistry textbooks. The results of the analysis are presented in Table 2 below:

Table 2. Results of coding and analysis of representation of six chemistry textbooks based on chemical representation criteria

Criteria	Tipology	Chemistry Textbook						
		Standard	A	B	C	D	E	F
Representation type (C1)	i	1	3	2	2	2	1	-
	ii	4	1	2	1	-	4	2
	iii	2	5	3	2	5	-	1
	iv	3	1	3	2	1	7	1
	v	2	4	-	2	-	6	1
	vi	-	-	-	-	-	-	-
Interpretation of image surface features (C2)	i	2	6	5	4	-	10	3
	ii	8	3	2	4	5	5	1
	iii	2	5	3	1	3	3	1
Image to text connection (C3)	i	12	10	-	1	1	15	5
	ii	-	3	6	5	3	2	-

	iii	-	-	-	2	3	1	-
	iv	-	1	4	1	1	-	-
	v	-	-	-	-	-	-	-
Existence and	i	11	6	4	5	-	16	4
nature of picture	ii	1	7	6	4	4	2	1
captions (C4)	iii	-	-	-	-	4	-	-
The level of	i	-	-	2	-	-	7	1
connectedness	ii	3	1	1	1	1	-	-
between	iii	-	-	-	-	-	-	-
representations consisting of multiple representations (C5)								

The percentage of the multirepresentation analysis results is presented in the form of a table containing representation criteria, typology and the number of representations of each typology contained in six chemistry textbooks. The results of the analysis are presented in Table 3 below:

Table 3. Total percentage of coding results and representation analysis of six chemistry textbooks based on chemical representation criteria

Criteria	**Tipology**	**Percentage of Chemistry Textbook Typology**						
		Standard	**A**	**B**	**C**	**D**	**E**	**F**
Representation	i	8%	21%	20%	22%	25%	6%	0%
type (C1)	ii	33%	7%	20%	11%	0%	22%	40%
	iii	17%	36%	30%	22%	63%	0%	20%
	iv	25%	7%	30%	22%	13%	39%	20%
	v	17%	29%	0%	11%	0%	33%	20%
	vi	0%	0%	0%	0%	0%	0%	0%
Interpretation of	i	17%	43%	50%	44%	0%	56%	60%
image surface	ii	67%	21%	20%	44%	63%	28%	20%
features (C2)	iii	17%	36%	30%	11%	38%	17%	20%
Image to text	i	100%	71%	0%	11%	13%	83%	100%
connection (C3)	ii	0%	21%	60%	56%	38%	11%	0%
	iii	0%	0%	0%	22%	38%	6%	0%
	iv	0%	7%	40%	11%	13%	0%	0%
	v	0%	0%	0%	0%	0%	0%	0%
Existence and	i	92%	43%	40%	56%	0%	89%	80%
nature of picture	ii	8%	57%	60%	44%	50%	11%	20%
captions (C4)	iii	0%	0%	0%	0%	50%	0%	0%
The level of	i	0%	0%	20%	0%	0%	39%	20%
connectedness	ii	25%	7%	10%	11%	13%	0%	0%
between	iii	0%	0%	0%	0%	0%	0%	0%
representations consisting of multiple representations (C5)								

Table 2 and Table 3 show the data of multirepresentation analysis results and the percentage of each typology of representation criteria in book A, book B, book C, book D, book E, and book F which have differences in each criterion as follows:

Criterion C1: Type of Representation

The criterion of representation type (C1) aims to identify the type of representation contained in the six textbooks. This C1 criterion has six typologies as shown in Table 1. Data from the analysis of chemical multirepresentation in Table 3 shows that books A and D generally contain symbolic typology (iii) with a percentage of 36% and 63%, book B generally contains symbolic typology (iii) and multiple (iv) with a percentage of 30% each, book C generally contains macroscopic (i), sub-microscopic (ii), symbolic (iii), hybrid (v) typologies with a percentage of 22% each, book E generally contains multiple (iv) typologies with a percentage of 39%, and book F generally contains sub-microscopic (ii) typologies with a percentage of 40%. However, for the mixed typology (vi) for all six books has a percentage of 0%, which means that there is not a single mixed typology (vi) in the books analyzed in this study. When compared to the standard book based on Table 3, the six books generally contain all types of representations.

Criterion C2: Interpretation of Surface Features

Criterion C2 aims to analyze the constituent elements of a representation (interpretation of surface features) that are clearly labeled or designated in a representation. Criterion C2 consists of three typologies including: i) explicit, ii) implicit, iii) ambiguous. From the data analysis results in Table 3, it shows that the surface feature interpretation criteria (C2) in book A and book B generally contain explicit typology (i) with a percentage of 43% and 50% respectively, book C generally contains two typologies namely explicit typology (i) and implicit (ii) with a percentage of 44% respectively, book D generally contains implicit typology (ii) with a percentage of 63%, book E and book F generally contain explicit typology (i) with a percentage of 56% and 60%.

Criterion C3: Linkage of Image to Text

Criterion C3 aims to analyze how the representation is linked to the text contained in the textbook. Criterion C3 has five typologies as shown in Table 1. From the data analyzed in Table 3, it can be seen that book A generally contains a fully related and related typology (i) with a percentage of 71%, book B and book C generally contain a fully related and unrelated typology (ii) with a percentage of 60% and 56%, book D generally contains a fully related and unrelated typology (ii) and partially related and related with a percentage of 38% respectively, book E and book F generally contain a fully related and related typology (i) with a percentage of 83% and 100% respectively.

Criterion C4: Presence and Nature of Image Captions

Criterion C4 aims to analyze the captions of the representations contained in the textbooks. This criterion contains three typologies as shown in Table 1. From the data analyzed in Table 3, it can be seen that the existence and nature of captions (C4) in each textbook include: book A and book B generally contain the typology of the existence of captions accompanied by problems (ii) with a percentage of 57% and 60% respectively, book C typology generally contains the existence of appropriate captions (explicit, clear, concise, comprehensive, autonomous) (i) with a percentage of 56%, book D generally contains the typology of the existence of captions accompanied by problems (ii) and without captions (iii) each with a percentage of 50%, book E and book F generally contain the typology of the existence of appropriate captions (explicit, (i) with a percentage of 56%, book D generally contains the typology of the existence of captions accompanied by problems (ii) and without captions (iii) with a percentage of 50%, respectively, book E and book F generally contain the typology of the existence of appropriate captions (explicit, clear, concise, comprehensive, autonomous) (i) with a percentage of 89% and 80%.

Criterion C5: The Degree of Connectedness between Representations Consisting of Multiple Representations

This C5 criterion has the purpose of analyzing the relationship between representations contained in images in textbooks including macroscopic representations, sub-microscopic representations and symbolic representations that are clearly connected but, provided that the representations presented by the C1 criterion are multiple representations. Criterion C5 contains three typologies as shown in Table 1. From the data analyzed in Table 5, it can be seen that book A generally contains the typology of insufficiently related (ii) with a percentage of 7%, book B generally contains the typology of moderately related (i) with a percentage of 20%, book C and book D generally contain the typology of insufficiently related (ii) with a percentage of 11% and 13% respectively, book E and book F generally contain the typology of moderately related (i) with a percentage of 39% and 20% respectively.

Discussion

This analysis of the criteria and typology of multirepresentation of the Merdeka Curriculum chemistry book examines the representations contained in the six chemistry textbooks of the Merdeka Curriculum. This multirepresentation analysis also pays attention to the concepts contained in the six chemistry textbooks on chemical bonding material. Based on this, researchers use a standard chemistry textbook, namely a chemistry textbook by Jespersen, (2014) 7th edition.

The results of the chemical representation analysis of these six books focus on multiple and sub-microscopic representations, only a few of which involve macroscopic representations. Multiple representation is a representation that

describes one chemical phenomenon at two or three levels of chemical representation simultaneously while sub-microscopic representation is a representation that describes the structure and movement of real particles of matter, but too small to be observed (atoms, molecules, ions, electrons, etc.) (Wu & Shah, 2004). Furthermore, macroscopic representation is a representation that describes various real things or phenomena that can be observed with the five senses (Gilbert & Treagust, 2009). The results of the analysis of chemical textbook representation of chemical bonding material based on the criteria and typology developed by Gkitzia et al. (2011) are described as follows:

The type of representation in book A generally contains symbolic representation which has a percentage of 36%. These symbolic representations explain the concepts of covalent bonds, coordination covalent bonds, and lewis structures in covalent bonds. Book B generally has symbolic and multiple representation types with a percentage of 30% each. However, there are no hybrid and mixed representation types presented in textbook B. The types of representation in book C generally contain macroscopic, symbolic, multiple, and hybrid representations with a percentage of 22% each. However, in book C there is no mixed representation in it.

Book D generally has a symbolic representation type with a percentage of 63%. This symbolic representation explains the concept of lewis structure, polar covalent bond and coordination covalent bond. The type of representation in book E generally contains multiple and hybrid representations with a percentage of 39% and 33% respectively. Multiple representations in book E explain the concept of ion bonds, properties of ion compounds, electron configurations, atomic stability, formation of ion compounds and formation of covalent bonds. Book F generally contains sub-microscopic representation types with a percentage of 40%. The sub-microscopic representation in book F explains the concept of ion bond formation and metal bond. However, book F does not contain macroscopic representations and mixed representations.

1st Criterion (C1): Types of Representation

The type of representation of the first criterion (C1) in the six Independent Curriculum chemistry books generally presents multiple and sub-microscopic representations However, it is inversely proportional to the number of macroscopic representations. Meanwhile, there is no mixed representation in the six chemistry books. The presence of images with sub-microscopic representations helps learners imagine how a concept is explained in particulate or molecular form. The sub-microscopic level of the atomic world and its derivatives, which cannot be observed and the explanation can be given in the form of visual representations, for example in the form of graphs or graphic diagrams in two-dimensional form or in material form (Gilbert & Treagust, 2009). The following is an example of the representation presented in the Merdeka Curriculum chemistry book and refers to the standard chemistry book:

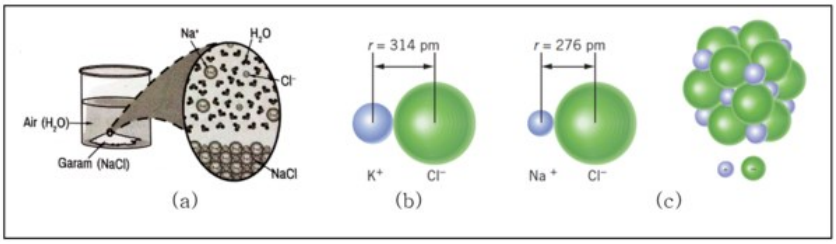

Figure 1. (a) Multiple representation types in textbook C, (b) Sub-microscopic representation types in the standard book, (c) Sub-microscopic representation types in the standard book

The representation presented in Figure 1 (a) is a type of multiple representation. Multiple representations are representations that describe one chemical phenomenon at two or three levels of chemical representation simultaneously (Wu & Shah, 2004). The representation shown in Figure 1 (a) explains the properties of ionic compounds that dissolve easily in water. However, the figure presented has a conceptual error in the sub-microscopic representation integrated in the multiple representation. This conceptual error lies in the representation of Na+ and Cl- ions. In Figure 1 (a), it can be seen that the size of Na+ ions is smaller than the size of Cl- ions. The size of Cl- ions should be larger than Na+ ions. Figure 1 (b) shows the representation in the standard book with sub-microscopic representation type. Figure 1 (b) explains the concept of ionic bonding. Ionic bonding is the force of attraction between positive and negative ions in ionic compounds (Jespersen, 2014). Figure 1 (b) and Figure 1 (c) are sub-microscopic representations that explain the concept of lattice energy and the effect of ion size on lattice energy. Lattice energy is the energy required to separate the ions in one mole of solid substance to produce a cloud of gas ions (Jespersen, 2014). In Figure 1 (b) and Figure 1 (c), there is an exact representation of the ion sizes of Na+ and Cl- ions. In both figures, the size of Cl- ions is larger than the ion size of Na+ ions.

2nd Criterion (C2): Interpretation of Surface Features

Criterion C2 aims to review the extent to which surface features (characteristics of each element that make up the representation or image presented in the textbook) are clearly labeled (description/explanation of each part). These three typologies were developed and can be used to analyze the C2 representation criteria in Table 1 as follows: Explicit surface feature interpretation is when all surface features or elements in a representation are clearly mentioned. Implicit surface feature interpretation is that only some surface features or elements on a representation are clearly labeled or indicated. Ambiguous surface feature interpretation is where no surface features or elements on a representation are clearly labeled or indicated (Gkitzia et al., 2011). The following are some examples of surface feature interpretations presented in the Merdeka Curriculum chemistry book and refer to standard books:

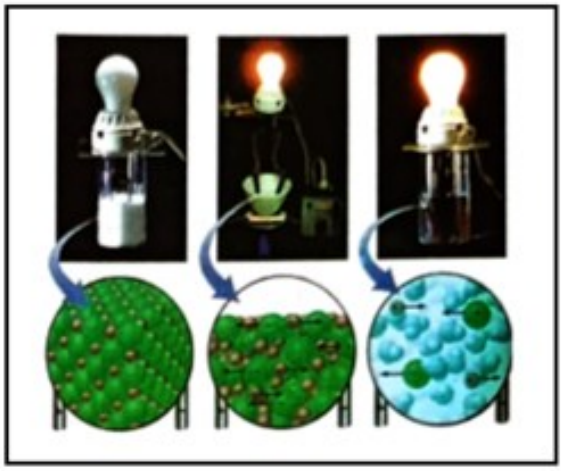

Figure 2. Interpretation of ambiguous typological surface features in book E

Figure 2 is a multiple representation with typology (iii) interpretation of ambiguous surface features contained in book E. The representation explains the concept of the nature of ionic compounds by representing three series of electrolyte solution test equipment, each of which contains solid NaCl, liquid NaCl (melt) and NaCl solution. However, in the representation presented there is no single surface feature in the representation so that the C2 representation criteria are included in the ambiguous typology. So it is necessary to add surface features to the representation so that students can understand the concept well. This is supported by the statement of Gkitzia et al. (2011). which states that the presence of simple representations in textbooks does not ensure that it can improve learning. Therefore, it is important to write labels or descriptions clearly on the elements that make up the representation.

Criterion 3 (C3): Image to Text Linkage

Criterion C3 aims to assess the extent to which the representations are connected and related to the content of the text, and whether there is a direct link from the text to the representations contained. Direct links are sentences or phrases that direct or refer the reader from the content of the text to the representations presented by the textbook. These include sentences such as “as seen in Figure 1” or “as seen in the representation”. The criterion of representation of the relationship between images and text in the six textbooks analyzed has five typologies that are in Table 1 in the C3 criteria section.

The six textbooks generally contain the first typology (i) in Table 1, namely when a representation describes and is directly related to the actual content of the text, and related here means that there are sentences or phrases that direct or connect readers directly to the representation presented. In books B and C in general contain fully related and unrelated typology, which is the same as the meaning of typology i), but unrelated here means that there is no connecting phrase or sentence between the text and the representation. In addition, there is a criterion C3 has another typology, the second typology (ii) in Table 1, which describes a

common subject in the text but not the actual subject. Unrelated is when a representation is unrelated and irrelevant to the content of the text. The following are some examples of the criteria (C3) of the relationship between the image and the text presented in the independent curriculum chemistry textbook and refer to the standard chemistry textbook for the C3 typology (iii) representation criteria in the following figure:

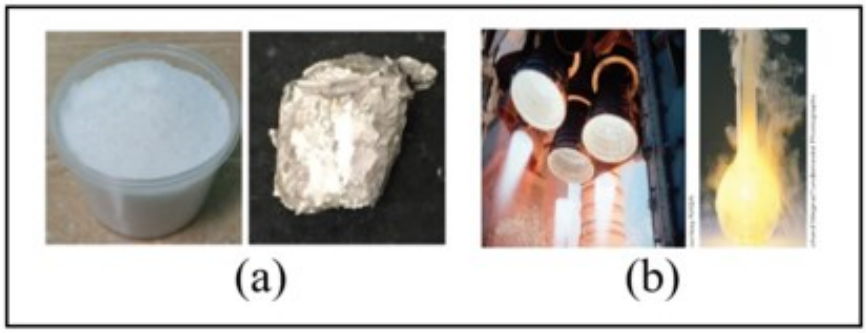

Figure 3. (a) Representation criterion C3 typology (iv) partially related and unrelated in book A and (b) Representation criterion C3 typology (i) fully related and related in the standard book.

Figure 3 (a) is a C3 representation criterion with typology (iv) partially related and unrelated in book A. Where the text explanation of the fully related representation example in Figure 4 (a) is “Try to hold a lump of table salt? It has a rough texture and is easy to crush, right? Table salt is also safe to touch the skin. It's very different from sodium metal. Sodium metal is very reactive. Sodium metal can react violently with the water content on the surface of the skin. Sodium metal is also not easily crushed, but easily cut with a knife...”. Meanwhile, it is said to be unrelated because in the content of the text there are no phrases or sentences that are directly linked to refer to the representations presented. Thus, there is a possibility that learners will skip these chemical representations without paying attention to them, either because they do not understand what they have to do with the content of the text, or because they generally have a tendency to read only the obvious (Gkitzia et al., 2011). However, when compared to the representations in the standard book in Figure 4 (b), the C3 representations presented are of typology (i) i.e. fully connected and related which, in terms of the text content, explains the representation as a whole.

Criterion 4 (C4): Existence and nature of picture captions

Criterion C4 in book A and book B generally contains the C4 typology of captions with problems (ii) with a percentage of 57% and 60% respectively. Book C, book E and book F generally contain the existence of appropriate captions typology (i) with percentages of 56%, 89% and 80% respectively. Book D generally contains the C4 criteria of the typology of captions accompanied by problems (ii) and typology without captions (iii) with a percentage of 50% for each typology. The typology without caption (iii) shows that 50% of the representations in textbook D do not include captions. The criterion for the presence of captions on images (C4)

is only used for representations that are not included in the text. This is because the included representations act as part of the text that precisely describes its content so there is no need for captions (Gkitzia et al., 2011). This is the case for some of the representations included in the textbook D.

Figure 3 (a) is a representation with the typology of a caption accompanied by a problem found in book D. This representation represents graphite and diamond which both have carbon atoms as their constituents. The caption on the representation is "Graphite and diamond". When referring to the image given where there are two objects presented in the representation, namely the first image is diamond and the second image is graphite. However, there is a caption in reverse order and only the caption "Figure 1.1 graphite and diamond" is written when the first image is a representation of diamond while the second image is a representation of graphite. Therefore, Figure 3 (a) should include a clear caption, namely "Figure 1.1 (a) Diamond and (b) Graphite" so that students can understand the meaning of the representation presented in book D. This is inversely proportional to the caption in the standard book.

Figure 3 (b) contains representations with two different objects that explain the need for energy in forming chemical bonds. The representation presented has the existence and nature of a clear caption. In object a the representation shows a violent reaction of hydrogen with oxygen that provides thrust to the engine of the shuttle and in object b the representation shows a small piece of sodium melting and burning immediately. when dipped in a flask containing chlorine gas and produces light and heat. Both objects in this representation contain the caption "Figure 8.1 (a) Reaction of hydrogen with oxygen, (b) Exothermic reaction of sodium with chlorine". The representations presented in book D should contain the existence and nature of clear information so that it helps students in understanding the representations presented in the textbook. This caption or caption is one of the important things in a representation, because it can clarify the message and content in the representation, so a caption or caption is needed that is in accordance with the representation presented, with the appropriate caption can help learners understand the message and content of a representation without having to see the related text (Gkitzia et al., 2011).

Criterion 5 (C5): Degree of Connectedness between Representations consisting of Multiple Representations

Criterion C5 is only used to analyze the first criterion (C1) with multiple typologies. This C5 criterion contains three typologies including: i) sufficiently related, ii) not sufficiently related, and iii) not related. The analyzed independent curriculum chemistry textbooks found several types of multiple representations. Multiple representations with typology (i) moderately related are generally contained by book E by 39% while multiple representations with typology (ii) not related enough are generally contained by book D by 13%. However, multiple representations of typology (iii) unrelated were not found in all textbooks analyzed. Representations are moderately related (typology i) when two or three representations integrated in the multiple are connected by an arrow so that the

relationship is visible. Representation is not sufficiently related (typology ii) when there is only some equivalence between two or three types of representations presented clearly depicted with parallel positions. However, in unrelated representations (typology iii) when the included subordinate representations are only positioned next to each other and there is no indication of equality in each type of representation presented.

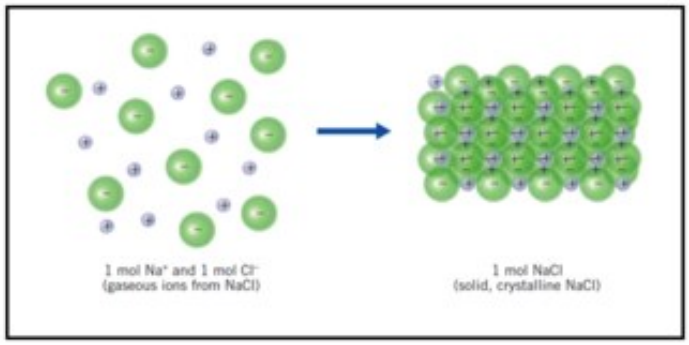

Figure 4. Representation of multiple typologies is not sufficiently linked to standard books

Figure 4 is an example of a representation that has been analyzed using the C1 criterion and has a multiple representation type that involves two levels of representation including sub-microscopic representation and symbolic representation. The sub-microscopic representation is Na+ ions and Cl- ions in the gas phase then form NaCl crystals in the solid phase. While the symbolic representation is indicated by the symbol of the unit of the amount of substance, namely one mole and the symbol of the cation (Na +) and anion (Cl-). These representations are grouped in multiple representations in the typology not sufficiently related (ii) because sub-microscopic and symbolic representations are placed in parallel or parallel, so that learners can understand the equivalence of these multiple representations, but not indicated by arrows or symbols between the two types of representation. This correlation is very important to build relationships between the three levels of chemical representations (Gkitzia et al., 2011).

4. Conclusion

The results of the analysis of multirepresentation criteria in chemistry textbooks of the independent curriculum show that in criterion C1 the type of representation of the six textbooks in general is multiple and sub-microscopic representations, in criterion C2 the interpretation of surface features of the six books is generally explicit typology, in criterion C3 the relationship between representation and text generally contains typology (i) fully related and related, in criterion C4 the existence and nature of image captions generally contains typology (i) the existence of appropriate captions (explicit, clear, brief, comprehensive, autonomous), and in criterion C5 the level of connection between representations generally contains typology (i) moderately related.

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References

Blongkod, R., Hafid, R., & Mahmud, M. (2022). Pengaruh Penggunaan Buku Teks Terhadap Hasil Belajar Siswa Pada Mata Pelajaran IPS Terpadu Kelas VIII Di SMP Cokroaminoto Solog Kabupaten Bolaang Mongondow. *Aksara: Jurnal Ilmu Pendidikan Nonformal*, *8*(3), 2131–2140. http://dx.doi.org/10.37905/aksara.8.3.2131-2140.2022

Gabel, D. L. (1993). Use Of The Particle Nature Of Matter In Developing Conceptual Understanding. ACS Publications. https://pubs.acs.org/doi/pdf/10.1021/ed070p193

Gilbert and Treagust, D. (2009). *Multiple Representasi in Chemical Education*.

Gkitzia, V., Salta, K., & Tzougraki, C. (2011). Development And Application Of Suitable Criteria For The Evaluation Of Chemical Representations In School Textbooks. *Chemistry Education Research and Practice*, *12*(1), 5–14. https://doi.org/10.1039/C1RP90003J

Hasanah, D., Mulyani, S., & Widhiyanti, T. (2024). Multiple Representations Analysis of Chemical Bonding Concepts in General Chemistry Books. *KnE Social Sciences*, 248–257. https://doi.org/10.18502/kss.v9i8.15554

Humayra, T. H. (2024). Analisis Pemahaman Kimia dan Keterampilan Proses Kurikulum Merdeka pada Materi Struktur Atom Fase E SMA/MA. Universitas Negeri Padang. https://doi.org/10.31004/jptam.v7i3.10774

Iswanto, E., Sumiharsono, R., & Hidayat, S. (2018). Pengaruh Penggunaan Media Pembelajaran Berbasis Powerpoint dan Buku Teks terhadap Hasil Belajar Ilmu Pengetahuan Alam (IPA) Materi Tata Surya Siswa Kelas VI Semester Ganjil Tahun Pelajaran 2018-2019 di MI Negeri 2 Jember. *Journal of Education Technology and Inovation*, *1*(2), 7–20. https://doi.org/10.31537/jeti.vli2

Jespersen, N. D. A. H. (2014). CHEMISRTY The Molecular Nature of Matter (7th ed.). Willey.

Lutviana, E., Sentot Budi, R., Vh, E. S., & Indriyanti, N. Y. (2019). Analisis Konten Buku Teks Sekolah Pada Materi Ikatan Kimia Ditinjau Dari Kriteria Representasi Kimia. *Jurnal Penelitian Pendidikan*, *22*(1). https://doi.org/10.20961/paedagogia.v22i1.29984

Magdalena, I., Sundari, T., Nurkamilah, S., Nasrullah, N., & Amalia, D. A. (2020). Analisis Bahan Ajar. *Nusantara*, *2*(2), 311–326.

Sugiyono. (2013). Metode Penelitian Kuantitatif Kualitatif dan R&D. Alfabeta.

Suparwati, N. M. A. (2022). Analisis Reduksi Miskonsepsi Kimia Dengan Pendekatan Multi Level Representasi: Systematic Literature Review. *Jurnal Pendidikan Mipa*, *12*(2), 341–348. https://doi.org/10.37630/jpm.v12i2.591

Tolingguhu, K., Panigoro, M., Bahsoan, A., Mahmud, M., & Toralawe, Y. (2024). Pengaruh Penggunaan Sumber Belajar Berbasis Buku Teks Terhadap Hasil

Belajar Siswa Pada Mata Pelajaran Ips Terpadu. *Damhil Education Journal*, *4*(2), 91–102. http://dx.doi.org/10.37905/dej.v4i2.2491

Upahi, J. E., & Ramnarain, U. (2023). Analysis of Chemical Representations in the Physical Sciences Textbooks for Grade 12 Learners in South Africa. *International Journal of Innovation in Science and Mathematics Education*, *31*(1). https://doi.org/10.30722/IJISME.31.01.004

Wu, H., & Shah, P. (2004). Exploring Visuospatial Thinking In Chemistry Learning. *Science Education*, *88*(3), 465–492. https://doi.org/10.1002/sce.10126

Yustin, D. L., & Wiyarsi, A. (2019). Students' Chemical Literacy: A Study In Chemical Bonding. *Journal of Physics: Conference Series*, *1397*(1), 12036. https://doi.org/ 10.1088/1742-6596/1397/1/012036

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