Developing Comprehensive Agricultural Supply Chain International Courses and their Key Market Driven Topics by Using Grey Relational Analysis (GRA)

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Abstract

This research aims to develop comprehensive agricultural supply chain international courses using a systematic approach. The study employs three key steps: 1) conducting a literature review to identify activities within the agricultural supply chain, 2) collecting data on market-driven topics from top-ranked agricultural universities, and 3) using Grey Relational Analysis (GRA) to determine key topics for each course. Data from agricultural professors and quantitative analysis are used to identify relevant themes. Respondents graded a statement on a Likert scale to rate each course topic's value. Teachers at Taiwan's top 7 agricultural schools from 30 world-class colleges were given questionnaires to collect data. Online surveys were distributed via Google Forms. Analysts utilized Grey Relational Analysis. This methodology ensures that the courses are aligned with current industry demands and educational gaps, providing relevant and up-to-date content for students. This analysis identified three to six market-driven subjects from each of the 17 comprehensive agriculture international courses. Educational institutions can utilize this article to build and improve international agriculture curricula. Building on the current study's conceptual foundations, especially the theoretically sound instrument for measuring agriculture supply chain international courses. Expand and explain this topic. This subject mix global agribusiness courses with transformative change for the first time. Nation advisors' innovation support is measured.

Keywords: Courses, College, Agriculture, Supply chain, GRA, Education

Introduction

Agriculture is a critical economic sector in many developing countries, significantly contributing to their GDP and providing livelihoods for a large portion of the population. In these regions, agriculture can account for more than 25 percent of GDP, starkly contrasting with less than two percent in developed countries (World Bank, 2024). This sector is vital for alleviating poverty and ensuring food security. However, the agricultural sector faces numerous challenges, including sustainability issues, the need for modernization, and a decline in youth involvement (Borda et al., 2023; Geza et al., 2021).

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A major concern is the decreasing participation of young people in agricultural production over the past two decades (Ruiz Salvago et al., 2019). This trend threatens the future viability of the agricultural sector, which requires a new generation of specialized experts and scholars to drive innovation and address complex sustainability issues. Innovative education programs are essential to attract and retain youth in agriculture, equipping them with the necessary skills and knowledge to contribute effectively to the sector. Developing a curriculum that addresses these challenges is academically important and necessary to bridge the current gaps in agricultural education.

This study aims to develop comprehensive agricultural supply chain international courses that are market-driven and aligned with current industry demands. By identifying 27 key activities within the agricultural supply chain and developing 17 corresponding courses, this research addresses the educational gaps and provides relevant, up-to-date content for students. The term "comprehensive" reflects the study's systematic approach, which includes three main data collection methods:

1) Literature Review: To develop courses based on the identified activities within the agricultural supply chain.

2) Market-Driven Data Collection: To gather data on relevant topics offered by top-ranked agricultural universities, ensuring the course content is aligned with market needs.

3) Quantitative Analysis Using Grey Relational Analysis (GRA): To determine the key "market-driven topics" for each course, ensuring that the curriculum focuses on the most critical and relevant areas.

Grey Relational Analysis (GRA) was utilized for data analysis in this study. Initially introduced by Deng (1989), GRA is an "impact measurement" model that assesses the degree of association between factors by analyzing their trend similarities or dissimilarities. This method evaluates the influence of each factor on the system, helping to identify the most and least significant factors for decision-making. GRA is advantageous because it does not require a large sample size or a typical distribution for analysis and can effectively handle uncertainty, multivariate input, discrete data, and incomplete data (Yang & Liu, 2011).

GRA has been widely utilized in various fields, including consumer decision-making and organizational training systems, demonstrating its versatility and robustness in handling complex data sets (Huang & Jiang, 2020; Lee et al., 2023; Liu et al., 2023). By applying GRA in this study, we ensure a rigorous analysis of the data collected, providing a solid foundation for developing effective and relevant agricultural supply chain courses.

The objective of this article is to create educational programs that not only fill the current gaps in agricultural education but also enhance the employability of graduates by aligning the course content with market demands. This approach aims to revitalize the agricultural sector by preparing a new generation of professionals equipped to meet the challenges of modern agriculture.

Literature Review

Course development theory

Course development theory involves the systematic design of educational programs to achieve specific learning outcomes and competencies. This theory has evolved significantly over time, from the early frameworks established by educational pioneers to contemporary models integrating advanced instructional design principles and technology (Diamond, 2008; Tractenberg et al., 2020). Initially focused on basic pedagogical methods, the theory now encompasses comprehensive approaches that include various educational technologies and methodologies to enhance learning experiences.

Application and Procedure

The application of course development theory includes several key steps:

1. Identifying Stakeholders and Objectives: Defining the stakeholders, potential professions, desired performance, and competencies expected from course completers.

2. Course Composition: Determining the duration, composition, content, and the balance between teaching and learning to ensure consistency and effective achievement of learning objectives (Tractenberg et al., 2020).

3. Assessment and Evaluation: Establishing mechanisms for assessing and evaluating learner progress and development over time (Diamond, 2008; Tractenberg et al., 2020). Nicholls (2002) proposed a five-phase model for course design:

1) Selecting or developing learning experiences to achieve the stated outcomes.

2) Choosing content relevant to the learning objectives.

3) Creating assessments to ensure learner progress.

4) Evaluating the effectiveness of the learning experiences.

Teaching should promote complex cognitive behaviors rather than simple memory recall, encouraging learners to develop higher-order thinking skills (Ambrose et al., 2010; Jensen et al., 2014; Knapper, 2006; Nilson, 2016; Roediger & Karpicke, 2006; Weinstein et al., 2018). This can be achieved through activities and materials that foster ongoing learning beyond the course (Knapper, 2006; Roediger & Karpicke, 2006; Jensen et al., 2014).

Developing Courses Based on Agricultural Supply Chain Activities
Concept and Procedure

A supply chain in agriculture encompasses the activities required to bring a primary agricultural product from production to final consumption, adding value at each stage through processing, packaging, storage, transport, and distribution. This concept involves creating a vertical link or network between various independent business organizations (Onwualu & Olife, 2013). The main purpose of developing courses based on agricultural supply chain activities is to provide students with comprehensive knowledge and skills that are directly applicable to the agricultural industry. This ensures that graduates are well-prepared to contribute to the economic growth and sustainability of the agricultural sector (John & De Villiers, 2022).

Steps in Developing Courses

Identifying Activities: Listing the key activities within each stage of the agricultural supply chain.

1. Consolidation: Grouping related activities into broader course categories to streamline the curriculum.

2. Customization: Tailoring the courses to focus on the unique aspects of agricultural supply chains, ensuring relevance and applicability.

Collecting Data on Market-Driven Topics

Importance and Linkage

The collection of market-driven topics is crucial for ensuring that the course content is aligned with current industry demands and educational gaps. This approach helps in developing courses that are relevant, up-to-date, and directly applicable to real-world scenarios. Market-driven topics were identified by analyzing course content from top-ranked universities, which reflects the industry's current needs and trends (Chatterji et al., 2022; Nyamweru et al., 2023). This ensures that the courses developed are not only theoretically sound but also practically relevant.

Procedure

1. Data Collection: Gathering course content from top-ranked universities using keywords related to agricultural supply chains.

2. Analysis: Evaluating the collected data to identify key topics that are market-driven and relevant to the agricultural industry.

3. Integration: Incorporating these topics into the course curriculum to ensure that the content is up-to-date and industry-relevant.

Quantitative Analysis to Determine Key Topics

Significance and Integration

Quantitative analysis is essential for identifying the most important topics within each course, ensuring that the curriculum focuses on key areas that are critical for student learning and industry relevance. This method provides an objective basis for selecting course content, which enhances the credibility and applicability of the curriculum.

Steps in Quantitative Analysis

1. Data Collection: Collecting input from agricultural professors on the importance of various topics.

2. Data Analysis: Using quantitative methods such as Grey Relational Analysis (GRA) to analyze the data and identify key topics.

3. Implementation: Integrating the identified key topics into the course curriculum, ensuring that the content is focused and relevant.

Course and Market-Driven Topics Development

In this study, we proposed courses based on stages and activities in the general agricultural supply chain. We used the agricultural supply chain model from the Food and Agriculture

Organization (FAO) of the (United Nations 2012). The model shows that the agricultural supply chain consists of seven main stages, starting from the input suppliers, growers (farmers), transport, storage, processing, and retail industries, as shown in Figure 1.
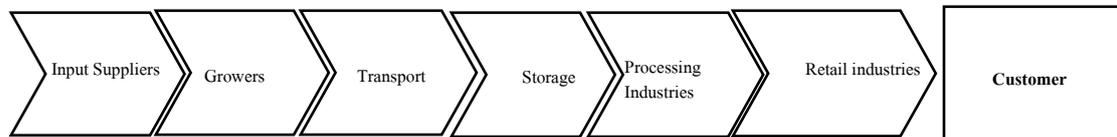

Figure 1 Agricultural supply chain model (FAO, 2012).

In addition, we did a literature review of those seven stages in the agricultural supply chain to list the activities done in every stage (shown in Table 1). In total, from 6 stages, there are 27 listed activities. We used the 27 listed activities to develop comprehensive market-driven agriculture international courses.

Furthermore, only some of the 27 listed activities are selected to be developed into courses. We set the activities based on the definition and scope of each activity. We made the selection in such ways as to determine which activities could be developed into single courses. For the input suppliers' stage (stage 1), five activities (irrigation, plant protection, agriculture equipment, plant material, and nutrients) can be developed into five courses. Therefore, for the grower stage (stage 2), four activities (nursery, plantation, maintenance, and harvest) can be developed into two courses, which are Plantation and Harvest, because "nursery" and "maintenance" can be included in the "plantation" activity. Provided that for the transport stage (stage 3), four activities (road freight, ocean freight, air freight, and rail freight) can be developed into one course, which is Transport, because "transport stage" is a general activity that can be found in any industry (not only in agriculture).

Therefore, the four activities were consolidated into one course, emphasizing the agricultural industry. Meanwhile, for the storage stage (stage 4), four activities (receiving of goods, preparation of records, identification, and storing) can be developed into one course, which is Storage/Warehouse service, because "storage stage" is also a general activity that can be found in any industry (not only in agriculture), so we merged the four activities to develop one course and put the focus on the agriculture industry. Specifically, for the processing industries stage (stage 5), six activities (research and development, design planning, supply management, production, distribution, and waste management) can be developed into six courses.

Consequently, for the retail industries stage (stage 6), two activities are duplicated with the processing industries stage (stage 5): supplier and distribution, so there is no need to develop a new course as the content/topic can be merged efficiently. In this way, in the end, there are 17 activities left to be developed into 17 courses. The name of the courses was modified and changed from activity to course title. The 17 courses are listed in Table 1.

Table 1 Selection of the courses based on the stages and activities of the agricultural supply chain.

Stages	Activities	Reference
1. Input suppliers	(1.1) Irrigation*; (1.2) Plant protection*; (1.3) Agriculture equipment*; (1.4) Plant material*; (1.5) Nutrients*;	Barnard et al. (2020)
2. Grower	(2.1) Nursery; (2.2) Plantation*; (2.3) Maintenance; (2.4) Harvest*;	Fernandez- Stark et al. (2011)
3. Transport*	(3.1) Road freight; (3.2) Ocean freight; (3.3) Air freight; (3.4) Rail freight;	Carnarius (2018)
4. Storage/ Warehouse service*	(4.1) Receiving of goods; (4.2) Preparation of records; (4.3) Identification; (4.4) Storing;	Ajeesh (2015)
5. Processing industries	(5.1) Research and development*; (5.2) Design planning*; (5.3) Supply management*; (5.4) Production*; (5.5) Distribution*; (5.6) Waste management*;	Manufacturing Metrics Expert Group [MMEG], (2013)
6. Retail industries	(6.1) Supplier; (6.2) Distribution; (6.3) Retail store*; (6.4) Customer management*;	Berman (2013)

Note: (*) The activities and stages will be developed into the course.

Seventeen comprehensive agricultural supply chain international courses were developed, including Irrigation Management, Plant Protection, Agricultural Machinery, and others.

Table 2 The courses offered in international universities are related to the 17 courses in this study.

International program title	Total available courses	Courses related to 17 courses in this study
1. Bachelor of Value Chain Management (VIA University College, Denmark)	32	Innovation, Simulation and Facility Layout, Quality Management, Purchasing and sourcing, Flow Optimization, Transport and Logistic, Inventory and Warehouse Management, Product Development and Innovation, Business and Sustainability Getting Started, Process Consultation and Relationship

Table 2 The courses offered in international universities are related to the 17 courses in this study. (Cont.)

	International program title	Total available courses	Courses related to 17 courses in this study
2.	Bachelor of Agriculture (The University of Melbourne, Australia)	60	Irrigation and Water Management, Soil Fertility and Nutrient Management
3.	Bachelor of Agricultural Structures and Irrigation (Ankara University, Turkey)	68	Irrigation and drainage, Plant protection, Agricultural machinery, Plant nutrition and fertilization
4.	Bachelor of Sustainable Agriculture and Rural Development (SUA in Nitra, Slovak Republic)	44	Biological Methods in Plant Protection, Management of Plant Protection
5.	BSc (Hons) Applied Farm Management (Royal Agricultural University, UK)	36	Farm Mechanization Management, Crop Production, Consumer Behavior
6.	BSc (Hons) Agriculture (Harper Adams University, UK)	24	Agricultural Mechanization and Buildings, Wastes - Manures and Renewables
7.	Bachelor of Plant Resource Science & Management (Universiti Malaysia Sarawak, Malaysia)	44	Plantation crop management
8.	BSc (Hons) Agri-Produce and Supply Chain Management (University of Lincoln, UK)	21	Postharvest Technology
9.	The Master of Machinery Trading and Business (SUA in Nitra, Slovak Republic)	30	Machinery for crop harvest
10.	Horticulture program (Oaksterdam University, USA)	33	Harvesting Strategies
11.	Master Programs Supply Chain Management (Michigan State University, USA)	13	Logistics Operations Methods and Systems, Analysis of Supply Markets and Suppliers, Distribution Fulfillment
12.	Business Logistics and Transport Management, BA Hons, (The University of Greenwich, UK)	19	Sustainable Transport, Operations Management

Table 2 The courses offered in international universities are related to the 17 courses in this study. (Cont.)

International program title	Total available courses	Courses related to 17 courses in this study
13. Bachelor of Business Administration Program (Khon Kaen University, Thailand)	46	Inventory and Warehoused Management, Marketing Research, Industrial Plant Design, Production Management and Service, Marketing Channels and Physical Distribution Management, Customer Relationship Management
14. Bachelor of Business Administration (Sikkim Manipal University, India)	30	Warehouse Management
15. GC in Research Commercialization (The University of Queensland, Australia)	6	Management of Research & Development
16. Business Management (BSc), (University of Southampton, UK)	24	Supply Management, Waste Resource Management
17. Supply Chain Management program (Auburn University, USA)	42	Supply Management and Searching
18. Master of Environmental Engineering (the University of Melbourne, AUS.)	11	Solid Wastes to Sustainable Resources
19. Bachelor of Science in Eco-logical Engineering (Oregon State University, USA)	24	Irrigation System Design
20. Master Program in Industrial Engineering and Management (Linköping University, Sweden)	15	Design and Development of Manufacturing Operations
21. BBA –Retail Management (Symbiosis Skills and Open University, India)	40	Retail Store Operations & Mall Management, Retail Store Design & Layout Planning

Table 2 shows that in each international program (column 1 in Table 2), there were found 6-68 courses offered (column 2 in Table 2). We listed the courses related to 17 courses in this study (generated from Table 1). Then we collected the course content/topics offered in each

course in column 3 in Table 2. We selected all topics, merged the similar topics, and listed them as the content/topics of the courses in this study. Table 3 shows the number of topics for each course.

Table 3 List of the course and number of topics for each course.

Course (Course code)	No of Topics	Course (Course code)	No of Topics
Irrigation Management (C1)	25	Research and Development (C10)	29
Plant Protection (C2)	23	Industrial Design (C11)	22
Agricultural Machinery (C3)	37	Supply Management (C12)	24
Plant Material (C4)	29	Production Management (C13)	23
Plant Nutrients Management (C5)	25	Distribution Management (C14)	32
Plantation (C6)	29	Waste Management (C15)	24
Harvest Management (C7)	24	Retail Store Management (C16)	35
Transport (C8)	30	Customer Management (C17)	27
Warehouse Management (C9)	28	-	-

From these 22 to 35 topics in a course (Table 3), it is important to determine the key topics and the most important topics that should be covered in the course. By highlighting the key topics, the lecturers could focus more on certain topics rather than cover a broad range of issues.

We determine the key topics by collecting data from agricultural professors and analysing the quantitative data. The data collection, analysis, and the result are explained in the next sections.

Methodology

Data Collection and Analysis

Based on the topics for each course, a questionnaire was created. In the questionnaire, respondents needed to grade statements to rate the importance of each topic in the course individually on a Likert scale from 1 to 5 (1: strongly not important, 2: not important, 3: neutral, 4: critical, and 5: strongly important). Higher scores indicated that more emphasis was placed on the particular topic.

Population and Sampling

The population for this study consisted of lecturers from the top 7 agricultural colleges across 7 universities in Taiwan. The sampling method used was purposive sampling, targeting lecturers based on their expertise and departmental affiliation. The data were collected by distributing questionnaires to lecturers in the top 7 agricultural colleges across 7 universities in Taiwan. Each of the 17 courses had a corresponding questionnaire, resulting in 17 different questionnaires.

Respondent Matching

Respondents were matched to questionnaires based on course titles and their department affiliations. he questionnaires (using Google Forms) were distributed via email to lecturers in relevant departments. For instance, the questionnaire for the Irrigation Management course (C1) was distributed among lecturers in water management-related departments, while the questionnaire for the Customer Management course (C17) was distributed among lecturers in agribusiness-related departments and others. Each questionnaire received between 9 to 27 responses, as shown in Table 4. This satisfied the requirement of Grey Relational Analysis (GRA), which required a minimum of 4 data observations (n ≥ 4) (Cempel, 2014).

Table 4 The number of respondents filling out each questionnaire.

Course code	No of Respondents	Course code	No of Respondents
C1	16	C10	22
C2	19	C11	15
C3	25	C12	9
C4	18	C13	19
C5	22	C14	13
C6	16	C15	11
C7	14	C16	27
C8	9	C17	18
C9	16	-	-

Data Analysis Using Grey Relational Analysis (GRA)

The data were analyzed using Grey Relational Analysis (GRA), a method that calculates the grey relational degree and determines the contribution measure. GRA consists of three steps, according to Deng (1989).

$$r(x_i(k), x_j(k)) = \frac{\min_i \min_k |x_0(k) - x_i(k)| + \zeta \max_i \max_k |x_0(k) - x_i(k)|}{|x_0(k) - x_i(k)| + \zeta \max_i \max_k |x_0(k) - x_i(k)|}. \qquad (1)$$

Calculation of the Grey Relational Coefficient: This involves calculating the grey relational coefficient using the formula shown in Formula (1). The distinguishing coefficient, ζ, usually set at 0.5, indicates the difference between the two parts.

Calculation of the Grey Relational Degree: The grey relational degree is computed as the arithmetic mean of the grey relational coefficients. It represents the relationship between two sequences. If two factors have the same trend, their correlation is high. The formula for this calculation is shown in Formula (2).

$$r(x_i, x_j) = \frac{1}{n} \sum_{k=1}^{n} r(x_i(k), x_j(k)). \hspace{3cm} (2)$$

Determination of the Grey Relational Sequence: This step involves arranging the grey relational degrees from largest to smallest, forming the grey relational sequence. Items with similar degrees are grouped, showing the relationship between factors. Key factors are selected from these groups based on their degree, indicating their importance. The principle of selecting three to six key factors, as suggested by Daniel (1976), is applied to determine the critical topics for each course.

Result

The sample for this study consisted of lecturers from the top 7 agricultural colleges across 7 universities in Taiwan. The sampling method used was purposive sampling, targeting lecturers based on their expertise and departmental affiliation. Each of the 17 courses had a corresponding questionnaire, resulting in 17 different questionnaires. The respondents were distributed across various departments, ensuring a representative sample for each course.

The GRA was done for each course, resulting in 17 separate analyses. For illustration, we present the results of the "Research and Development" course (C10). This course was chosen because its results are more complex compared to the other 16 courses, providing a comprehensive example of the GRA process. The "Research and Development" course (C10) contains 29 topics. The GRA results for determining the key topics of the "Research and Development" course (C10) are shown in Table 5 and Figure 2 below.

Table 5 GRA results for Research and Development course (C10).

	Topics	Grey relational value	Rank	Grey relational group*	Grey relational sub-group**	Key topics
1.	Market Research	0.818	1	A	-	Yes
2.	Analysis and interpretation of data	0.818	1	A	-	Yes
3.	Managing the development team	0.816	2	A	-	Yes
4.	Roles and importance of marketing research on business	0.773	3	B	-	-
5.	Managing intellectual property	0.758	4	C	C1	-
6.	Introduction, How R&D contributes to profitability	0.758	4	C	C1	-

Table 5 GRA results for Research and Development course (C10). (Cont.)

Topics	Grey relational value	Rank	Grey relational group*	Grey relational sub-group**	Key topics
7. Innovation management)	0.758	4	C	C1	-
8. Designing data collection methods	0.758	4	C	C1	-
9. Management of R&D	0.754	5	C	C2	-
10. Research design	0.750	6	C	C3	-
11. Different innovation strategies	0.742	7	D	-	-
12. Marketing research process	0.742	7	D	-	-
13. How technologies and markets co-evolve	0.735	8	D	-	-
14. The Innovator's Dilemma/Solution: Like a thief in the night)	0.727	9	D	-	-
15. Marketing research application	0.712	10	E	-	-
16. Sampling design and data collection	0.712	10	E	-	-
17. Research report	0.712	10	E	-	-
18. Managing innovation within companies	0.705	11	E	-	-
19. Product development	0.705	11	E	-	-
20. Business Case Report and Presentation	0.697	12	E	-	-
21. Prototypes & Experimentation	0.682	13	F	-	-
22. Product strategy	0.682	13	F	-	-
23. The process from technology development to product development	0.667	14	G	-	-
24. Problem definition and research proposal	0.667	14	G	-	-

Table 5 GRA results for Research and Development course (C10). (Cont.)

Topics	Grey relational value	Rank	Grey relational group*	Grey relational sub-group**	Key topics
25. Strategic alliances and networks	0.645	15	H	-	-
26. The role of technology transfer in innovation	0.644	16	H	-	-
27. The role of market research in product development	0.636	17	H	-	-
28. The role of innovation in business Strategy and Organizational knowledge	0.621	18	I	-	-
29. Innovation and operations management	0.583	19	J	-	-

* Groups are determined based on the factor distribution for 20 factors

**Sub-groups are determined based on the factor distribution for some top groups

In the GRA figure, values of grey relations are plotted on the X-axis. The 29 topics for the Research and Development course (C10) are divided into groups (*), depending on the values differences between factors. Similar values are grouped into one grey relational group (*). From the groups, some top groups are selected to be zoomed in to make it easier to see the value differences between the factors and put them into sub-groups (**). The selection of three to six key factors, based on the principle of Daniel (1961), is done from these sub-groups.
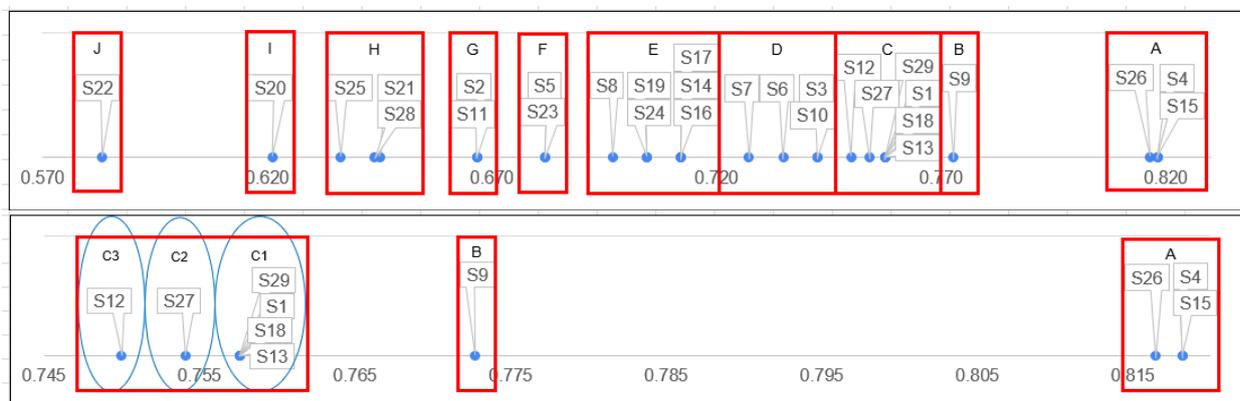

Figure 2 Distribution chart of grey relation among 29 subjects for the Research and Development course.

In Figure 2, the upper part, the 29 subjects for the Research and Development course (C10) are divided into 10 groups (A to J). The top three groups, which consist of 10 subjects, are selected to be zoomed in. Figure 10 lower part shows that group A has no sub-group (A) with three subjects, group 2 has no sub-group (B) with one subject, and group C has three sub-groups (C1, C2, and C3) with six subjects.

In the first sub-group (A), three subjects can satisfy the requirement of three to six key factors. The relationship or the distance between the first sub-group (A) and the second sub-group (B) is far. Therefore, the second sub-group (B) and the following group (C) are not selected. Consequently, there are three key topics selected through this analysis, which are "Market research," "Analysis and interpretation of data," and "Managing the development team." The same GRA process was done for the other 16 courses. The summary of the results (key subjects) is shown in Table 6.

Table 6 GRA results for the critical topic of 17 agricultural supply chain courses.

Course Code	Key Topics
C1	(1) Plant water requirements in terms of water quality and frequency of supply, (2) The need for efficient irrigation drainage as well as water supply, (3) Soil-Water-Plant relations, (4) The scale and distribution of the major irrigation systems, (5) Crop Water Requirements, (6) Determination of water demands
C2	(1) Biotechnical, Quarantine, and Chemical Pest Control Methods, (2) Chemical control method and Integrated Pest Control Concept, (3) Symptoms of plant diseases, (4) Control of plant diseases, (5) Biological control of selected plant pests and pathogens, (6) Plant viral diseases
C3	(1) Basic concepts of agricultural machinery, (2) Introduction of agricultural power and machinery, (3) Plant protection machines, (4) Harvesting machines
C4	(1) Plant physiology, (2) Plantation management, (3) Plant breeding, (4) Diseases and pests
C5	(1) Nitrogen in soil (N), (2) Introduction-Plant Nutrient Elements, (3) Organic and inorganic fertilizer, (4) The concepts of soil fertility and nutrient management, (5) Key nutrient cycles in soil, (6) Minimize environmental impacts of fertilizer application
C6	(1) Site selection and preparation, (2) Climate and cropping systems, (3) Drainage system, (4) Crop types and markets, (5) Fertilizer application
C7	(1) Systems of grading, handling, cooling, storage, and inspection, (2) Harvesting a crop, (3) Techniques to improve flow and processes
C8	(1) Market forms and the importance of these for the company, (2) Transport management in a supply chain, (3) Purchasing, production, and distribution functions, including logistics service

Table 6 GRA results for the critical topic of 17 agricultural supply chain courses. (Cont.)

Course Code	Key Topics
C9	(1) Warehouse management, (2) Inventory stock analysis, (3) Inventory and statistics, (4) Supply chain and warehousing
C10	(1) Market research, (2) Analysis and interpretation of data, (3) Managing the development team, (4) Roles and importance of marketing research on business
C11	(1) Solutions of design problems, (2) Data collection and analysis, (3) Resource allocation, (4) Simulation, (5) Industrial plant design and layout techniques, (6) Factors and causes influencing new layout
C12	(1) The role of purchasing in the value chain, (2) Models for analyzing purchasing and business strategies, (3) Supply relationships, chains, and networks, (4) Purchasing and supply management strategies, (5) Optimizing the supplier relationships in the chain, (6) Total cost management
C13	(1) Production and service processes, (2) Quality management, (3) Technology to improve agricultural production processes
C14	(1) Distribution system, (2) Solving problems in distribution, (3) Purchasing, production, and distribution functions including logistics service, (4) Distribution channel information system management, (5) Different logistics systems, (6) Market forms and the importance of these for the company
C15	(1) Renewable energy, (2) How waste can be minimized and utilized, (3) Waste disposal, (4) Energy conservation and renewable energy, (5) Recycling of solid wastes, (6) Re-use of solid wastes
C16	(1) Factors for choosing a location, (2) The choice of location, (3) Marketing, (4) Location and Site evaluation, (5) Operations & supply chain, (6) Distribution center
C17	(1) CRM as business strategy and model, (2) Information technology and collecting customer data, (3) Understand customer expectations and consumer behavior, (4) CRM value chain, (5) Consumer's Decision-making and Satisfaction, (6) Economic Behavior and Social Class

Discussion

The findings of this research align with and expand upon the body of existing literature on curriculum development and agricultural education. By integrating key elements identified through Grey Relational Analysis (GRA) and comparing these results to those of previous studies, we can better understand the similarities, differences, and reasons behind these observations.

Alignment with Theoretical Foundations: Previous studies have emphasized the importance of aligning educational curricula with industry needs to enhance graduate employability and relevance. For instance, Diamond (2008) highlighted the necessity of integrating

stakeholder feedback and industry demands into curriculum design, a principle that this study upholds by using market-driven topics to shape the course content.

Emphasis on Practical Skills and Market Relevance: The focus on practical skills such as "Market research," "Managing the development team," and "Irrigation Management" parallels findings from studies like those of John and De Villiers (2022), which stressed the importance of practical, hands-on learning experiences in agricultural education. These practical skills are crucial for preparing students to tackle real-world challenges, a theme consistently echoed in the literature.

Integration of Innovation and Technology: Innovation and technology's pivotal role, as highlighted in this research, aligns with the findings of Ruiz Salvago et al. (2019), who discussed the decreasing involvement of young people in agriculture and the need for innovative educational approaches to reverse this trend. The identified key topics such as "Innovation management" and "Designing data collection methods" underscore the critical need to prepare students for technological advancements in the agricultural sector.

Interdisciplinary and Holistic Approaches: This study's interdisciplinary approach, incorporating elements of economics, technology, and social sciences, mirrors the recommendations of Onwualu (2012), who advocated for a comprehensive understanding of the agricultural supply chain. The inclusion of topics like "Strategic alliances and networks" and "Role of technology transfer in innovation" supports the holistic education model suggested by previous research.

Addressing Dynamic Industry Needs: The adaptability of the curriculum to changing industry needs, highlighted through topics like "Different innovation strategies" and "Market forms and their importance," resonates with the findings of Nyamweru et al. (2023). They emphasized the importance of educational programs that can evolve with market demands and technological advancements, ensuring long-term relevance and effectiveness.

Enhancing Employability: The direct correlation between curriculum content and employability, as found in this study, is supported by Chatterji et al. (2022), who linked well-structured educational programs to better job prospects for graduates. By focusing on market-driven topics identified through GRA, this research ensures that the courses remain aligned with the skills and knowledge required by employers in the agricultural sector.

In summary, the findings of this research not only align with but also expand upon previous studies in the field of agricultural education and curriculum development. By utilizing Grey Relational Analysis to identify key topics, this study reinforces the importance of aligning educational programs with industry needs, integrating practical skills, and fostering innovation and interdisciplinary learning. These insights contribute to a deeper understanding of effective curriculum development practices and provide a robust framework for future educational initiatives in agricultural supply chain management.

Conclusions

This study provides a new approach to developing comprehensive agricultural supply chain international courses through a scientific and systematic methodology. The term "comprehensive" is used because the study employs three approaches to data collection: 1) a literature review to develop courses based on activities in the agricultural supply chain; 2) collecting data on "market-driven topics" to tailor the content of each course; and 3) conducting a quantitative analysis to determine the key "market-driven topics" for each course.

The term "market-driven" refers to the course topics offered by universities with high rankings in agriculture, indicating that their graduates secure good jobs due to relevant training (Desiderio et al., 2022; Shukla et al., 2022). This study compiled "market-driven" topics from top-ranking universities for each agricultural supply chain course developed.

Seventeen comprehensive agricultural supply chain international courses were developed, each with a list of "market-driven" topics. By using Grey Relational Analysis (GRA), the study highlighted the three to six key "market-driven" topics for each course. References from 21 universities with good rankings in agriculture were used to determine these topics (Nayak et al., 2022).

Although it is challenging for universities to consider their universal goal of knowledge generation, the examples provided reveal future possibilities. Universities are increasingly devising measures to enhance their contributions to student learning and development. They play a critical role in conceptualizing development challenges and strategies, supporting education and development initiatives, and promoting lifelong learning (O'Dea et al., 2023; Tran & Vu, 2022). To fulfill their roles as contributors to the agricultural supply chain of learning, institutions must engage directly and effectively in partnerships and dialogue with other educational institutions.

This research offers 17 comprehensive agricultural supply chain international courses for higher education institutions, serving as a reference or guideline for developing and improving international agriculture courses.

Disclosure statement

No potential conflict of interest was reported to all authors.

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