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Bridging Vocational Needs with Chemistry Content: Designing an Outline of Chemistry Teaching Materials for Textile Dyeing Context

Muhammad Syahrur Royhan[1], Sjaeful Anwar[1*], Ijang Rohman[1]

[1] Chemistry Education, Universitas Pendidikan Indonesia, Bandung, Indonesia.

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Corresponding Author:
Sjaeful Anwar
sjaefulanwar@upi.edu

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Abstract: The merging of adaptive chemistry subjects (C.1) into the IPAS project subject in the Independent Curriculum causes the chemistry content to be non-specific and not adapted to all vocational elements. This has the potential to hinder students' understanding of relevant chemistry concepts in their vocational context. This study aims to design an outline of chemistry teaching materials that are relevant to the needs of dyeing subjects in Textile Finishing Engineering VHS. The method used is Qualitative Content Analysis (QCA) with four stages to obtain and evaluate chemistry content related to the dyeing context. The results show that there are 19 chemistry contents that have been systematically arranged and validated based on the sequence, details, and their relationship to the dyeing context. For example, the content of electrolyte solution, acid base, ion equilibrium in solution, and reaction rate plays an important role in regulating the affinity of dyes to fibers and the speed of the dyeing process. This outline is useful for teachers or education practitioners as a clear guide to integrating chemistry content and vocational contexts into learning or teaching materials. For students, it can help them understand chemistry concepts that are more contextual and applicable to their vocational fields.

Keywords: Dyeing context; Needs analysis; Outline of teaching materials; Textile finishing engineering

Introduction

The mismatch between chemistry content in the Independent Curriculum and vocational needs in Vocational High Schools (VHS) is a major problem in learning chemistry. In the curriculum, adaptive content group subjects (C.1) have been merged into the Natural and Social Sciences (IPAS) project subject (Nengsih et al., 2023). This causes the chemistry content in VHS to be non-specific and not adapted to the characteristics of the field of expertise (Haryani et al., 2022; Hidayah et al., 2023). In fact, chemistry is an important discipline in understanding technical processes in various vocational fields (Aeni, 2019; Wiyarsi et al., 2020; Wiyarsi et al., 2020). This has the potential to hinder students' understanding of chemistry concepts that are relevant in their vocational context.

One of the causes is the assumption that chemistry is not related to the vocational field (Hofstein & Kesner, 2006; Rahmawati et al., 2021) so that the interest and attitude of vocational students towards chemistry is low (Wiyarsi et al., 2020). This assumption has an impact on the lack of emphasis on relevant chemistry content in the curriculum. Several studies show the consequences, including students' low understanding of the concept of changes in the state of matter in the context of chemical analysis (Abdullah et al., 2021) and misconceptions about the concept of chemical equilibrium in Pharmacy VHS (Ranggu, 2023). Another problem is that there is still little availability of teaching materials that are

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integrated with their vocational context (Kartini et al., 2022; Masbukhin & Sausan, 2023). These findings indicate the need for a more contextual chemistry content outline that is in line with the needs and characteristics of VHS.

In Indonesia, most vocational high school expertise programs are dominated by engineering. In this expertise program, chemistry learning is needed to equip students with knowledge and skills that can be applied to solve problems in everyday life, which ultimately supports the development of their vocational subjects (Lehn, 2015; Yuliastini et al., 2018). This is in line with the concept of Context-Based Learning (CBL) as a learning approach that integrates science concepts with everyday life and real contexts in the classroom (Broman et al., 2022; Fayzullina et al., 2023; Wei & Long, 2021). Several studies also support that vocational contexts can be used to develop chemistry learning content in VHS (Dinihari et al., 2021; Firdaus et al., 2024; Wiyarsi et al., 2020).

One of the engineering expertise program in Indonesia is the Textile Finishing Engineering VHS. The results of observations and interviews with the IPAS project teachers and several vocational teachers at this VHS show that the chemistry content in the IPAS project is still general and does not match what is needed in the vocational content. This can be proven through the chemistry content in the IPAS project module. The chemistry content only consist of chapters on Material & Its Changes and Energy & Its Changes (Sagendra et al., 2021). In fact, an understanding of basic chemistry is very necessary in the textile field (Sun, 2017) because it is directly related to the processing of textile materials (Arputharaj et al., 2016). Therefore, the basic chemistry content must be accommodated in the adaptive chemistry content contained in the IPAS project subject (Maryanti et al., 2021). For example, the concept of physical and chemical properties of substances helps students understand the importance of work safety in laboratories or the textile industry (Lau et al., 2017), chemical bonds are needed to understand how fibers bind to dyes (Ketema & Worku, 2020), and reaction rates are needed to understand the effects of concentration and temperature on the process of dye absorption in fibers (Siddiqua et al., 2017).

One of the subjects in Textile Finishing Engineering VHS is the dyeing process (BSKAP, 2024). Dyeing is the process of coloring textile materials into dyes that are dissolved or dispersed into water or other mediums (Repon et al., 2024; Uddin et al., 2022). The main purpose of dyeing is to produce even and long-lasting colors through chemical binding of dyes to textile fibers (Islam et al., 2022). However, this subject is often not associated with chemical knowledge. In fact, dyeing is highly dependent on chemistry principles. First, from the aspect of the chemical properties of the dye, the molecular structure and functional groups of the dye determine its solubility, stability, and affinity for the fiber (Islam et al., 2022). Second, the chemical interaction between dyes and fibers is greatly influenced by the type of textile fiber, which has different polarity properties, availability of functional groups, and absorption capacities (Yi-wei et al., 2023). Third, environmental conditions in the dyeing process such as concentration of the dye (Islam et al., 2022) and auxiliaries (Ji et al., 2024), pH value, and temperature (Moula et al., 2022; Rápó & Tonk, 2021) also play an important role in determining the quality of dyeing results.

However, until now there has been no reference document or outline that systematically identifies relevant chemistry content to the dyeing context. Therefore, this study aims to design an outline that contains relevant chemistry content relevant to the dyeing context in Textile Finishing Engineering VHS. This outline includes identification of chemistry content, details of chemistry content, and its relationship to the dyeing context based on an analysis of the dyeing textbooks used in the VHS. This study is important as an initial step in providing a reference for learning and developing contextual chemistry teaching materials by referring to the outline.

Method

This study uses the Qualitative Content Analysis (QCA) method according to Mayring (2000). QCA is a methodological approach to empirical text analysis with textual materials such as interview transcripts and/or document analysis (P. Mayring, 2000, 2015; P. A. E. Mayring, 2023). The stages of analysis carried out follow Figure 1.

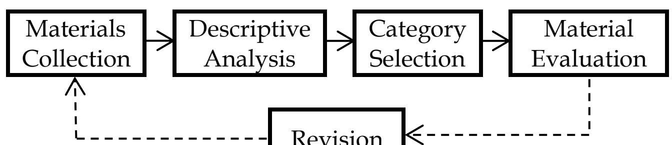


Figure 1. Stages of qualitative content analysis

This research was conducted in one of the VHS in Bandung City that has the expertise of Textile Finishing Engineering. This school was chosen because it planned to organize a special chemistry subject to support vocational subjects. Participants in this study consisted of an IPAS project teacher, four vocational teachers, a chemistry teacher, and two chemistry education experts who were the authors of this study.

In the first phase, the materials were collected through several techniques, namely documentation study and interviews. Documentation study consisted of collecting several data sources such as transcripts of the Independent Curriculum VHS and dyeing textbooks used by dyeing subject teacher. Meanwhile, interviews aimed to collect data related to the suitability of the Independent Curriculum in facilitating students' needs for chemistry content that needs to be taught to support vocational subjects. Interviews were conducted with an IPAS project teacher and four vocational teachers.

The second phase is descriptive analysis, all data sources that have been collected are analyzed to determine the category (dyeing content) related to chemistry content. This dyeing content is based on Learning Outcomes (CP) and textbooks used in the VHS. The third phase is category selection, where categories are used to generate themes (chemistry content) based on basic chemistry content that is related to the dyeing context. For example, in the textbook, an explanation is found regarding "the effect of concentration and pH of dye solution on the speed of dyeing process". This is included in the category of "factors that affecting dyeing". Therefore, the theme of the chemistry content is "reaction rate".

Finally, the fourth phase is the material evaluation. First, the results of the analysis of the second and third phases are validated for their suitability by the dyeing subject teacher. Second, the results of the validation are developed into prerequisite chemistry content and validated by the chemistry teacher. After obtaining complete chemistry content with prerequisite content, an outline of the teaching material is designed that contains chemistry content, details, and its dyeing context in sequence. Third, the results of this outline of the teaching material are evaluated for their correctness including the sequence based on prerequisite chemistry content, material details based on CP, and the appropriate link between chemistry content and dyeing context based on the relationship between the two. This is done by two chemistry education experts and verified through data triangulation with the results from vocational teacher and chemistry teacher. The resulting feedback is then used to improve the outline. All stages in this evaluation phase are assessed based on the criteria of "Yes/Appropriate" or "Not Appropriate" and a suggestion column to improve inappropriate results.

Overall, this study used two instruments, namely interview guidelines and validation sheets. The interview guidelines contained questions related to the suitability of the Independent Curriculum in facilitating chemistry content in a vocational context. Interviews were conducted by the IPAS project teacher and four vocational teachers. The validation instruments consisted of: first, a validation sheet of the suitability of chemistry content with dyeing content. This was validated by the dyeing subject teacher. Second, a validation sheet of the truth of the prerequisite chemistry content validated by the chemistry teacher. Third, a validation sheet of the suitability of the outline of chemistry teaching material validated by two chemistry education experts, a vocational teacher, and a chemistry teacher. This validation instrument was designed based on the findings in the previous phase.

Result and Discussion

Curriculum Suitability with Chemistry Content

Based on the results of the analysis of several transcripts of the Independent Curriculum VHS and the results of interviews with an IPAS project teacher and four vocational teachers, it was found that the current curriculum does not facilitate chemistry content for vocational subjects. For example, the IPAS project teacher stated.

> *"…. In the Independent Curriculum, the chemistry content provided in the IPAS project is inadequate to support vocational subjects. On the other hand, chemistry content cannot be accommodated in the IPAS project subject."*

Meanwhile, one of the vocational teachers stated

> *".... When the adaptive chemistry subject was removed from the Independent Curriculum, students did not understand their vocational content. .... Even during the practicum, they could not choose the right chemicals because they could not read the chemical formula of the chemicals. As a result, students made many mistakes in choosing chemicals for practicums."*

This is in line with the research of Hidayah et al. (2023) that the Independent Curriculum does not facilitate knowledge of science content (chemistry) to support vocational subjects. In fact, students can understand vocational content comprehensively if students are able to understand the chemistry content involved in it (Wiyarsi et al., 2020).

Teaching Resource of Dyeing Subject

Table 1. Teaching Resource of Dyeing Subject

Author	Title	Year
Sunarto	Dyeing and Printing Techniques	2008
Noerati et al.	Textile Technology	2013
Zyahri	Introduction to Textile Science 2	2013
Ichwan	Dyeing Technology	2014

The results of the interview showed that there was a mismatch between the curriculum and the needs of the chemistry content in the vocational school. Therefore, further analysis is needed regarding the chemistry content contained in several textbooks used. Based on the results of collecting several textbooks used by dyeing subject teachers, four textbooks were obtained which are presented in Table 1. These textbooks are available on the internet, three of which are published by the Ministry of Education and Culture and the rest are published by the Textile Technology College.

Categorization of Dyeing Content

In this phase, all textbooks used by the dyeing subject teachers were analyzed descriptively based on the CP of the dyeing subject. This phase aims to obtain categories (dyeing content) related to chemistry content. The results obtained seven categories related to dyeing content, namely Definition of Dyeing; Classification of Textile Dyes; Structure of Textile Dyes; Types of Fiber and Their Functional Groups; Dyeing Mechanism; Classification of Textile Auxiliares; and Factors Affecting Dyeing. The analysis process that refers to the curriculum or CP aims to regulate the level of depth of content that will be given to students. This refers to the extent to which the curriculum can develop students' conceptual understanding and internalize it meaningfully (Schwartz et al., 2009). The results of the descriptive analysis of the four textbooks are explained in Table 2 in the right column.

Table 2. Categories of Dyeing Content

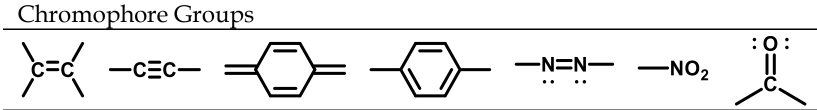
Categories (Dyeing content)	Analysis
Definition of Dyeing	Dyeing is the process of evenly coloring textile materials, whether in the form of fibers, threads or fabrics, using dyes that are dissolved or dispersed in water or other mediums (Ichwan, 2014; Sunarto, 2008; Zyahri, 2013). This process involves the absorption of dye into the fiber through exothermic and equilibrium reactions (Zyahri, 2013), so that it produces a color that matches the target, is even, and has good fastness (Ichwan, 2014).
Classification of Textile Dyes	Textile dyes are classified based on their group or type of fiber (Ichwan, 2014; Noerati et al., 2013; Sunarto, 2008; Zyahri, 2013).

Based on Class/Group		Based on Fiber Type						
Class/Group	Types of Dyes	Types of Dyes	C	P	A	PA	PAAc	PES
I	Direct dyes	Direct dyes	+	+		+		
	Acid dyes	Acid dyes		+		+	+	
	Basic dyes	Basic dyes	+	+	+		+	
	Disperse dyes	Disperse dyes			+	+	+	+
	Metal complex dyes	Metal complex dyes		+		+	+	
II	Sulfur dyes	Sulfur dyes	+	+				
	Vat dyes	Vat dyes	+	+				+
	Aniline black dyes	Mordant dyes		+				
III	Direct dyes	Oxidation dyes	+					
	Naphthol (azo) dyes	Naphthol (azo) dyes	+		+		+	+
IV	Pigment dyes	Pigment dyes	+	+	+	+	+	+
	Reactive dyes	Reactive dyes	+	+		+		

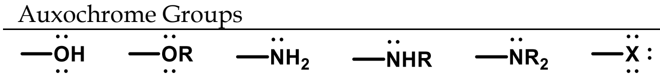
Notes: C = Cellulose; P = Protein; A = Acetate; PA = Polyamide; PAAc = Polyacrylate; PES = Polyester; + = Can bind to certain fibers.

Categories (Dyeing content)	Analysis
Structure of Textile Dyes	Textile dyes are compounds that can absorb and reflect light in the visible spectrum range (400 - 700 nm), which allows humans to see color. In addition, textile dyes can also absorb light in the UV spectrum range (100 - 400 nm). This is because the dye molecules have chromophore and auxochrome groups. The chromophore group is an unsaturated group that is responsible for the absorption of UV or visible light (Sunarto, 2008; Zyahri, 2013). While the auxochrome group is a saturated group that is bound to the chromophore and can intensify the color. The most common chromophore group found in textile dyes is the benzene ring (Ichwan, 2014).

Chromophore Groups



Auxochrome Groups



Categories (Dyeing content)	Analysis
Types of Fiber and Their Functional Groups	Dyeing aims to provide even color to the fabric through the absorption or binding of dyes to textile fibers (Sunarto, 2008). Based on their chemical structure, fibers are classified into natural fibers (cellulose and protein) and synthetic polymers (polyester, polyamide, & polyacrylate) (Noerati et al., 2013; Zyahri, 2013). The functional groups in these fibers can be seen in the table below.

Types of Fiber	Functional Group	Functional Group Name
Natural fiber		
Cellulose	R – OH	Hydroxyl / Alcohol

Categories (Dyeing content)	Analysis		
	Protein	R – CHO	Aldehyde
		R – CO – R′	Ketone
		$R - NH_2$	Amine
		R – OH	Hydroxyl / Alcohol
		R – COOH	Carboxylate
		R – SH	Thiol
	Synthetic Polymer		
	Polyester (PES) (Polyethylene terephthalate (PET))	R – COO – R′	Ester
		R – COOH	Carboxylate
		R – OH	Hydroxyl / Alcohol
	Polyamide (nylon)	$R - CNO - R_2$	Amide
		$R - NH_2$	Amine
	Polyacrylate	R – COO – R′	Ester
		$- CH = CH_2$	Vinyl / Ethenyl
	Each type of fiber has different functional groups and affects its interaction with the dye. Therefore, the selection of dye must be adjusted to the type of fiber so that the dyeing produces optimal color (Sunarto, 2008).		
Dyeing Mechanism	In general, the dyeing mechanism consists of dissolving and dispersing textile dyes into water or other mediums. Then, the textile material is put into the solution so that the dye is absorbed into the fiber (Ichwan, 2014; Zyahri, 2013). Specifically, the dyeing mechanism consists of several stages (Noerati et al., 2013; Sunarto, 2008), namely: 1. Diffusion & Migration: Dye molecules will undergo diffusion when dissolved. Dye molecules in solution will approach textile materials (migration) because the surface of textile fibers is negatively charged, thus affecting the interaction with dye molecules. At this stage, there are two possibilities, namely dye molecules are attracted to the fiber or repelled away from the fiber. To ensure that dye molecules are more easily approached the fiber surface, textile auxiliaries need to be added to the solution. 2. Adsorption: Dye molecules that have enough energy to overcome the repulsive force from the fiber surface and stick to the fiber surface. The process of attaching dye molecules to the fiber surface is called adsorption. 3. Diffusion: Dye molecules penetrate from the fiber surface to the inside of the fiber. This process is the slowest and is therefore used as a reference to determine the rate of the dyeing process. 4. Fixation: The process of forming a strong chemical bond between the dye and the fiber, so that it has good color fastness. This process is called dye fixation and is carried out by controlling the conditions of the solution and/or textile fibers. Good dyeing results mean that the dye and fiber have strong chemical interactions. In other words, the bond and/or intermolecular force between the dye and the fiber must be greater than the dye with water or its solvent (Sunarto, 2008). Ionic bonds can form between the dye and functional groups on the fiber or metal ions with opposite charges (Ichwan, 2014). Covalent bonds occur between reactive dyes and fibers, making them difficult to remove. Intermolecular forces, such as van der Waals forces and hydrogen bonds, also affect the interaction between the dye and the fiber, which contributes to the color fastness to washing (Noerati et al., 2013; Sunarto, 2008).		
Classification of Textile Auxiliares	The dyeing process requires textile auxiliaries to optimize the dyeing process on the fiber. In general, textile auxiliaries function to prepare and improve the readiness of the fiber for dyeing, modify the characteristics of dye absorption, stabilize and protect the dye dissolving/dispersing media, and increase color fastness (Sunarto, 2008). Based on their properties, textile auxiliaries consist of electrolyte solutions, pH regulators, complexing agents, solvents and dispersing agents, thickeners, and surfactants (Ichwan, 2014).		
Factors Affecting Dyeing	Several factors that can affect the dyeing process of textile dyes include the type of dye, the structure and size of the dye molecules, and the physical and chemical properties of the dye. In addition, the use of auxiliary substances such as electrolyte solutions, the concentration of dyes and auxiliary substances, temperature, and the pH of the dye solution can affect the dyeing process of certain textile dyes (Noerati et al., 2013; Sunarto, 2008).		

Relevance of Chemistry Content Themes

Based on the analysis results of the seven categories of dyeing content, 19 chemistry content themes were obtained that were directly related to the dyeing process (see Table 3). Each category can be related to several themes or vice versa, each theme can be related to several categories. These themes are important because they have the potential to develop students' understanding and application in the dyeing process.

For example, the hydrocarbon & its derivatives theme includes an understanding of hydrocarbon structures and functional groups. This concept is the basis for students to understand the structures of textile dyes which can affect their solubility and affinity for fibers. The benzene & its derivatives theme provides an understanding of how the benzene ring as one of the chromophore groups can be responsible for the appearance of color considering that most dyes have an aromatic core as their chromophore group. Substitution reactions are also the basis for synthesizing textile dyes. For example, diazotization reactions and coupling reactions are two-step dyeing methods used in the azo dyeing process so that the color bound to the fabric has good color fastness.

Another more applicable example can be seen in the theme of chemical bonds, hydrocarbon & its derivatives (functional groups), and polymers. These three themes are related to dyeing mechanism and types of fiber & their functional groups. These three themes can help students understand what chemical interactions occur for each dye against the types of fibers that are suitable. For example, the use of reactive dyes is able to bond tightly with cellulose fibers while acid dyes are not. This is because reactive dyes have reactive groups that are able to bond covalently with cellulose fibers through their – OH groups while acid dyes bond ionically with protein fibers (wool and silk) through intermolecular forces. This allows students to choose the appropriate type of dye based on its chemical affinity for the fiber.

Then, the theme of electrolyte solution, acid base (pH value), and ion equilibrium in solution plays an important role in regulating the affinity of dyes to fibers. In dyeing practice, electrolyte solutions such as NaCl are often added to increase the affinity of dyes to fibers by reducing the repulsion of their intermolecular charges. In addition, understanding the pH value is also important because each type of dye has an optimal pH range to interact optimally with fibers. For example, basic dyes work optimally at neutral to weakly basic pH while acidic dyes require a lower pH.

Finally, the reaction rate theme explains the effect of dye concentration and temperature on the speed of dye fixation to the fiber. Setting the optimal conditions of concentration and temperature is crucial to achieve even color and good color fastness. For example, increasing the temperature can speed up dye absorption, but if it is too high, it can cause color degradation or fiber damage. Thus, the implication is clear, namely to help students optimize dyeing conditions. The examples above show why some of these themes are important in the context of dyeing.

Other themes have the same pattern of connections as the previous examples. The list of 19 themes is listed in Table 3 in the left column. Meanwhile, their connection to the dyeing context can be seen in the right column. Therefore, these themes are important to support the context in vocational subjects.

The Results of Material Evaluation

First, the previously obtained themes were validated by the dyeing subject teachers. The validation results showed that all of the themes were directly related to the dyeing context taught in schools. The teachers assessed that the scope of the themes was complete and the contents could support students' understanding of the dyeing process. This is an initial reference that the results of the theme mapping have adequately captured the conceptual and practical needs in dyeing learning.

Second, the validated themes are analyzed for their prerequisite chemistry content. Each theme is analyzed to obtain the prerequisite chemistry content theme and the underlying subtheme (chemistry content details). For example, before students understand the concept of functional groups, they first need to master the structure of hydrocarbons (alkanes, alkenes, alkynes) and the concept of hydrocarbon structure can be understood if students have mastered the concept of chemical bonds (covalent bonds). Another example is, before they understand the concept of pH, they must study the properties and characteristics of acids and bases based on Arrhenius theory and the concept of chemical reaction equations. This approach shows that mastery of one theme cannot stand alone, but requires a foundation from other more basic concepts. Determining this prerequisite chemistry content allows for the systematic arrangement of a hierarchy of chemistry content starting from simple concepts to more complex concepts and the appropriate content sequence. As the results of Sveinbjornsson (2021) study stated that students who master the prerequisite chemistry content have a more complete understanding than those who do not. The results of the chemistry teacher validation stated that all prerequisite chemistry content was declared good and could be developed into an outline of the teaching material.

Third, the chemistry content is arranged into an outline. This outline consists of three columns, namely the theme of chemistry content, details of chemistry content, and its context in the dyeing process. The validation results from two chemistry education experts, a dyeing subject teacher, and a chemistry teacher stated that the structure and sequence of the theme were logical, the details of the subthemes were quite complete and in accordance with the needs of the dyeing context, and each theme had a clear connection to the dyeing context.

However, one of the chemistry education experts suggested that the periodic table of element theme need to be linked to the context related to the influence of transition metal elements on textile dyes. Transition metal elements are usually able to form coordination complexes with certain dye structures so that they can increase their color fastness. Further verification was carried out with chemistry teachers and dyeing subject teachers and stated that it was true that the transition metal context could be added. However, this context needs to be limited to the topic of mordanting only. For example, transition metal ions such as Al (from alum) can form coordination complexes with the molecular structure of natural dyes so that the size of the molecules becomes larger and can be trapped in the fiber structure, thereby increasing their color fastness. Therefore, in the revised outline, this context is added specifically to the discussion of mordanting only. Overall, this outline is stated to be appropriate based on the sequence, content details, and their relationships. The complete outline of this chemistry teaching material is presented in Table 3 below.

Table 3. Outline of Chemistry Teaching Material for Dyeing Context

Themes (Chemistry Content)	Chemistry Content Details	Context in Dyeing Process
Classification of Materials	A. Based on Phase of Matter (Solid, Liquid, Gas) B. Based on Composition of Matter 1. Elements 2. Compounds 3. Mixtures	• The phase of dyestuffs and textile auxiliaries in dyeing.
Properties of Matter and Its Changes	A. Properties of Matter 1. Physical Properties 2. Chemical Properties B. Changes in Matter 1. Physical Changes 2. Chemical Changes	• Physical and chemical properties of dyestuffs and textile auxiliaries in dyeing.
Periodic Table of Elements	A. Electron Configuration B. Period and Group C. Periodic Properties of Elements 1. Periodic Properties of Main Group Elements 2. Periodic Properties of Transition Group Elements	• The effect of transition metal ions on mordant dyes. • The effect of the electronegativity of an element on the polarity and intermolecular forces of textile dyes.
Nomenclature and Formula of Chemical Compounds	A. Nomenclature and Formulas of Binary Compounds B. Nomenclature and Formulas of Polyatomic Compounds	• Nomenclature and chemical formulas of acidic/basic textile auxiliaries, reducing/oxidizing agents, and thickeners in dyeing
Chemical Reaction Equations	A. Chemical Reaction Equations B. Balancing Chemical Reaction Equations	• Reaction equations in the process of making dye solutions or in the dyeing process.
Chemical Bonds	A. Ionic Bonds B. Covalent Bonds 1. Single Covalent Bonds 2. Double Covalent Bonds 3. Triple Covalent Bonds 4. Polar and Nonpolar Covalent Bonds 5. Nonpolar Covalent Bonds 6. Coordinate Covalent Bonds C. Intermolecular Forces 1. Hydrogen Bonds 2. Van der Waals Forces • Dipole-Dipole Forces • Induced Dipole-Dipole Forces • London Dispersion Forces	• Ionic bonds and intermolecular forces in the preparation of dye solutions. • Ionic, covalent, hydrogen bonds, and other intermolecular forces in the process of dye absorption on fibers.
Classification and Management of Hazardous and Toxic Materials	A. Hazardous and Toxic Materials Classification B. Material Safety Data Sheet (MSDS) C. Hazardous and Toxic Materials Management 1. Storage Procedures	• Identification of hazardous and toxic materials in the dyeing process. • Management of dye-containing textile wastewater using eco-friendly technologies.

Themes (Chemistry Content)	Chemistry Content Details	Context in Dyeing Process
	2. Labeling According to Globally Harmonized System (GHS) and National Fire Protection Agency (NFPA). 3. Waste Management	
Occupational Health and Environmental Safety (OHS)	A. Concept of OHS B. Potential Hazards in the Laboratory and in Industry C. Personal Protective Equipment (PPE) D. Use of Laboratory Equipment 1. Glassware 2. Non-Glassware 3. Machines	• OHS in the textile industry such as the use of PPE, glass and non-glass equipment, and/or machines in the dyeing process.
Stoichiometry	A. Mole Concept 1. Relative Atomic Mass 2. Molar Mass 3. Avogadro's Number and Mole B. Concentration of Solution 1. % (w/v) 2. % (w/w) 3. Parts Per Million (ppm) 4. Molarity (M) C. Preparation and Dilution of Solutions D. Stoichiometry in Reactions	• Preparation or dilution textile auxiliary solutions or dye solutions with certain concentrations.
Electrolyte & Non-electrolyte Solution	A. Electrolyte Solution 1. Strong Electrolyte Solution 2. Weak Electrolyte Solution B. Non-electrolyte Solution	• The effect of electrolyte solutions on the absorption of dyes in the dyeing process.
Reaction Rate	A. Factors Affecting Reaction Rate 1. Concentration of Reactants 2. Temperature 3. Surface Area 4. Catalyst	• The effect of concentration, temperature, and/or catalyst on the rate of dye absorption in fibers in the dyeing process.
Acid Base	A. Arrhenius Acid and Base Theory B. Properties and Characteristics of Acids and Bases C. Strength of Acids and Bases 1. Strong Acids and Bases 2. Weak Acids and Bases D. Concept of pH E. Acid Base Indicator	• The effect of acidic or basic textile auxiliary on the preparation of dye solutions. • The effect of controlling pH in the dyeing process on the dyeing results.
Ion Equilibrium in Solution	A. Factors Affecting Equilibrium Shifts 1. Changes in Concentration 2. Changes in Temperature B. Buffer Solutions	• The use of buffer solutions in the preparation of dye solutions and the dyeing process.
Colloidal System	A. Classification of Colloids B. Stability of Colloids C. Making Colloids D. Coagulation	• Dye solution as colloid and its stability in dyeing process • The role of emulsifier or dispersing agent on dyeing results • Coagulation in dye-containing textile wastewater treatment process
Redox Reactions	A. Definition of Redox Reactions 1. Oxygen Binding 2. Electron Transfer 3. Oxidation Numbers B. Reducing and Oxidizing Agent	• The use of reducing/oxidizing agents as textile auxiliary in dyeing process.
Hydrocarbons and Its Derivatives	A. Characteristics of Carbon Atoms B. Alkane, Alkene, and Alkyne 1. Nomenclature 2. Physical and Chemical Properties	• The influence of functional groups of dyes and textile auxiliary on the selection of these substances that are appropriate to the type of fiber in the dyeing process.

Themes (Chemistry Content)	Chemistry Content Details	Context in Dyeing Process
	C. Functional Groups (Hydroxyl, Carboxylic, etc.) 1. Nomenclature of Compounds Containing Certain Functional Group 2. Physical and Chemical Properties 3. Reactivity D. Chromophore and Auxochrome Groups	
Benzene and Its Derivatives	A. Structure of Benzene B. Physical and Chemical Properties of Benzene and Its Derivatives C. Nomenclature of Benzene Derivative Compounds D. Benzene Substitution Reactions 1. Halogenation Reaction 2. Nitration Reaction 3. Alkylation Reaction 4. Sulfonation Reaction 5. Diazotation and Coupling Reaction	• Benzene ring as a chromophore group of textile dyes. • Halogenation and nitration reactions to increase the color fastness of fabrics to washing and/or sunlight. • Alkylation reactions in the manufacture of polystyrene (PS) fibers • Sulfonation reactions to increase water absorption in polyester fibers. • Diazotation and coupling reactions in the synthesis and dyeing process of azo dyes.
Polymers	A. Polymers 1. Polymer Forms 2. Homopolymers and Copolymers 3. Polymer Formation • Addition Polymerization • Condensation Polymerization B. Classification of Polymers Based on Their Source 1. Synthetic Polymers: Structure and Properties • Polyester • Polyamide 2. Natural Polymers: Structure and Properties • Carbohydrates • Proteins 3. Semi-Synthetic Polymers: Structure and Properties • Cellulose Acetate (Rayon) • Cellulose Nitrate.	• The effect of fiber structure and properties on the selection of appropriate dyes and textile auxiliaries in the dyeing process.
Fats and Oils	A. Structure and Properties of Fats and Oils 1. Structure of Fats and Oils 2. Properties of Fats and Oils B. Soap and Detergent 1. Soap 2. Detergent	• The use of soap and/or detergent as a textile auxiliary surfactant in the process of making dye solutions and the dyeing process.

This outline provides information related to the sequence, details, depth, and relevance of 19 chemistry contents with dyeing contexts that can be used in Textile Finishin Engineering VHS. This outline can be a reference for teachers or education practitioners in the learning process or development of chemistry teaching materials that accommodate the needs of the dyeing subject context. In other words, teachers or education practitioners can use this outline as a clear and systematic guide to integrate chemistry content with vocational contexts into more contextual learning or teaching materials. Each chemistry content can be developed into teaching materials with one or more dyeing contexts as needed. Thus, this outline is expected to be able to address the gap in chemistry content needed by the immersion context in the VHS.

The development of chemistry teaching materials that are relevant to the dyeing context is expected to provide students with a deeper and more applicable understanding of the chemistry concepts underlying the dyeing process. This is in accordance with the demands of the curriculum which states that chemistry teaching materials must be relevant to their needs (Novianti & Hardeli, 2024). In other words, the use of teaching materials with the required context can provide meaningful learning activities for students (Alamin et al., 2024). In line with this, the results of the study by Wiyarsi et al. (2020) stated that chemistry teaching materials with a vocational context can improve students' mastery of concepts.

Then, the systematic sequence of chemistry content can prevent students from understanding chemistry content partially. The use of this outline is also expected to increase students' interest and attitude towards chemistry considering the assumption that chemistry is not related to vocational fields. The results of Yuliastini et al. (2018) study reported that the integration of chemistry content with vocational contexts can increase students' interest in learning. Furthermore, this can increase students' readiness to work in industry, where a good understanding and skills in chemistry are competencies that are very much needed for VHS graduates.

Conclusion

This study aims to design an outline of chemistry teaching materials that are relevant to the needs of dyeing subjects in Textile Finishing Engineering VHS. This study obtained 19 chemistry content that have been systematically arranged based on the sequence, details, and their relation to the dyeing context in the form of an outline of chemistry teaching material. This outline has been validated by two chemistry education experts, chemistry teachers, and dyeing subject teachers. The findings of this study indicate that this outline of chemistry teaching material can bridge the inconsistency between the Independent Curriculum and the chemistry content needed in Textile Finishing Engineering VHS. Therefore, this outline can be used as a basis for learning and developing chemistry teaching materials in these VHS by both teachers and education practitioners. We hope that the use of this outline can help students understand chemistry content related to their vocational context. That way, students can apply it theoretically and/or practically. Future research should be able to use this outline to develop and/or implement their chemistry teaching materials. The approach used can be Context-Based Learning (CBL), especially in the context of dyeing to improve students' mastery of concepts, interests, and attitudes. In addition, there needs to be other researchers who examine the needs of chemistry content and context to support other vocational subjects or in other expertise competencies.

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The authors declare no conflict of interest.

References

Abdullah, R., Pikoli, M., & Suleman, N. (2021). Analysis of scientific argument of vocational high school students on the topic of substance change. *Journal of Physics: Conference Series*, *1760*(1), 012008. https://doi.org/10.1088/1742-6596/1760/1/012008

Aeni, N. (2019). Pengembangan Modul Bermuatan Pendidikan Karakter materi Elektrokimia Program Keahlian Teknik Instalasi Tenaga Listrik. *Journal of Educational Chemistry (JEC)*, *1*(2), 69. https://doi.org/10.21580/jec.2019.1.2.4321

Alamin, A., Nurhanurawati, N., Rohman, F., & Perdana, R. (2024). Development of Learning E-Modules Based on Contextual Teaching and Learning on the Material of Changing the Form of Energy to Improve Students' Science Literacy. *Jurnal Penelitian Pendidikan IPA*, *10*(8), 6095–6103. https://doi.org/10.29303/jppipa.v10i8.8323

Arputharaj, A., Raja, A. S. M., & Saxena, S. (2016). Developments in Sustainable Chemical Processing of Textiles. In *Green Fashion* (pp. 217–252). Springer Singapore. https://doi.org/10.1007/978-981-10-0111-6_9

Broman, K., Bernholt, S., & Christensson, C. (2022). Relevant or interesting according to upper secondary students? Affective aspects of context-based chemistry problems. *Research in Science & Technological Education*, *40*(4), 478–498. https://doi.org/10.1080/02635143.2020.1824177

BSKAP. (2024). *Keputusan BSKAP Kemendikbudristek Nomor 032/H/KR/2024 Tentang Capaian Pembelajaran Pada Pendidikan PAUD, Jenjang Pendidikan Dasar, dan Jenjang Pendidikan Menengah Pada Kurikulum Merdeka*. Jakarta: Kemendikbudristek.

Dinihari, P., Effendy, E., Rahayu, S., & Dasna, I. W. (2021). Evaluation of Learning Cycle 4E-RE to

Improve Chemistry Learning of Vocational High School Students. *Journal of Technical Education and Training*, *13*(2). https://doi.org/10.30880/jtet.2021.13.02.010

Fayzullina, A. R., Zakirova, C. S., Dobrokhotov, D. A., Erkiada, G., Muratova, O. A., & Grishnova, E. E. (2023). Bibliometric review of articles related to context-based learning in science education. *Eurasia Journal of Mathematics, Science and Technology Education*, *19*(9), em2330. https://doi.org/10.29333/ejmste/13534

Firdaus, H., Syafrizal, S., & Nulhakim, L. (2024). Improving learning quality through the implementation of electronic teaching materials. *Journal of Education and Learning (EduLearn)*, *18*(3), 727–733. https://doi.org/10.11591/edulearn.v18i3.21362

Haryani, S., Prasetya, A. T., Dewi, S. H., & Fadillah, A. (2022). Penyusunan Bahan Ajar SMK Terintegrasi Konteks Kejuruan pada Pembelajaran Kimia. *Jurnal Inovasi Pendidikan Kimia*, *16*(2), 131–137. https://doi.org/10.15294/jipk.v16i2.31633

Hidayah, A. K., Budi Rahardjo, S., & Saputro, S. (2023). Pengembangan Modul Projek IPAS Pada Jurusan Teknik Kendaraan Ringan (TKR) di SMKN 1 Ngrayun Ponorogo. *Kwangsan: Jurnal Teknologi Pendidikan*, *11*(2), 625. https://doi.org/10.31800/jtp.kw.v11n2.p625--638

Hofstein, A., & Kesner, M. (2006). Industrial Chemistry and School Chemistry: Making chemistry studies more relevant. *International Journal of Science Education*, *28*(9), 1017–1039. https://doi.org/10.1080/09500690600702504

Ichwan, M. (2014). *Teknologi Pencelupan*. Jakarta: Kemendikbud.

Islam, M. T., Islam, T., Islam, T., & Repon, Md. R. (2022). Synthetic Dyes for Textile Colouration: Process, Factors and Environmental Impact. *Textile & Leather Review*, *5*, 327–373. https://doi.org/10.31881/TLR.2022.27

Ji, Y., Li, X., Jin, K., Fan, Z., Hou, K., Du, P., Xu, B., & Cai, Z. (2024). Research Progress and Development Trend of Textile Auxiliaries. *Fibers and Polymers*, *25*(5), 1569–1601. https://doi.org/10.1007/s12221-024-00545-0

Kartini, C. D., Chastanti, I., & Harahap, D. A. (2022). Analysis on Obstacles to the Science Education Process. *Jurnal Penelitian Pendidikan IPA*, *8*(1), 309–315. https://doi.org/10.29303/jppipa.v8i1.1282

Ketema, A., & Worku, A. (2020). Review on Intermolecular Forces between Dyes Used for Polyester Dyeing and Polyester Fiber. *Journal of Chemistry*, *2020*, 1–7. https://doi.org/10.1155/2020/6628404

Lau, K. W., Kan, C. W., & Lee, P. Y. (2017). Doing textiles experiments in game-based virtual reality: A design of the Stereoscopic Chemical Laboratory (SCL) for textiles education. *The International Journal of Information and Learning Technology*, *34*(3), 242–258. https://doi.org/10.1108/IJILT-05-2016-0016

Lehn, J. (2015). Perspectives in Chemistry—Aspects of Adaptive Chemistry and Materials. *Angewandte Chemie International Edition*, *54*(11), 3276–3289. https://doi.org/10.1002/anie.201409399

Maryanti, R., Hufad, A., Sunardi, S., Nandiyanto, A. B. D., & Kurniawan, T. (2021). Analysis of Curriculum for Science Education for Students with Special Needs in Vocational High Schools. *Journal of Technical Education and Training*, *13*(3), 54–66. https://doi.org/10.30880/jtet.2021.13.03.006

Masbukhin, F. A. A., & Sausan, I. (2023). Analyzing the Implementation of Kurikulum Merdeka: Insights from Chemistry Educators in Gunung Kidul Vocational Schools. *Jurnal Penelitian Pendidikan IPA*, *9*(12), 11250–11260. https://doi.org/10.29303/jppipa.v9i12.5991

Mayring, P. (2000). Qualitative Content Analysis. *Forum: Qualitative Social Research*, *1*(2). https://doi.org/10.17169/FQS-1.2.1089

Mayring, P. (2015). Qualitative Content Analysis: Theoretical Background and Procedures. In A. Bikner-Ahsbahs, C. Knipping, & N. Presmeg (Eds.), *Approaches to Qualitative Research in Mathematics Education* (pp. 365–380). Springer Netherlands. https://doi.org/10.1007/978-94-017-9181-6_13

Mayring, P. A. E. (2023). Qualitative content analysis. In *International Encyclopedia of Education (Fourth Edition)* (pp. 314–322). Elsevier. https://doi.org/10.1016/B978-0-12-818630-5.11031-0

Moula, A. T. M. G., Hosen, M. D., Siddiquee, M. A. B., Momin, M. A., Kaisar, Z., Mamun, M. A. A., & Islam, M. A. (2022). Effect of dye bath pH in dyeing of cotton knitted fabric with reactive dye (Remazol Yellow RR) in exhaust method: Impact on color strength, chromatic values and fastness properties. *Heliyon*, *8*(11), e11246. https://doi.org/10.1016/j.heliyon.2022.e11246

Nengsih, A. W., Q'Aini, F., & Fitriza, Z. (2023). Analisis Struktur dan Konten Kurikulum Merdeka Fase F untuk Bidang Studi Kimia pada Materi Asam Basa. *Entalpi Pendidikan Kimia*, *4*(4), 21–23. https://doi.org/10.24036/epk.v4i4.357

Noerati, Gunawan, Ichwan, M., & Sumihartati, A. (2013). *Teknologi Tekstil*. Bandung: Sekolah Tinggi Teknologi Tekstil.

Novianti, E. R. & Hardeli. (2024). Development of IPAS on Matter and its Changes Based on PjBL to Improve the Science Process Skills for Grade E Vocational High School. *Jurnal Penelitian Pendidikan IPA*, *10*(7), 4066–4074. https://doi.org/10.29303/jppipa.v10i7.7801

Rahmawati, Y., Hadinugrahaningsih, T., Ridwan, A., Palimbunga, U. S., & Mardiah, A. (2021). Developing the critical thinking skills of vocational school students in electrochemistry through STEM - project-based learning (STEM-PjBL). *AIP Conference Proceedings*, 040002. https://doi.org/10.1063/5.0041915

Ranggu, N. P. (2023). The Development of Four-tier Diagnostic Test for Identifying Misconception in Chemical Equilibrium of Students Pharmacy Vocational School. *Educational Studies: Conference Series*, *3*(1), 88–95. https://doi.org/10.30872/escs.v3i1.2597

Rápó, E., & Tonk, S. (2021). Factors Affecting Synthetic Dye Adsorption; Desorption Studies: A Review of Results from the Last Five Years (2017–2021). *Molecules*, *26*(17), 5419. https://doi.org/10.3390/molecules26175419

Repon, M. R., Dev, B., Rahman, M. A., Jurkonienė, S., Haji, A., Alim, M. A., & Kumpikaitė, E. (2024). Textile dyeing using natural mordants and dyes: A review. *Environmental Chemistry Letters*, *22*(3), 1473–1520. https://doi.org/10.1007/s10311-024-01716-4

Sagendra, B., Harti, D., Widodo, J., & Atmaja, H. T. (2021). *Proyek IPAS: Ilmu Pengetahuan Alam dan Sosial*. Jakarta: Erlangga.

Schwartz, M. S., Sadler, P. M., Sonnert, G., & Tai, R. H. (2009). Depth versus breadth: How content coverage in high school science courses relates to later success in college science coursework. *Science Education*, *93*(5), 798–826. https://doi.org/10.1002/sce.20328

Siddiqua, U. H., Ali, S., Iqbal, M., & Hussain, T. (2017). Relationship between structure and dyeing properties of reactive dyes for cotton dyeing. *Journal of Molecular Liquids*, *241*, 839–844. https://doi.org/10.1016/j.molliq.2017.04.057

Sun, G. (2017). Creating Novel Functions on Textiles by Applying Organic Chemistry. *AATCC Review*, *17*(3), 38–47. https://doi.org/10.14504/ar.17.3.3

Sunarto. (2008). *Teknik Pencelupan dan Pengecapan*. Jakarta: Kemendikbud.

Sveinbjornsson, B. R. (2021). What Is in a Prerequisite? An Observational Study on the Effect of General Chemistry on Organic Chemistry Performance. *Journal of Chemical Education*, *98*(2), 368–373. https://doi.org/10.1021/acs.jchemed.0c01065

Uddin, M. A., Rahman, M. M., Haque, A. N. M. A., Smriti, S. A., Datta, E., Farzana, N., Chowdhury, S., Haider, J., & Muhammad Sayem, A. S. (2022). Textile colouration with natural colourants: A review. *Journal of Cleaner Production*, *349*, 131489. https://doi.org/10.1016/j.jclepro.2022.131489

Wei, B., & Long, F. (2021). Teaching chemistry in context: What we know from teachers' lesson plans. *International Journal of Science Education*, *43*(8), 1208–1227. https://doi.org/10.1080/09500693.2021.1905906

Wiyarsi, A., Damanhuri, M. I., & Fitriyana, N. (2020). Exploring Pre-Service Chemistry Teachers' Problem Solving Skills On Vocational Context-Based Learning. *Jurnal Kependidikan: Penelitian Inovasi Pembelajaran*, *4*(2), 185–199. https://doi.org/10.21831/jk.v4i2.35302

Wiyarsi, A., Pratomo, H., & Priyambodo, E. (2020). Vocational High School Students Chemical Literacy on Context-Based Learning: A Case of Petroleum Topic. *Turkish Journal of Science Education*, *17*(1), 147–161. https://doi.org/10.36681/tused.2020.18

Yi-wei, H., Qian-xi, Z., Xin-xin, H., Ying, W., Jia-qing, W., Xin-min, H., Mei-hui, W., & Ya-fei, G. (2023). Discussion on Factors Affecting Dyeing of Bio-based Polyamide 5,6 Fibers Compared with Polyamide 6,6 Fibers. *Journal of Macromolecular Science, Part B*, *62*(9), 463–477. https://doi.org/10.1080/00222348.2023.2221506

Yuliastini, I. B., Rahayu, S., Fajaroh, F., & Mansour, N. (2018). Effectiveness of POGIL with SSI Context on Vocational High School Students' Chemistry Learning Motivation. *Jurnal Pendidikan IPA Indonesia*, *7*(1), 85–95. https://doi.org/10.15294/jpii.v7i1.9928

Zyahri, M. (2013). *Pengantar Ilmu Tekstil 2*. Jakarta: Kemendikbud.