The Inquiry-Driven VCoP Model to Promote Digital Agriculturalists' Learning Competencies in the Agriculture 4.0 Era

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***Abstract*—This research was conducted to develop the Inquiry-Driven Virtual Communities of Practice model (The ID VCoP model) in order to enhance the learning competencies of Thai digital agriculturists in preparation for the agriculture 4.0 era. The objectives of this study were to 1) develop the ID VCoP model to promote digital agriculturalists' learning competencies, and 2) evaluate the suitability of the ID VCoP model. The research procedure consisted of two phases. The first phase involved the development of the model: 1) studying, analyzing, and synthesizing existing documents and previous research findings; 2) organzing the ID VCoP model; and 3) establishing the ID VCoP model. The second phase involved model validation and evaluation. This study's expert panel was divided into two expert groups: 1) qualitative research by the focus group method, consisting of seven experts recruited through purposive sampling; and 2) quantitative research by the expert judgment method, consisting of five experts recruited through purposive sampling. Five components with 19 subcomponents comprise the model's structure. The model contributes to VCoP members' digital agriculturalists' learning competencies. Experts agreed that the model as a whole was suitable at a very high level.**

***Keywords*—Virtual Communities of Practice (VCoP), critical inquiry methods, digital agriculturalists' learning competencies, instructional system design**

I. Introduction

The international challenge is well understood: by 2050, global food production must increase by 70%. Smallholder farmers in developing and emerging countries, who produce 80% of the world's food, will need to almost double their productivity. In light of the fact that many regions of the world are already struggling with a range of problems, such as population increase, rising housing demand, shrinking agricultural land, desertification, and climate change, as well as its consequences, the question is how we should approach this issue. Support and social co-knowledge construction are expected to be crucial in increasing yields, but as smallholder agriculturalists often live on the margins of society, it is difficult for them to have equal access to knowledge and resources. One approach is to proactively provide timely, reliable, and localized agricultural knowledge to agriculturalists [1].

The concept of Communities of Practice (CoP), which is based on social learning theory, has a close relationship with social knowledge construction. A CoP is a large group of people who learn together to better the lives of community and society members. It is used in modern society to perform jobs that require a high level of knowledge, skills, and abilities. It is critical to the exchange of knowledge and the creation of value for both their people and their organizations. A CoP is made up of three essential components: community, domain, and practice, which serve as a guide for community development [2].

The term "Virtual Learning Environment" (VLE) refers to a set of teaching and learning tools made for an online learning environment. These tools, which help and improve a learner's ability to learn with digital devices and the Internet, include curriculum planning, learning support, online tracking for both teachers and students, and online communication (e.g., e-mail, discussion forums, live chat, web publishing, and links to external course resources) [3]. However, the Virtual Communities of Practice (VCoP) have emerged as a result of the combination of the CoP and the Virtual Learning Environment (VLE). Additionally, the VCoP encourages communication, personal growth, and resource sharing [4].

Digital Learning Resources (DLRs) are online resources that engage learners in learning activities and support their learning goals, such as mobile applications, software, programs, or websites [5]. Digital learning tools for digital agriculturalists can be divided into seven categories: digital library, crop advisory, fertilizer calculator, automated disease alerts, weather forecasting, retailer connection, and virtual community that enables cross-learning and discussions among all agricultural stakeholders. It is an interactive, national forum where users may discuss best practices and seek assistance from other users for their concerns [6]. Agriculturalists in the digital era need to use a digital inquiry approach in their daily lives.

Thus, this study was significant for the following theoretical and practical reasons: First, this study suggests, from a theoretical standpoint, that the model of the ID VCoP increases learning competencies among digital agriculturalists. This allowed educational technology researchers to learn more about the components of the ID

VCoP model for promoting the learning competencies of Thai digital agriculturalists. Second, the study was important for practical reasons. It created the ID VCoP model that could be used to improve the learning effectiveness of agriculturalists in three areas: learning achievements, learning competencies, and learning satisfaction. This provided agricultural stakeholders with information on facilitating or limiting input factors compatible with Thai digital agriculturalists.

The research objectives are 1). to develop the Inquiry-Driven VCoP model)The ID VCoP model(to promote digital agriculturalists' learning competencies; 2). to evaluate the suitability of the ID VCoP model to promote digital agriculturalists' learning competencies.

II. Literature Review

A. Virtual Communities of Practices (VCoPs)

The phrase "community of practice" was first used in a book, namely "Situated Learning: Legitimate Peripheral Participation" by Lave & Wenger [7]. This focused on what they termed "situated learning," which was developed by several social theorists, including Vygotsky's theories of social learning [8, 9]. Essentially, CoPs are voluntary associations of people who, united by a shared interest or concern, convene to explore, exchange, and develop their practice. More generally, communities of practice have always existed and still exist in every aspect of human life. Moreover, Wenger *et al*. [10] state, "We all belong to a number of them at work, at school, at home, in our hobbies." According to Rheingold [11], "the Virtual Community of Practices (VCoPs) is a network of people who may or may not meet in person and who exchange words and ideas through a specific organization."

Behera *et al*. [12] proposed E-Governance Mediated Agriculture for Sustainable Life in India to facilitate the linking up of agriculture produce marketing cooperatives. ITCs, E-chaupal, IT-Kiosks, Eid-party agriline, Gyandoot Project, Warana Weired Village, Information Village Project of MSSRF (MS Swaminathan Research Foundation), I-Kisan Project of the Nagarjun Group of Companies, Kisan Call Center (KCC), Bhoomi Project, Village Knowledge Center, etc. are the recent developments in e-governance-mediated agriculture in India. It adds value to the lives of farmers and end-users in a sustainable way through knowledge management portals, e-kiosks, and common service centres at the grass-roots level.

Liu and Zhang [13] also stated that a *"virtual community refers to an online site where people come together, communicate, and relate to one another" and defined it as "a network of individuals who share a domain of interest about which they communicate online."* It is where community members improve their knowledge through their contributions, e.g., experiences and resources within the domain. The online contributions include knowledge exchange, discussion, normal chat, brainstorming, and intellectual wellness activities.

Moreover, Sayavaranont and Piriyasurawong [14] defined a *"virtual community of practice" as an "online or web-based collaborative and interactive knowledge-generating process developed to support knowledge management initiatives that allow members to create, share, and use knowledge even if they are in different places and different time zones."*

B. Critical Inquiry Methods

Critical inquiry is defined as the act of searching, gathering, and evaluating information, ideas, and assumptions from various points of view in order to produce well-reasoned analysis and knowledge that leads to innovative ideas, applications, and questions [6]. Also, social media makes it easier for the VCoP to form by making it easier for people with similar interests in the domain to talk to each other [6, 15].

C. Digital Agriculturalists' Learning Competencies

The OECD Learning Framework 2030 adds value by clearly referring to the holistic concept of competence, which implies the mobilization of a mix of knowledge, cognitive, practical, and socio-emotional skills, attitudes, and values. This whole-person view is similar to UNESCO's main goal for its education program, which is "education for peace and sustainable development" [16].

Digital agriculture, sometimes known as smart farming or e-agriculture, is a concept that reflects the practices of agriculturalists in the digital era regarding the digital collection, storage, analysis, and sharing of digital data and/or information in agriculture. The Food and Agriculture Organization of the United Nations has called the process of digitalizing agriculture the "digital agricultural revolution" and emphasized the role of digital technology in making food systems better [17, 18].

Manyuen *et al*. [19] propose that the conceptual framework will lead to practical ways to incorporate agricultural communication to increase participation in the VCoPs among the agricultural workforce, including for all ages in the digital transmedia era, towards the digital agriculturalists' learning competencies, which include six expected learning outcomes: 1) Seeking opportunities for lifelong learning; 2) a self-concept of being an effective digital learner; 3) initiative, creativity, and independent learning concerning digital agriculture learning issues; 4) self-responsibility in digital agriculture occupations; 5) optimistic about agriculture's evolution in the digital era; and 6) problem-solving and decision-making concerning agriculture practices in the digital era.

III. Conceptual Framework

The four concepts are: 1(Communities of Practices (CoPs), 2(Virtual learning ENVIRONMENTS (VLEs), 3(Digital Learning Resources (DLRs), and 4(the critical inquiry method. The four concepts were incorporated into the conceptual framework of this study to develop the learning model. This conceptual framework, adapted from Manyuen and Boonlue *et al*. [19], aims to promote digital agriculturalists' learning competencies towards the agriculture 4.0 era. As shown in Fig. 1.

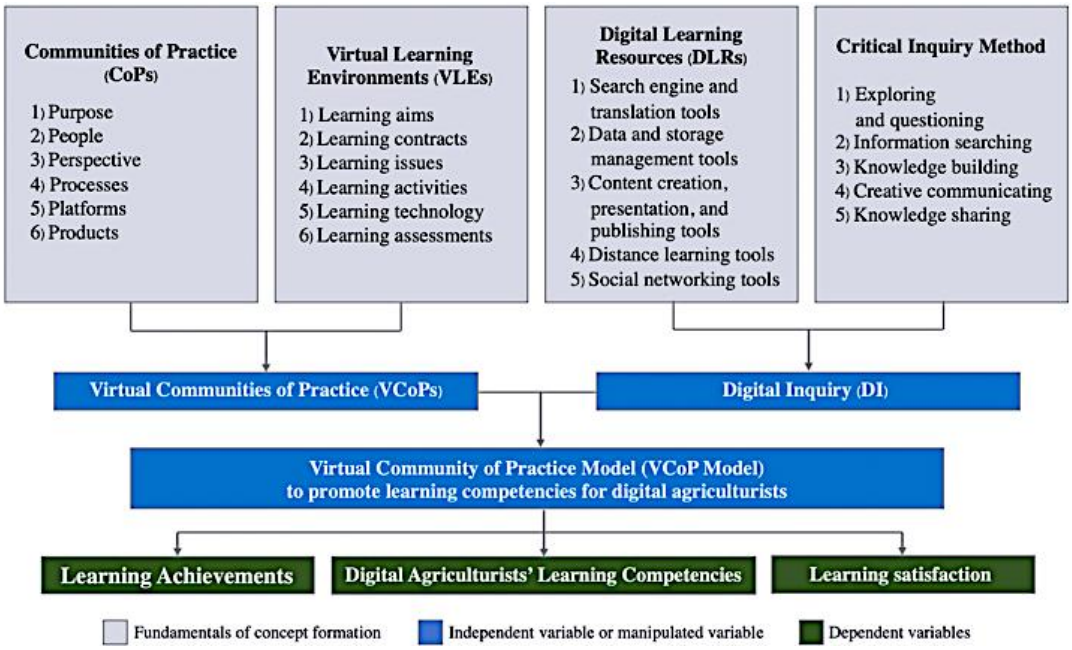

Fig. 1. The conceptual framework.

IV. Research Methodology

A. The First Phase

The first phase involved the development of the model, which included the following processes:

1) Researchers jointly review and synthesize relevant documents and prior research findings. This is a qualitative data collection from research articles in ERIC, Scopus, and the Web of Science online databases that were published between 2015 and 2022. The text data from research articles was used for the content analysis of the data.
2) Set up a model based on the results of putting together relevant documents and research from the past.
3) Establish the ID VCoP model in order to promote digital agriculturalists' learning competencies. The systems approach, or input-output cycle [21], was used to establish the ID VCoP model with five main parts: input, processing, control, output, and feedback.

B. The Second Phase

The second phase of the research focused on model evaluation, with the following steps:

1) Creating research tools used to collect qualitative data. This tool provides a framework [22] to raise questions with experts about the correctness and modernity of the various components of the developed model.
2) Qualitative data collection by the focus group method, which has seven experts recruited by using purposive sampling. This stage focused on proposing and validating the developed ID VCoP model with seven experts in agricultural communication, information technology, and instructional system design. Each of these experts has a PhD or its equivalent, works as an instructor or agricultural scholar, and has at least three years of experience in the field.
3) Researchers jointly analyzed the qualitative data from focus groups. Data from the focus group was used for the content analysis, and researchers jointly refined the ID VCoP model based on experts' suggestions.
4) Creating research tools that use quantitative data collection, this tool is used by experts who are the respondents to assess the suitability of the ID VCoP model to promote digital agriculturalists' learning competencies. This tool features an evaluation form built on a five-point Likert scale (5 = very high, 4 = high, 3 = moderate, 2 = low, 1 = very low).
5) Quantitative data collection by the expert judgment method, which has five experts recruited by using purposive sampling. This stage focused on evaluating the suitability of the developed ID VCoP model with five experts in agricultural communication, information technology, and instructional system design. Each of these experts has a PhD or its equivalent, works as an instructor or agricultural scholar, and has at least three years of experience in the field.
6) Analyzed quantitative data on the suitability of the ID VCoP model to promote digital agriculturalists' learning competencies by the mean and Standard Deviation (SD).

V. Research Results

A. The ID VCoP Model to Promote Digital Agriculturalists' Learning Competencies

Fig. 2 depicts the ID VCoP model for fostering digital agriculturalists' learning competencies. This model was comprised of five major components and the following 19 subcomponents:

1) **Component 1:** Input factors represent the basic resources and digital infrastructure that will be transformed into the outputs. There were five subcomponents:)1(Purpose,)2(People,)3(Perspective,)4(Platform, and)5(Policy. Each of these subcomponents has the following key attributes:
   - Purpose: This subcomponent represents the social learning objectives of the ID VCoP to fulfil the shared interests and best practices in the ID VCoP as they pertain to digital agriculture. The social learning goals of the ID VCoP are mostly about getting and making

knowledge that can be used to develop, improve, and solve agricultural problems with knowledge, best practices, and digital technologies.

- People: This subcomponent symbolizes the individuals who are interested in digital agriculture. Such individuals could be agricultural scholars, agriculturalists, and digital citizens with an interest in digital agricultural career prospects. Such a person must have a digital communication device to access the ID VCoP space.
- Perspective: This subcomponent symbolizes tacit and explicit knowledge concerning digital agriculture. Perspectives are the opinions, factual, conceptual, procedural, and metacognitive views of practitioners concerning the application of a body of knowledge to develop, improve, and solve agricultural problems in the digital era.
- Platform: This subcomponent symbolizes the digital learning resources that fit the agriculturalists' contexts. Digital learning resources are divided into five categories: 1) search engine and translation tools; 2) social networking tools; 3) data and storage management tools; 4) content creation, presentation, and publishing tools; and 5) distance learning tools.
- Policy: This subcomponent symbolizes the setting of the rules and learning guidelines for members' collaborative learning in the ID VCoP space. Rules are important in the learning orientation for new members participating in the ID VCoP space. Learning guidelines are useful in encouraging self-directed learning and self-regulation while learning.

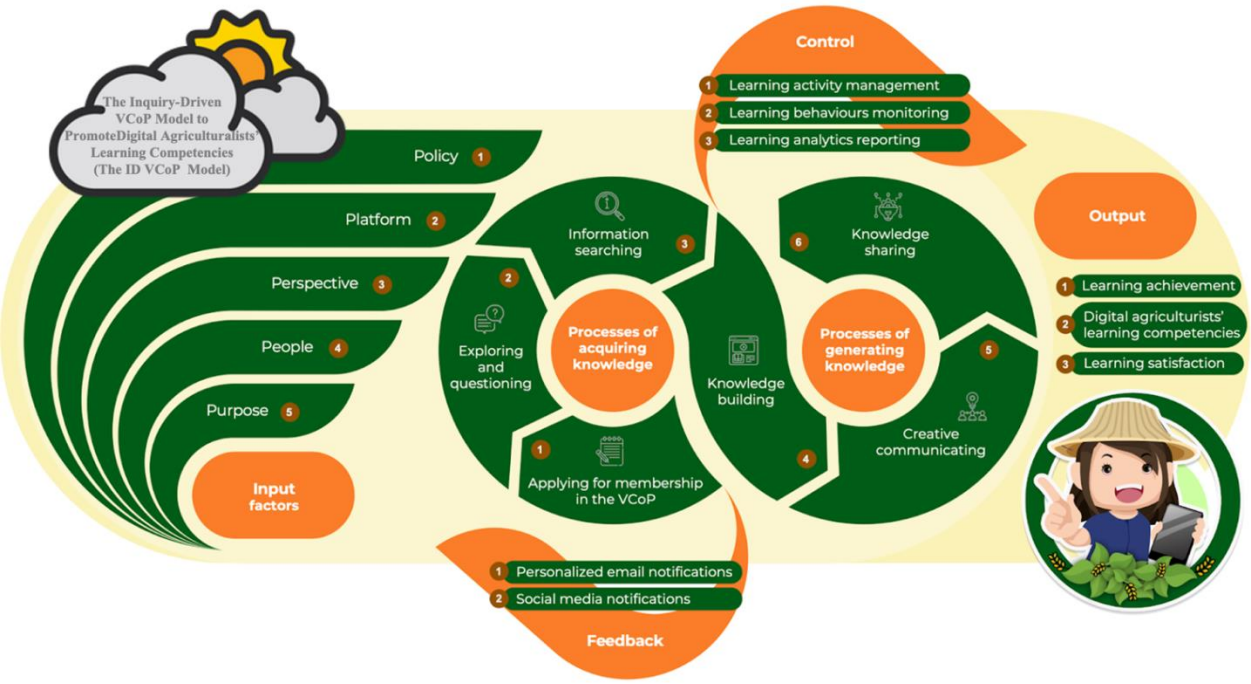

Fig. 2. The ID VCoP model to promote digital agriculturalists' learning competencies towards agriculture 4.0 era.

2) **Component 2**: Processes represent the dynamic human learning processes using Personal Digital Inquiry (PDI) via digital technology to promote knowledge, skills, and attitudes. This component had six subcomponents:)1) Applying for membership in the ID VCoP space,)2) Exploring and questioning,)3) Information searching,)4) Knowledge building,)5) Creative communicating, and)6) Knowledge sharing. Each of these sub-elements has the following key attributes:

- Applying for membership in the ID VCoP space: This is the first step in learning in the ID VCoP space, which focuses on comprehending the VCoP's rules and learning guidelines for self-directed and collaborative learning.
- Exploring and questioning: This stage symbolizes personalized learning via social networking tools to explore the Agricultural Social Movement (ASM). Social media stimuli encourage members to learn to ask questions automatically.
- Information searching: This stage symbolizes personalized learning via search engines and translation tools for seeking factual, conceptual, procedural, and metacognitive views of practitioners in the agricultural sector, the manufacturing sector, and others.
- Knowledge building: This stage symbolizes personalized and social learning via various authoritative tools (i.e., search engine and translation tools, social networking tools, data and storage management tools, content creation, presentation, and publishing tools, and distance learning tools) for building a learning achievement and cognitive artefact. Social media posts, drawings, photographs, diagrams, models, and anything else capable of explicit knowledge to develop, improve, and solve agricultural problems in the digital era are examples of cognitive artefacts.
- Creative communicating: This stage symbolizes social learning via various authoritative tools for creative communication among ID VCoP members. Communication modes are divided into two categories: 1) Formal modes of communication, such as emails,

announcements, forums, and webinars, frequently have specific structures or channels; and 2) informal modes of communication, such as chat, dialogue, and microblogging, frequently flow freely in any direction.

- Knowledge sharing: This stage symbolizes social learning via content creation, presentation, and publishing tools, as well as social networking tools. Knowledge sharing bridges the gap between personalized and social learning among Inquiry VCoP members. Sharing knowledge fosters an absorptive and innovative capacity to develop, improve, and solve agricultural problems. This gives agriculturalists a competitive advantage in the digital age.

3) **Component 3:** Control entails managing, monitoring, and reporting on the inquiry's VCoP participants' behaviors and learning activities. There were three subcomponents:)1(Learning activity management,)2(Learning behaviors monitoring, and)3(Learning analytics reporting. Each of these sub-elements has the following key attributes:

- Learning activity management: This subcomponent symbolizes the management of the ID VCoP's events, seminars, or workshops. Such management is planned, organized, operated, and evaluated to promote efficient and effective learning.
- Learning behaviors monitoring: This subcomponent stands for scanning information about ID VCoP on different digital platforms to check how ID VCoP members learn.
- Learning analytics reporting: The learning analytics reports of ID VCoP members. These reports aid in understanding and improving the inputs, processes, and outputs.

4) **Component 4:** Output represents the expected learning outcomes and desired results. This component had three subcomponents:)1(Learning achievement,)2(Digital agriculturalists' learning competencies, and)3(Learning satisfaction. Each of these sub-elements has the following key attributes:

- Learning achievement: This subcomponent is a representation of the digital agriculturalists' assessment of their learning achievement using the Revised Bloom's Taxonomy [20].
- Digital agriculturalists' learning competencies: This subcomponent symbolizes the learning competencies assessment applied to the OECD learning framework [16] and digital agriculturalists' learning competencies, which include six expected learning outcomes [19]: 1) Seeking opportunities for lifelong learning; 2) self-concept of being an effective digital learner; 3) initiative, creativity, and independent learning concerning digital agriculture learning issues; 4) self-responsibility in digital agriculture occupations; 5) optimistic about agriculture's evolution in the digital era; and 6) problem-solving and decision-making concerning agriculture practices in the digital era.
- Learning satisfaction: This subcomponent symbolizes the learning satisfaction survey based on input factors (purpose, people, perspective, platform, and policy).

5) **Component 5:** Feedback represents the informative transmission that comes directly from the virtual communities of practice (VCoP) via digital learning tools to participants in the ID VCoP space. There were two subcomponents:)1) Personalized email notifications; and)2) Social media notifications. Each of these sub-elements has the following key attributes:

- Personalized email notifications: This subcomponent symbolizes the personalized email notifications that are sent primarily via two channels: (1) web push email notifications and (2) app push email notifications.
- Social media notifications: This subcomponent symbolizes the social media notifications that are sent primarily via three channels: (1) web push social notifications, (2) app push social notifications, and (3) in-app messages.

B. The Suitability Evaluation of the Inquiry-Driven VCoP Model to Promote Digital Agriculturalists' Learning Competencies

Table 1 shows that the rating scale for the results of the suitability evaluation form for the ID VCoP model to promote digital agriculturalists' learning competencies was very high (mean = 4.83, S.D. = 0.18).

Table 1. The suitability evaluation of the inquiry-driven VCoP model to promote digital agriculturalists' learning competencies

	Details of Evaluation List	Result		Rating
		Mean	S.D.	
1. Component 1: Input factors	1.1 Purpose	5.00	0.00	Very high
	1.2 People	5.00	0.00	Very high
	1.3 Perspective	5.00	0.00	Very high
	1.4 Platform	5.00	0.00	Very high
	1.5 Policy	4.60	0.49	Very high
2. Component 2: Processes	2.1 Applying for membership in the ID VCoP space	4.20	0.40	High
	2.2 Exploring and questioning	5.00	0.00	Very high
	2.3 Information searching	4.60	0.49	Very high
	2.4 Knowledge building	5.00	0.00	Very high
	2.5 Creative communicating	5.00	0.00	Very high
	2.6 Knowledge sharing	5.00	0.00	Very high
3. Component 3: Control	3.1 Learning activity management	4.60	0.49	Very high
	3.2 Learning behaviors monitoring	4.60	0.49	Very high
	3.3 Learning analytics reporting	4.60	0.49	Very high
4. Component 4: Output	4.1 Learning achievement	5.00	0.00	Very high
	4.2 Digital agriculturalists' learning competencies	5.00	0.00	Very high
	4.3 Learning satisfaction	5.00	0.00	Very high
5. Component 5: Feedback	5.1 Personalized email notifications	4.60	0.49	Very high
	5.2 Social media notifications	5.00	0.00	Very high
	Overview	**4.83**	**0.18**	**Very high**

VI. Discussion

The developed model adds value to the current context of learning by promoting digital agriculturalists' learning competencies through personal and social learning. The model emphasizes Personal Digital Inquiry (PDI) via digital technology and provides a structured approach. By merging personal and social learning, the model offers a dynamic, fluid, and adaptable approach to learning that meets the learning requirements of individuals while fostering collaboration and information exchange. Specifically, cognitive artefacts, refer to the products of learning or the tangible representations of knowledge and understanding. In the context of the ID VCoP model, cognitive artefacts can include things like social media posts, drawings, photographs, diagrams, models, and others. explicit expressions of knowledge that can be developed, improved and used to solve agricultural problems in the digital era. These artifacts are regarded as valuable because they are the results of the learning processes that occur in the ID VCoP space, and they represent the knowledge, skills, and attitudes that participants have acquired through their learning experiences.

In the future directions of EdTech research in order to promote digital agriculturalists' learning competencies [1, 23–26], it will still be challenging to integrate strategies (e.g., pedagogy, andragogy, heutagogy, and cybergogy) with emerging technology to help agriculturalists gain access to learning and gain an appropriate learning process that affects productivity and improves the quality of life and well-being.

VII. Conclusions

The researchers developed a suitable Inquiry-Driven VCoP model to promote digital agriculturalists' learning competencies. The highlights of this model are the processes of acquiring knowledge and generating knowledge. This model could be used to promote the learning effectiveness of agriculturalists in three areas: learning achievements, learning competencies, and learning satisfaction. According to the results of the suitability evaluation of the developed ID VCoP model, it was at a very high level (mean = 4.83, S.D. = 0.18). Based on these results, we think that the developed ID VCoP model will be used to help agriculturalists learn more effectively in the Agriculture 4.0 Era.

The highlight of the ID VCoP model is its promotion of digital agriculturalists' learning competencies through a combination of personal and social learning. The model provides a structured approach to learning that includes input factors, processes, control, output, and feedback components and emphasizes personal digital inquiry (PDI) via digital technology. In addition, the model facilitates the production of important cognitive artifacts, which are tangible representations of information and understanding that aid in the development, improvement, and resolution of agricultural challenges in the digital era.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

M.M., S.B., J.N., and V.N. contributed to the design and implementation of the research, and the analysis of the results. M.M., V.N., and A.B. developed the model and performed the computations. S.B. and J.N. verified the analytical methods and supervised the findings of this work. All authors have read and agreed to the published version of the manuscript.

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