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International Journal of Evaluation and Research in Education (IJERE)
Vol. 12, No. 4, December 2023, pp. 2316~2326
ISSN: 2252-8822, DOI: 10.11591/ijere.v12i4.25665 ❒ 2316

Science, technology, engineering, agriculture, mathematics, and health in agribusiness curriculum

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Article Info

Article history:

Received Oct 9, 2022
Revised Jul 28, 2023
Accepted Aug 18, 2023

Keywords:

Concept connection
Conceptual integration
Contextual integration
Curriculum coherence
Integrated curriculum

ABSTRACT

Vocational high school curriculum can provide various solutions to problems in the business and industrial worlds that require a variety of disciplines. The complex problem-solving in the real world has increased the multidisciplinary boundaries of science, technology, engineering, agriculture, mathematics, and health (STEAM-H). Therefore, this study investigated teachers' understanding of the coherence and integration of the vocational high school curriculum in the crop agribusiness program in STEAM-H. The sample population consisted of science, mathematics, and productive teachers from a crop agribusiness vocational high school in Ciamis, Indonesia. The results showed that participants' understanding of curriculum coherence began with the knowledge of the existence of conceptual connections between subjects, essential concepts, explicit or implicit, and concepts outside or within the curriculum. Furthermore, the productive teachers were more aware of implicit subject connections in this study. Teachers often had different points of view on the essential concepts listed in the curriculum. The results also showed that agriculture is a conceptual integrator for science, technology, engineering, mathematics, or health for integrated STEAM-H learning, as well as a contextual integrator for subject-centered education. The teachers argued that the multidisciplinary, interdisciplinary, and transdisciplinary patterns were suitable for implementation with strategies agreed upon across all subjects. Therefore, the understanding of teachers is expected to change integrated learning in crop agribusiness schools to an independent curriculum.

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1. INTRODUCTION

Science, technology, engineering, agriculture, mathematics, and health (STEAM-H) is an extension of multidisciplinary study boundaries [1]. Studies are often developed in the STEAM-H area to advance various disciplines or generate interdisciplinary interactions. In education, several interdisciplinary curricula have been developed, such as science, technology, engineering, and mathematics (STEM), which is a subject-based or integrated curriculum [2]. The use of STEAM-H in education expands the boundaries of the disciplinary integration of STEM with the advent of agriculture and health. Agriculture is a specific discipline studied by vocational students, and several vocational high schools in Indonesia are in the agricultural area, namely agribusiness and agrotechnology. One of the programs studied in the school includes crop agribusiness.

The vocational high school curriculum was designed based on the actual requirements in the world of work [3]. The need to adjust the general curriculum to support complex problem-solving [4] has led to the development of integrated curricula, such as the interdisciplinary curriculum [5]. This integration emphasizes the features of the combination between two or more disciplines [6] that study connection of concepts and skills [7]. Furthermore, the crop agribusiness vocational high school curriculum requires students to have competencies as stated in the content standards. Several studies revealed that agriculture has contributed as an integrator for other disciplines [8].

The non-explicit content standards of mathematics and social sciences in the national requirement for secondary schools create the need to establish an operational curriculum that is specific to students' expertise program. Vocational high school teachers need to understand the coherence between subjects to create integration between disciplines. A previous study stated that a quality curriculum integrates several coherent disciplines [9]. The integration and coherence of the curriculum show a logical condition, which helps to achieve goals with a measurable academic plan by considering educational strategies, as well as the needs of the community and students [10].

During the curriculum design, it is important to consider the mapping of professional competencies [11] as well as connectivity at the social, material, programmatic, and didactic levels as a principle for a coherent trajectory that supports students' learning success [12]. It also needs to take into consideration the connection with the environment because the school climate significantly affects students' academic attitudes [13] and positively strengthens students' learning success [14]. The explicitness of the integrated curriculum is the connection between the experiences and interests of students, school and community contexts, as well as problem-based learning and real-world projects supporting students. These connections provide access to information, knowledge, and experiences in different ways across disciplines for students [15].

To understand the nature of coherence and integration of curriculum, teachers must understand the main concepts, the content association between subjects, and learning objectives [9]. Teachers also need to articulate coherent content knowledge to increase teaching capacity and organize the sequence of learning materials for students [16]. Furthermore, teachers and the professional community often process big ideas from core curriculum documents at the school level [17]. The coherence of the integrated curriculum can lead to explicit consideration of the curricular association of each unit by sequencing and connecting concepts within and across various lessons [9]. Coherence is the synchronization of cultural differences between disciplines in terms of terminology, notation, and sign conventions [18].

Several studies explored the coherence and integration of curriculum [9], [15], [17]. Based on the results, interdisciplinary relationships are used to categorize and understand the nature of integration and coherence within each unit that makes up the broad types of integrated curriculum. Furthermore, the broad types include coherence of science units and loosely connected engineering design challenges, engineering design units and science with limited connections, engineering design units and science as context, as well as integrated and coherent STEM units. These aspects can be understood and built into integrated curricular units [9]. The presence of the independent curriculum in Indonesia and STEAM-H studies to support cross-disciplinary problem solving provides opportunities to build integrated STEAM-H curricular units.

Therefore, this study aims to investigate teachers' understanding of the coherence and integration of STEAM-H in the crop agribusiness vocational high school curriculum. A proper understanding is expected to help teachers prepare for the Independent Curriculum implementation in vocational schools, specifically in crop agribusiness, mathematics, and social studies. The coherence and integration of STEAM-H also need to be understood to provide proper knowledge on effective integration [19].

2. RESEARCH METHOD

2.1. Study design

A case study design was used [20] to explore teachers' understanding of coherence as well as the nature of STEAM-H integration in the crop agribusiness independent curriculum. Furthermore, coherence involved the connection between concepts in crop agribusiness, mathematics, and science. It also entailed an understanding of the essential concepts within the scope of STEAM-H. The nature of integration focused on understanding combination patterns as well as conceptual and contextual integration. Questionnaires were distributed to participants to explore their knowledge about the connection between concepts in crop agribusiness, mathematics, and science subjects. Interviews were also carried out to explore the understanding of essential concepts within the scope of STEAM-H. Focus group discussion (FGD) explored the participants' understanding of combination patterns as well as conceptual and contextual integration.

2.2. Participants

The study participants were productive, mathematics, physics, chemistry, and biology teachers from a vocational high school that organizes a crop agribusiness program in Ciamis, Indonesia. Furthermore, 4

productive teachers were people who teach vocational subjects in the program. The characteristics of the participants are presented in Table 1.

Table 1 shows that the distribution of teachers in each school was different. Furthermore, the needs of teachers in each school varied based on the ratio of the number of students and classes. The first school was a public school, while the second and third were private. Public schools have a higher number of students compared to the private. Agribusiness subjects have a longer teaching duration in the curriculum compared to math and sciences, hence, the teachers involved made up a higher percentage of participants. Each private school has only one teacher with a science background. All the schools in this study stated that the number of teachers was sufficient to meet the needs of the students.

Each participant contributed to the exploration of the study data. The uneven availability of each scientific background was anticipated using a data collection strategy that began with a questionnaire, followed by interviews and FGD. All the information was then validated by the participants through FGD.

Table 1. Participants' data

Subject teachers	Quantity		
	School 1	School 2	School 3
Crop agribusiness	5	3	1
Mathematics	2	1	1
Physics	1	1	1
Chemical	1	1	1
Biology	1	1	1

2.3. Data collection

Data were collected through questionnaires, interviews, and FGD. The first stage was giving open questionnaires and interviews to productive, mathematics, physics, chemistry, and biology teachers, and Table 2 shows its content. Based on the responses from productive, mathematics, physics, chemistry, and biology teachers, the interviews to separate the essential concepts were explicit or implicit. The concepts were also listed in the standard content of the secondary school education curriculum [21].

The second stage was collecting data through FGDs on learning integration patterns, as well as conceptual and contextual integrators. All participants have the opportunity to give arguments about disciplinary, multidisciplinary, interdisciplinary, and transdisciplinary integration [9]. Furthermore, they expressed the opinions about conceptual integrators and contextual integrators, which are means of integrating two or more subjects to improve knowledge and skills in students' learning [22].

Table 2. Questions to participants

No.	Questions
1	Is the scope of crop agribusiness material on "health and safety at work, as well as the environment (HSE), including HSE concepts, principles, and procedures, first aid in accidents, personal protective equipment, environmental conservation," connected with the concepts of mathematics, physics, chemistry, and biology? Please explain!
2	Is the scope of crop agribusiness material on "Business processes in the crop agribusiness sector, including industrial classification, business scope, product planning, production processes, marketing, equipment repair and maintenance as well as human resource management, logistics, job profile," connected with mathematics, physics, chemistry, and biology? Please explain!
3	Is the scope of the crop agribusiness material on "Technological developments in terms of equipment, product development, and global issues connected to the concepts of mathematics, physics, chemistry, and biology? Please explain!
4	Is the scope of crop agribusiness material on "Entrepreneurial development, including identification of business ideas/types, calculation, and risk-taking in developing and managing businesses, business management by utilizing knowledge and skills in the field of crop agribusiness expertise" connected with mathematics, physics, chemistry, and biology? Please explain!
5	Is the scope of crop agribusiness material on "Basic techniques of crop cultivation, which includes: media preparation/land preparation, soil, water, fertilizer/crop nutrition, crop-disturbing organisms, and their control, crop treatment, harvesting, and post-harvest handling" connected with the concept mathematics, physics, chemistry, or biology? Please explain!
6	Is the scope of crop agribusiness material on "Crop propagation/breeding techniques, which include: generative and vegetative crop propagation," connected with mathematics, physics, chemistry, and biology? Please explain!
7	Is the scope of the crop agribusiness material on "Handling of waste from crop agribusiness, including handling solid waste, liquid waste, and hazardous and toxic waste materials" connected with mathematics, physics, chemistry, and biology? Please explain!
8	Is the scope of crop agribusiness material on "On expertise related to cropation agribusiness including garden management and land mapping" connected with mathematical concepts, physics, chemistry, and biology? Please explain!
9	Is the scope of the crop agribusiness material on "On expertise related to seed agribusiness including seed production/breeding and seed quality testing" connected with mathematics, physics, chemistry, and biology? Please explain!
10	Is the scope of crop agribusiness material on "In skills related to landscaping including garden design, garden management, and hard element development" connected with mathematical concepts, physics, chemistry, and biology? Please explain!
11	Is the scope of crop agribusiness material on "On expertise related to agricultural ecology including the development of microorganisms/biological agents" connected with mathematics, physics, chemistry, and biology? Please explain!

2.4. Data analysis

The data collected were summarized and interpreted based on two stages. In the first stage, the summary started with the productive teachers' response to the concepts of mathematics, physics, chemistry, and biology required in each material theme in the standard content of crop agribusiness. The responses showed the level of understanding of productive teachers about the concepts of mathematics, physics, chemistry, and biology in the content standards. Furthermore, the productive teachers' explanations were compared with the opinions of mathematics and science teachers. This comparison was carried out to ensure that the identified mathematics and science concepts can support students' vocational skills. This study used both explicit or implicit concepts, where some were outside the curriculum, while others were outside.

The second stage of data analysis involved the pattern of integration, as well as conceptual and contextual integrators. The integrators are essential concepts used as integration centers [9] based on data from the first stage. Figure 1 shows the flow of data analysis from left to right.

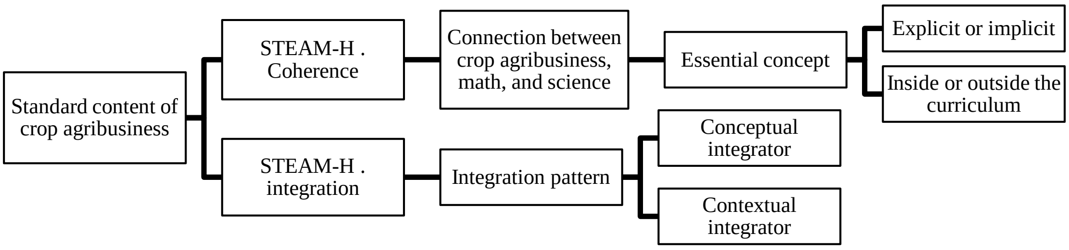

Figure 1. Data analysis flow

3. RESULTS AND DISCUSSION

3.1. STEAM-H coherence in crop agribusiness curriculum

The first step in assessing curriculum coherence is gaining a proper understanding of the connection of concepts between subjects. Crop agribusiness materials include health, occupational safety, and environment (HSE), business, technology, entrepreneurship, cultivation, breeding, waste, cropation, seedling, landscaping, and ecology. Furthermore, Figure 2 describes the response of productive teachers whether there is a connection between material in the scope of crop agribusiness and mathematics, physics, chemistry, and biology. These responses showed the level of understanding of the concepts of mathematics, physics, chemistry, and biology required in each material theme in the standard content. The questionnaire indicated the teachers' knowledge of material connections in agribusiness, mathematics, and other science subjects.

Productive teachers argued that chemistry and biology are more connected to crop agribusiness compared to mathematics and physics, except on the theme of business processes and entrepreneurship development. Furthermore, they agreed that mathematics, business processes, and entrepreneurship development are connected. An explanation of the connection of mathematical, physical, chemical, biological, and crop agribusiness based on the opinions of productive teachers is presented in Table 3.

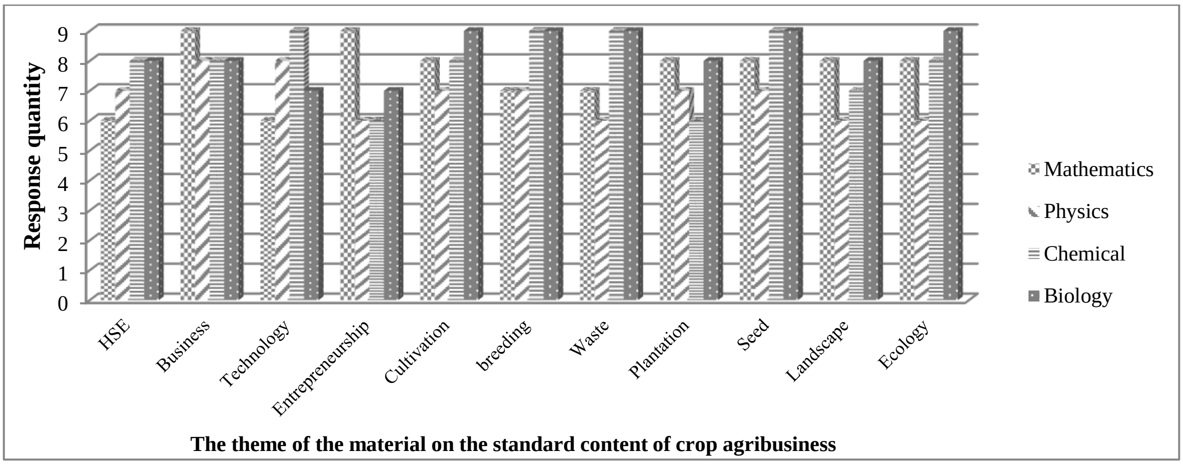

Figure 2. The responses of productive teachers on the connection between agribusiness themes and mathematics, physics, chemistry, and biology

Table 3. Perceptions of productive teachers about conceptual connections between mathematics, physics, chemistry, biology, and crop agribusiness

Theme	Mathematics	Physics	Chemical	Biology
HSE	Calculate the area of land (environment), population, the right dose, tools, and supporting materials for occupational health and safety.	Cardinal directions when spraying, machine adjustment to soil structure.	Chemical elements, chemical properties, and chemical composition for work safety.	Crop growth and development, crop breeding (vegetative /generative; microorganism (biological agent), environment; biotic and abiotic environment; ecosystem, standard of work operation, light intensity, conservation of narrow land.
Business process	Calculation of the need for fertilizers, seeds, raw materials, and labor profit/loss in the production and marketing process.	Determination and placement of agricultural machine tools used in the production and packaging process.	Determination of pesticide dose, resident level of production, calculation of nutrient composition, safe use of chemicals in equip-ment repair/maintenance.	Types of crops, crop health, and yields, Microorganisms (biological agent), environment, resource management.
Agricultural technology	Time management, spacing, the need for tools to increase productive results.	Use of agricultural machine tools for land processing or production use, tool layout, automatic watering device.	Use of chemicals for pests and diseases, fertilization technology.	Creation/adaptation of crops, crop waste
Entrepreneur-ship development	Farming analysis, business calculations, business opportunities, and decision-making techniques.	Development of tools and packaging of business results.	Residential level of agri-cultural products, chemical concepts in product development/production materials, crop nutrition.	The suitability of the crop to the climate, product development/ production materials, crop characteristics.
Plant cultivation	Calculation of land area, fertilizer needs, seeds, cropping holes, and spacing.	Soil tillage and post-harvest tools.	Chemical dilution	Crop properties, pests/diseases, biological and organic fertilizers, crop nutrition, environmentally friendly pesticides.
Crop breeding	Calculation of growing time, incision size.	Temperature, weather, breeding tools and materials, breeding technique.	Growth stimulant.	Rotation of crop species to reduce the cycle of pest and disease development, crop classification and growing conditions/natures, microorganisms
Waste handling	Calculation of environmental impact analysis (normal limits and comparison of waste quantity with land area).	Waste handling equipment, physical properties of the waste	Production of growing substances (liquid and solid), waste chemical elements, waste decomposing agent	Types of waste, utilization of microorganisms to protect the natural environment and humans, waste impact.
Cropation	Measuring plots of land (land mapping), calculate crop population.	Supporting management and arrangement technologies (GPS, Arcgis, and theodo-lites) to determine global land landscapes, weather forecast	Chemical elements of fertilizers and pesticides.	Soil fertility, vegetation type.
Seeds	Calculation of seed preservation dose, calcula-ting captive yields, weight measurement, calculating seed germination.	Seed management techniques and technologies, an instrument for measuring the moisture content of seeds	Chemical treatment of seeds, seed preservation, growth stimulants, seed quality testing	Seed growth, seed characteristics based on climate, seed physiology, ecosystem, seed germination
Landscaping	Calculating the area of land and parks, calculating the angle of each required design (mapping), counting population.	Creating garden installations and interiors, land management tools and technology	Creating sufficient nutrient media, fertilizer chemical elements.	Environment, plant characteristic based on growth capacity, plant type, characteristics and types of microorganisms.
Agricultural ecology	Calculate the number and dose of microorganisms needed by crops, calculate the volume of the solution, comparison of microorga-nisms and land area.	Microorganism tools and technology.	Stimulates the development of microorganisms, plant regulating substances, dilution principle, soil pH	Environmental ecology, nature and type of microorganism, ecosystem.

Table 3 shows that the concepts mentioned by productive teachers are implicit in the context. The term of calculate, measure, and analyze are embedded in a context that suggests a connection between agriculture and mathematics. The terms of science embedded in a context that suggests a connection between agriculture and science. Meanwhile, the responses of mathematics, physics, chemistry, and biology teachers showed explicit concepts, as shown in Table 4. Tables 3 and 4 show the connections within the scope of STEAM-H, which are also considered essential by participants. These results show relationship between coherent content, because the curriculum requires coherence [23]. The teachers' understanding in determining explicit concepts of the vocational high school curriculum is presented in the sub-sections.

Table 4. Summary of teachers' responses to mathematics, physics, chemistry, and biology regarding essential concepts on the theme of crop agribusiness

Theme	Mathematic teachers	Physics teachers	Chemistry teachers	Biology teachers
HSE	Real numbers, situation modeling, system of linear equations, linear programming.	Standards for the use of personal protective equipment and occupational health and safety procedures.	Structure, composition, and chemical changes, use of personal protective equip-ment, occupational health and safety procedures.	Preservation of living things and solving environmental problems caused by human activities.
Business process	Real numbers, sequence and series, equations and systems of equations, linear programming; Math logic.	Equipment repair and maintenance.	-	Environment
Agricultural technology	Real numbers, linear equations, and systems of linear equations.	The basis for technological equipment (stationary fluids, moving fluids), electricity.	Chemicals in crop production, such as insecticides and fertilizers.	Technology to anticipate the spread of disease/virus, Biotechnology innovation.
Entrepreneurship development	Equations and systems of linear equations.	-	-	-
Plant cultivation	Real numbers, compa-rison; measurement.	-	Chemical base.	Environment, crop growth.
Crop breeding	Trigonometric compare-sons, growth opportu-nities, comparison, measurement.	Greenhouse.	Basic chemistry.	Crop breeding.
Waste handling	System of linear equations.	Waste handling equipment (vacuum, aerator).	Biofiltration, aeration, oxidation (redox) ponds, and separation of mixtures.	Waste and pollution
Cropation	Two dimensional	Power point, energy, digital processing and transmission	-	Types of living things
Seeds	Combinations and permutations, equality		Chemical treatment, test water capacity and degree of acidity, titration.	Genetics, living things.
Landscaping	Measurement, trigonometry, scale.	Temperature, energy	-	Crop type and layout, species diversity, crop biological properties.
Agricultural ecology	Comparison	Heating	Hydrocarbons, colloid.	Types of bacteria, microorganisms, ecosystem.

3.1.1. Teachers' understanding of science in the crop agribusiness curriculum

The concepts understood by teachers are expected to explain the essentials of science explicitly contained in the secondary school curriculum, specifically the scope of material in the content standards. Based on Tables 3 and 4, productive and physics teachers argued that there was a connection between the concepts of physics and crop agribusiness regarding agricultural support equipment. The breadth of the crop agribusiness context led to different perspectives about the connection of concepts to each of these themes. For example, on the HSE theme, productive teachers stated that the direction of the wind and machines were connected with soil structure. Meanwhile, physics teachers revealed that occupational health and safety protective equipment were associated. The term equipment, such as agricultural machinery was not explicit in high school physics content standards. Excavation through interviews revealed that the basic concepts for equipment were related to fluid and electricity. These concepts in the standard content of physics showed that fluids are stationary, they are moving, and used in technology and daily life. Static electricity, electric circuits, magnetism, magnetic induction, electromagnetic induction, electromagnetic waves, and their technology were also applied in daily activities.

Another concept related to physics in the secondary school curriculum based on teachers' understanding was force and digital transmission. This involved straight and curvilinear motion, the relationship of force to motion, momentum and impulse, and their application to relevant contexts, including planetary motion and orbiting the sun. Furthermore, the concept also comprised digital data processing (logic gate) and transmission, as well as their application in information and communication technology. The physics teachers also expressed other terms outside the curriculum, such as temperature and heating. After the interview phase, the concepts entered the standard of physics: Heat and its transfer, processes, laws of thermodynamics, and their use in technology and daily life. This indicated that five out of the nine materials in the content standard were connected to crop agribusiness.

In chemistry (Table 3), productive teachers expressed terms, such as chemicals, chemical elements, and treatment, as well as growth substances. Meanwhile, chemistry teachers mentioned terms inside the curriculum, such as the concepts of change of substances and basic chemicals, separation of mixtures, and hydrocarbons, as shown in Table 4 column 4. This condition showed the strong connection between chemical concepts and crop agribusiness.

For biology (Tables 3 and 4, column 5), productive and biology teachers shared the same opinion regarding crop growth and development, the environment, crop classification, and genetics, which are essential concepts connected to agribusiness. These materials are the content standards of high school, namely: Growth and development in living things; Diversity and classification, the interactions with the environment, preservation of living things and solutions to environmental problems caused by human activities; Inheritance of traits based on Mendelian laws, and solving problems of daily life. Based on the opinion of biology teachers, biotechnology was connected to crop agribusiness in the high school curriculum. The productive and biology teachers stated that there were biological concepts outside the secondary school curriculum, namely crop breeding, microorganisms, waste, pests/diseases, and crop physiology.

The results showed that productive teachers were more aware of the connection between crop agribusiness and science, although most of the conceptual arguments were implicit in the context. Furthermore, there were three themes of crop agribusiness that physics teachers lacked an understanding of their connection. The questionnaire revealed that chemistry and biology teachers were not aware of the connection of 4 and 3 themes, respectively.

An understanding of the association of concepts can provide teachers with more knowledge of the main content of the curriculum. Connections can also lead to the comprehension of curriculum coherence, which helps science teachers map science concepts based on those in crop agribusiness. Knowledge about connections helps to achieve congruent understanding, namely alignment to unite the elements of curricular content and coherence in a way that optimizes learning centered on the theme of scientific inquiry [14], [22]. This process of alignment is expected to support the development of students' critical thinking [24], [25].

3.1.2. Teachers' understanding of technology in the crop agribusiness curriculum

The word technology was explicitly contained in the content standards of crop agribusiness, physics, and biology. This theme in the agribusiness curriculum was specifically in one material scope, namely technology developments in terms of equipment, product creation, and global issues. Furthermore, productive teachers stated that material science and mathematics were connected. A similar response was also given by the mathematics, physics, chemistry, and biology teachers.

Several productive teachers stated that technology has various associations with physics, as shown in Table 3. It was also related to the themes of cropations, hatcheries, landscaping, and agricultural ecology. Physics teachers can identify technology-related concepts in high school content standards, such as fluids, heat, thermodynamics, wave motion, electricity, and digital transmission, as shown in Table 4 column 3. In biology content standards, the concepts related to technology include viruses and biotechnology. Productive and biology teachers agreed that viruses and biotechnology in the curriculum were less relevant due to their association with humans, and not crops, as shown in Table 3 and Table 4, column 5.

The responses showed that participants understood the connection between technology in crop agribusiness, both explicit and implicit. Mathematics and chemistry teachers were also fully aware of the nature of the implicit connections that existed between their disciplines and crop agribusiness. In the implementation aspects, these concepts in technology disciplines were known as technological literacy, where students are allowed to think critically to become literate [22].

3.1.3. Teachers' understanding of engineering in the crop agribusiness curriculum

Techniques were explicitly in the scope of crop agribusiness material in the aspects of cultivation, breeding, and seeding. This understanding of engineering was only possessed by productive teachers. Further exploration through interviews obtained responses from physics teachers about crop automation engineering and biology teachers regarding tissue culture and genetic engineering. However, further discussions between the participants are still needed to explore and understand engineering contexts. This is because engineering-based design promotes learning design, and can serve as a conceptual integrator for other concepts [22].

Engineering schools have widely implemented designs using approaches that are beneficial to students. This implementation process can help in the development of conceptual knowledge, higher-order thinking skills, and design-project activities [25]. Engineering practice with an epistemic facilitates content learning and the development of realistic and comprehensive thinking among students [24]. The integration of science and engineering in education has been carried out, but techniques in agriculture have not yet emerged. Curriculum redesign can facilitate the integration of these fields of study. One of the effective strategies is to create a discipline-based design that requires an educational research community with a deep foundation in disciplinary priorities, worldviews, knowledge, and practice [26].

3.1.4. Teachers' understanding of mathematics in the crop agribusiness curriculum

The term counting dominated the productive teachers' understanding of mathematical connections, as shown in Table 1. Furthermore, mathematics teachers argued that it was essential in the content of numbers and their operations. Based on high school mathematics curriculum, the concept studied consisted of "Understanding the real number system, various types, including power numbers and their uses in various appropriate contexts." The participants also revealed that students must have the ability to carry out mental and rough calculations, as well as reasonable judgments [27]. Mathematics teachers referred to the word analyze as a connection to the essential concepts of mathematics in terms of systems of equations, mathematical modeling, linear programming, and probability, which were in the high school curriculum.

The respondents also argued that there was a connection between the context of crop agribusiness and geometric content, such as the concept of flat shapes in the calculation of land area and angles in landscaping. The geometry material in the curriculum was "Application of trigonometric comparisons in right triangles to determine angles, distances, or heights." The productive teacher mentioned the word "measuring", which was connected to the content of the measurement. Findings showed that this content was not in the high school curriculum.

The responses obtained revealed that mathematics and productive teachers understood the connection between crop agribusiness concepts and mathematics even though productive educators were more implicit. Furthermore, mathematics teachers have a proper understanding of the essential concepts for crop agribusiness students, as shown in Tables 3 and 4, column 2. Mathematical thinking is an important aspect needed by students in solving problems. The integration of mathematics and other disciplines plays a major in this aspect [22], including the knowledge and skills to implement the subject into a context. Several studies proved that the agricultural context can stimulate students' mathematical thinking processes. Knowledge of agricultural context affects mathematical understanding [28] and reasoning [29].

3.1.5. Teachers' understanding of healthy in the crop agribusiness curriculum

The term health in the agribusiness curriculum has the minimum portion compared to other disciplines. Productive teachers understood this terms in the aspects of crop, occupational, and environmental health, as shown in Table 2 of the HSE theme. Crop health was mainly related to business processes to obtain optimal production results. In the aspect of occupation, it was related to the tools and chemicals for workers and the quantity needed. Furthermore, it involved being free from the dangers of waste and adjusting agricultural equipment and chemicals that are environmentally friendly in the environmental aspect. This indicated that occupational health and the environment were connected with science and mathematics.

3 The essential concepts of mathematics and science in the health sphere tended to be implicit. These concepts were explicitly in the agribusiness content standards on occupational health. In its implementation, science and environmental literacy have the opportunity to be integrated into everyday environment studies [30] which will support students' thinking abilities regarding science [31].

3.2. Integration of STEAM-H in the crop agribusiness curriculum

Teachers' understanding of the integration pattern was the first step to determining the nature of integration and the integrator theme for students' learning. Integrator can be a concept or context that unites various disciplines [9]. Based on the connections described in the first chapter, the themes within the scope of the agribusiness concept can unify the disciplines within STEAM-H. This section discusses teachers' understanding of the pattern of integration disciplines.

3.2.1. Teachers' understanding of discipline integration

The responses showed that all teachers have conducted monodisciplinary learning. By understanding the connection of content standards to the independent curriculum, participants realized the importance of interdisciplinary integration. Teachers argued that multidisciplinary, interdisciplinary, and transdisciplinary were integration patterns to be implemented in vocational high schools.

All participants believed that multidisciplinary was an ideal pattern for their schools. Teachers can cooperate with each other to create coherence between subjects and set the same theme even though learning was carried out separately according to the disciplines in the curriculum structure. Furthermore, teachers' understanding of this integration was similar to the subject-based view of STEM education [2].

All the participants believed that interdisciplinary patterns were possible but require significant changes in the structure of the curriculum. They also argued that interdisciplinary learning was likely to encounter obstacles during its implementation. The responses from the questionnaire revealed that the distribution of the workload of teachers was uneven. Each learning theme only required some disciplines, hence, there was an imbalance in the number of hours of lessons between subjects. Cooperation between teachers was not really effective due to the lack of understanding of the connection between concepts by some of them. There was also a tug-of-war between the essential concepts that were assumed to be more important based on their respective perspectives. In Independent Curriculum, social science subjects were only studied in class X. The results of a study showed that curriculum integration is complex and can create tension in the construction of the curricular structure. This is to ensure that the integration process required alignment of learning perspectives and was collaborative [19].

Teachers argued that interdisciplinary learning can take the form of crop cultivation and agricultural practices, and it was beneficial to students. Furthermore, this type of learning helps students to develop knowledge and skills in connecting various disciplines to solve complex problems [7]. Participants also realized that collaboration was beneficial in the implementation of interdisciplinary learning.

Teachers revealed that transdisciplinary learning can involve several disciplines in STEAM-H. The implementation of transdisciplinary learning can strengthen the Pancasila profile. Teachers emphasized that real-world problems must refer to the theme of agribusiness. Participants understood the integration of learning of at least two disciplines. STEM with agricultural literacy is a study showing that several disciplines can be integrated [8]. Furthermore, a previous study revealed that the combination of mathematics and agriculture has a high degree of integration [32].

3.2.2. Teachers' understanding of conceptual and contextual integrators

Teachers have opinions on specific topics that they find easy to implement in some disciplines. Table 5 summarizes the integration themes selected by participants. The majority of teachers understood that agribusiness is a conceptual integrator for mathematics and science subjects. Furthermore, agriculture is a conceptual integrator for science, technology, engineering, mathematics, or health. This is inconsistent with Vallera and Godzin that it was a contextual integrator for STEM [8]. These differences of opinion cannot be separated from the position of the concept of agriculture itself, where it was the main concept that must be possessed by students in high vocational schools. In Vallera and Godzin's study, the field was not the main concept for elementary school students.

There are mathematics teachers who argued that agriculture can be a contextual integrator for mathematics when the agricultural context was used as a word-problem in contextual-based learning. This opinion referred to the multidisciplinary implementation that made the agribusiness theme a context for solving mathematical problems. Agriculture's position as a contextual integrator also occurred when STEAM-H was implemented in subject-centered learning. Mathematics and science teachers revealed that the possibility of mathematics being a conceptual integrator was difficult to implement. The understanding of integrators raised awareness to build coherence of mathematical material in accordance with the concepts learned by students.

Table 5. Teachers' perceptions of the integrator theme

Integrator	Discipline integration
Agricultural land processing	Science-Technology-Agriculture-Mathematics
Crop population	Science-Agriculture-Mathematics-Health
Dosage of fertilizers, pesticides and crop nutrients	Science-Agriculture-Mathematics
Crop tissue isolation method	Science-Technology-Engineering-Agriculture-Mathematics-Health
Crop business analysis	Agriculture-Mathematics

4. CONCLUSION

Teachers' understanding of curriculum coherence begins with knowledge of the existence of conceptual connections between subjects, both explicit and implicit. The breadth of the concept of crop agribusiness makes teachers often have different perspectives on the connection of cross-subject concepts, which they think are essential. The opinion of the participants showed that there was a conceptual association within the scope of STEAM-H, and it was considered essential. Productive teachers argued that the order of quantity of connections between mathematics and science was chemistry, biology, mathematics, and physics.

They were also more aware of the implicit connection between crop agribusiness and science, while cynical educators considered the association a scientific inquiry. All teachers understood the connection of technology to crop agribusiness, both explicitly and implicitly. The majority of productive teachers also had an understanding of engineering compared to mathematics and science teachers. Furthermore, productive educators understood health in terms of crop, occupational, and environmental health.

Agriculture is a conceptual integrator for science, technology, engineering, mathematics, or health in crop agribusiness vocational high schools. This condition is ideal when it is implemented in integrated learning. The results also showed that agriculture can be a contextual integrator when learning is subject-centered. The pattern of subject integration that allows for implementation in vocational high school based on the opinion of the majority of teachers was multidisciplinary, interdisciplinary, and transdisciplinary. The pattern of multidisciplinary integration was considered the most ideal for vocational high schools because it was appropriate for independent schools and curriculum. The interdisciplinary pattern can be implemented by making significant changes in the curriculum structure and it was predicted to face many challenges. Teachers' understanding of the coherence and integration of STEAM-H contributed to the presence of integrated learning in crop agribusiness schools for Independent Curriculum. Further studies can review the design of learning, teaching materials, assessment, and the environment in STEAM-H.

ACKNOWLEDGEMENTS

The authors are grateful to Directorate General of Higher Education, Research and Technology of the Ministry of Education, Culture, Research, and Technology for funding through the Decentralization Program Study in Higher Education (based on Decree Number 156/E/PG.02.00.PT/2022 and Agreement/Contract Number 081/SP2H/RT-MONO/LL4/2022 and 0165/4123/SPK/LPPM/VI/2022).

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