CHAPTER 4

Results and Analysis

4.1 Chapter Overview

This research proposed effective tutorial social science ontologies on organic rice farming as an appropriate technology based on sustainable development projects for non-science and technology educated farmers using knowledge engineering approach. An organic rice farming domain knowledge was captured, analyzed and structured from experts using CommonKADS and the social science ontology on organic rice farming was identified and developed based on lower secondary school of Thai curriculum which provides biology, chemistry, mathematics and physics concepts. The effective tutorial social science ontologies on organic rice farming knowledge contain the conceptualization within the biology, chemistry, mathematics and physics concepts and the relations among them. Consequently, this study has mainly concerned with measurement of effective tutorial ontology which a commonly-agreed understanding of expert's jargons (domain knowledge) that can be shared, reasoned, reused and operationalized across communities in learning process by semantic annotation technique on Bloom's Taxonomy vocabulary.

This study developed additional social science ontologies from the organic rice farming knowledge as an appropriate technology to transfer knowledge to rural non-science and technology educated farmers of Phrao District, Chiang Mai Province, Thailand as a research case study. The effective tutorial social science ontologies on organic rice farming knowledge contain specification of the conceptualization within the biology, chemistry, mathematics and physics concepts. The vocational learning process was experimented with Bloom's Taxonomy framework to evaluate additional ontologies effectiveness and vocational life-long learning of case study.

This study was focusing on the organic rice farming knowledge, particularly useful in rural areas and communities as appropriate technology and using Phrao District, Chiang Mai Province, Thailand as a case study where most people had a highest education level at basic education level or primary school (Pratom 4-6). Knowledge workers in Phrao local community also require a social scientific knowledge episodic scenario as a tool to inform their decision making as experts when they disseminate appropriate technology knowledge and research knowledge to communities.

This chapter shows the result and result analysis of this research that explains the conceptual framework of this research methodology to the expected results. This chapter also shows the understanding of the research problem, providing of the idea and solution of this study.

4.2 Initial Finding

Ontology-based knowledge management focuses on providing knowledge support for construction of the Chaipattana Aerator in first year project. This project focuses on integration of two forms of knowledge, firstly, the principle, essence and practice concepts and secondly, ontologies. The ontology categories were based on the King of Thailand's working concepts in order to effectively structure knowledge of the Chaipattana Aerator. This study has been mainly concerned with capturing and representing knowledge found in the logic and structure of the Chaipattana Aerator knowledge through ontology-based knowledge management. This research aims at capturing domain knowledge in a generic way and a commonly-agreed understanding of domain which can be shared, reused and operationalized across communities. The ontologies contain the ideas within the principle, essence and practice concepts and the relations between them. This project has developed ontology enabled annotation and knowledge management with a perspective on provision of a knowledge package. In this project, ontologies provide a means for knowledge acquisition and modeling of the relevant Chaipattana Aerator oxygenation knowledge. Specifically, ontologies are developed based on operation of existing Chaipattana Aerator construction documents. The most important role of ontology-based knowledge management is to enable and to enhance knowledge sharing and reusing. This project has focused on ontology creation using a semantic annotation technique with experts' jargons and knowledge structuring using CommonKADS which provides tools to support structuring knowledge. This knowledge structure will facilitate storage, sharing and reuse of knowledge for rural communities and high school students in order to understand the Chaipattana Aerator and sustainable development project knowledge, based on the King of Thailand's working concepts.

An initial finding of the first year project showed explicit knowledge existed in appropriate technology knowledge from the sustainable development projects, mainly in the form of economic information and documentation, which was not recorded by expert workers and lacked of expert scientific knowledge in these. Many projects were conducted by universities, government officers and a new generation of experts who create new knowledge autonomously. Most sustainable development project documents defined only capital, budgets and policy but did not describe scientific processes or talk about knowledge delivery (episodic knowledge). A sustainable development project stakeholders and knowledge workers tend to utilize this knowledge without self-belief and confidence. A lack of knowledge from within the sustainable development projects was identified. Scientific and engineering knowledge should be the keystone of appropriate technology knowledge in sustainable development projects which knowledge workers need to understand and solve real world problems. Most people in rural community in Thailand are non-science and technology educated farmers and had highest education level in primary school. That is a difficult situation to transfer appropriate technology knowledge from sustainable development projects and academic researches successfully. The findings highlight a lack of specification of conceptualization understanding in basic education level of rural community people in Thailand being unsuccessfully transferred appropriate technology knowledge and experts' jargon which is maintained in the sustainable development projects.

Moreover, the initial finding of knowledge transferring model to Phrao community where there are has high mountains dominating the ground views from the valley of the farmlands. Local people in Phrao District community mostly are agriculturists who grow organic rice, longan, mango and corn, etc. There are many researches about highland agriculture which were needed to transfer knowledge from the research results to local highland community. The use of knowledge, finding of researches, local resources, skills and wisdom can be done to solve issues of poverty as well as issues of environmental and resource management. This is particularly important for the social landscape in Thailand where there is a relatively high inequality of income distribution.

This initial study provided scientific and engineering knowledge of Royal Initiative Projects and researches for Royal Project Officers, practitioners, local people and students in Phrao community to utilize this knowledge in order to improve their capital, solving problems in their communities which in turn allow them to develop their community and disseminate knowledge to people in local area via a knowledge scenario. This initial study aimed to propose a knowledge transfer framework for local community by implementing knowledge and appropriate technology to improve their sustainable community. The initial finding of this knowledge transferring model to Phrao community indicated that the large amounts of research knowledge and Royal Project knowledge can be stored, shared, reused and learned via the knowledge transfer framework. An episodic knowledge scenario for local community who were considered as knowledge workers in Phrao District, Chiang Mai, Thailand. Knowledge workers could also used the episodic knowledge scenario to develop this work as an educational tool to improve their competency and disseminate knowledge to people in rural areas in order to develop their community effectively.

This study has mainly concerned with transferring an appropriate technological knowledge for people who have not enough basic education because most rural farmers lack science and technology knowledge which is important to understand and apply appropriate technology to enhance their community and solve their rural community problems successfully.

Thai education system provides nine years as Pratom 6 of compulsory education, with twelve years as Mattayom 3 of free basic education guaranteed and set by the 1999 National Education Act. The compulsory education was extended to nine years, with all students expected to complete with fifteen years: Mattayom 6 in 2003 (Ministry of Education, Thailand, 2008). Most rural people in Thailand had education at elementary education level which are 92.58% of elementary school (Pratom 4-Pratom6), 46.82%

lower secondary school (Mattayom 1-3) and 25.29% upper secondary school (Mattayom 4-6) (Office of the Permanent Secretary, Ministry of Education, 1992). Additionally, it can be seen from Office of the Permanent Secretary, Ministry of Education, (2013) that 91.36% of most rural people in Thailand completed elementary education level more than other levels. Then, the findings highlight a lack of specification of conceptualization understanding in basic education level of rural community people in Thailand being unsuccessfully transferred appropriate technology knowledge which is maintained in the sustainable development projects. The science and technology knowledge in appropriate technology from sustainable development projects should be the keystone of sustainable development projects which knowledge workers need to understand and solve real world problems.

This study developed additional social science ontologies from the organic rice farming knowledge as an appropriate technology to transfer knowledge to rural non-science and technology educated farmers of Phrao District, Chiang Mai Province, Thailand as a research case study. The vocational learning process was experimented with semantic annotation on Bloom's Taxonomy vocabulary framework to evaluate additional ontologies effectiveness and vocational life-long learning of case study. This research studied on learning process measurement of the organic rice farming knowledge by semantic annotation technique on Bloom's Taxonomy vocabulary to prove the effectiveness of tutorial ontology. The science ontologies were used as knowledge representation to transfer knowledge to rural farmers of Phrao District, Chiang Mai Province, Thailand as a research case study as shown in **Figure 4.1**.

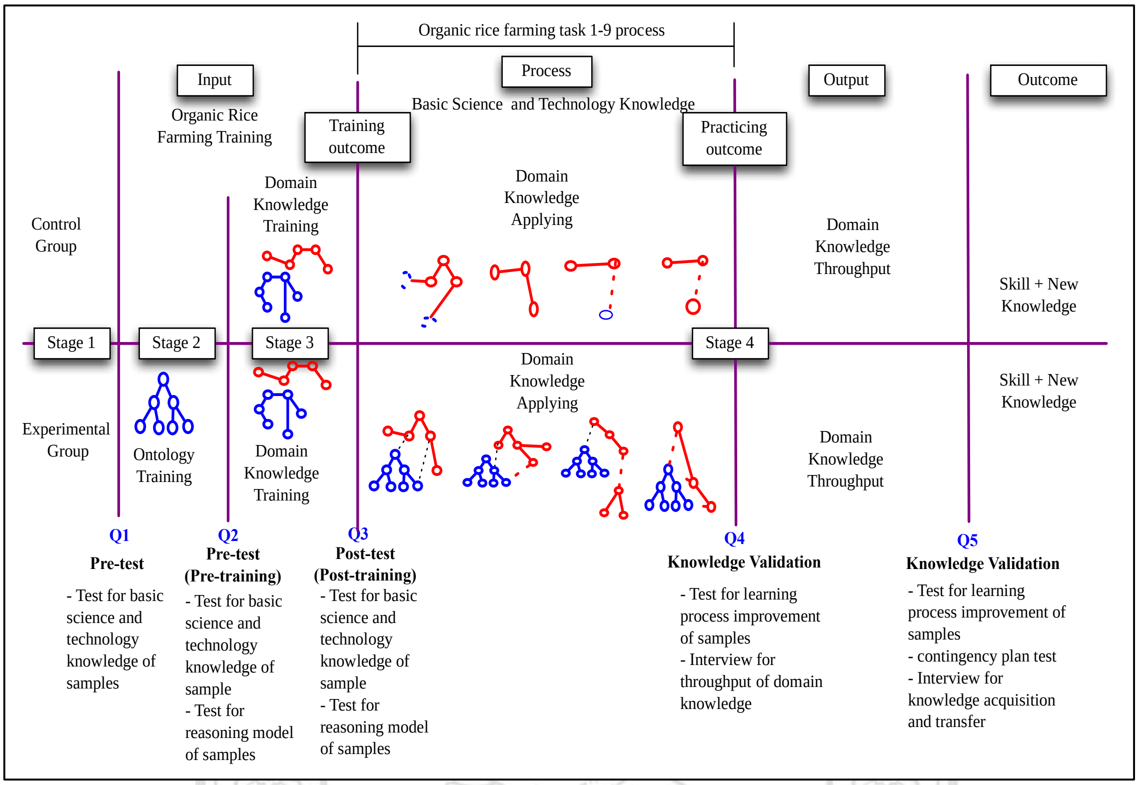

Figure 4.1 The Research Design Framework

4.3 Quality of Samples from Sample Selection

A suitable case study is identified to develop a solution for scientific knowledge. It was Phrao District; Chiang Mai Province which was selected as an appropriate case study. Phrao District exists partnership and representative of developing area of Chiang Mai University and uses the knowledge from the sustainable development projects to develop the community. Phrao area has a good environment and resource for agriculture that is ready to be developed for sustainable living. There are 12,120 families from 11 Tumbons that are 36,393 populations in Phrao District as shown in **Table 4.1**.

There were 53.43% of rural people in Phrao District who graduated in the highest education at elementary school level which it was lack of science and technology knowledge. It showed that most people in this rural completed basic education that was not enough to transfer knowledge from appropriate technology successfully for rural development to be a sustainable community. Non-science and technology knowledge educated people do not understand and apply knowledge which have many conceptualization and social science vocabulary.

Table 4.1 Bio-data of education of rural people in Phrao District, Chiang Mai Province

	Numbe r of people	Number of people in Elementary School	Number of people in Lower Secondary School	Number of people in Upper Secondary School	Number of people of Diploma	Number of people of Bachelor's degree	Number of people of Master's degree	Number of people of Doctoral degree
Men	18,160	9,727	1,797	1,409	644	773	27	1
Women	18,233	9,716	1,463	1,392	501	1,064	45	0
Total	36,393	19,443	3,260	2,801	1,145	1,837	72	1
Percentage		53.43 %	8.96 %	7.70 %	3.15 %	5.05 %	0.20 %	0.003 %

In **Table 4.2,** 29.50% of people in this area were working as general employees who had not certain incomes and 19.37% were farmers. There was 322 rural people who could not read and write Thai language that was related to people education in this area. There were 162 families that had average income under 23,000 Baht per person per year. The average income was 51,927.28 Baht per person per year.

Consequently, the rural people in Phrao District could be research problem representation because most rural people graduated at primary school and lacked of science and technology knowledge. It was envisaged that Phrao District, Chiang Mai Province, Thailand was selected as a case study to transfer organic rice farming knowledge. The knowledge requirement to renew the case study community was validated by non-structured interviews with stakeholders from the case study.

Table 4.2 Bio-data of occupation of rural people in Phrao District, Chiang Mai Province

	Number of people	Number of unemployed people	Number of people of farmers	Number of people of gardening farmers	Number of people working as general employee	Number of people in trading business	Number of people of official officers
Men	18,160	780	3,842	2,234	5,527	698	336
Women	18,233	1,101	3,208	1,962	5,210	1,309	307
Total	36,393	1,881	7,050	4,196	10,737	2,007	643
Percentage		5.17 %	19.37 %	11.53 %	29.50 %	5.51 %	1.77 %

This research involved the deciding upon, and then, reviewing existing knowledge from a sustainable development project and an organic rice farming knowledge as an appropriate technology. An organic rice farming as an appropriate technology from a suitable sustainable development project was identified to develop additional ontologies solution for appropriate technology.

This research focuses on adaptive organic rice farmer to be a study sample to prove learning skill from additional ontologies which was developed and cognitive level of samples on learning process. The samples of the case study were divided into a control group and an experimental group in order to test the effectiveness of additional social science ontology of appropriate technology and to measure the learning process by semantic annotation technique on Bloom's Taxonomy vocabulary.

There were only 37 pure organic rice farmers in Phrao District community that included 12 farmers in adaptive organic rice farmer stage in this organic rice farming community. All 37 organic rice farmers took the test that was designed the questions in science and technology ontology knowledge by a researcher to qualify sample for this research. The questions are shown as following:

1. What decomposes fossil that is found in soil? (1 point)
2. What decomposes it into humus? (1 point)
3. What are appropriate compositions in soil in agriculture and useful for growing? (1 point)
4. What are the objectives of cover crop? (1 point)
5. How to eliminate pests and insects during crop by biological methods? (1 point)
6. What is microorganism in soil and how microorganism is useful in agriculture? (1 point)

All 37 organic rice farmers answered 6 questions which these famers had to response to these questions together at the same time in front of the researcher.

Table 4.3 A test result of organic rice farmers in Phrao District

Organic rice farmers status level	Number of Farmers	Number of farmers in correct answers (6 scores)	Number of farmers in wrong answers (less than 2 scores)
1. Organic rice farmer level (Do organic rice farming more than 3 years)	25	10	15
2. Adaptive organic rice farmer (Do organic rice farming at first year or less than 3 years)	12	0	12
Total	37	10	27

This research focused on the answer from 12 adaptive organic rice farmers who could be the research problem representative samples. The qualification of adaptive organic rice farmers must be non-science and technology education or lacked of science and technology basic education. The 12 adaptive organic rice-farmer samples were selected for research examination samples because they could not answer 6 of social science questions that were mentioned above (shown in **Table 4.3**). The test scores of 12 farmers were less than half of full scores that meant they did not know and understand about concept of organic rice farming and lacked of science and technology knowledge. There were only 10 adaptive organic rice farmers who were willing to participate in this research as a research sample, so the bio data and some education background are shown in **Table 4.4**. Then, the adaptive organic rice farmer samples were divided equally into control and experimental groups.

In **Table 4.5**, the samples were divided equally in five people into control and experimental groups based on education level, number of land area, age and number of years of doing organic rice farm, respectively.

In control group, there were two samples who were 59 and 58 years old and had the highest education at elementary school (Pratom 4) but they had 2 years' experience in organic rice farm. Three farmers graduated in the highest education at upper secondary school (Mattayom 6) and one was 22 years old who just finished upper school for 4 years. In experimental group was designed that has every education level in this group in order to prove the tutorial social science and technology ontology effectiveness between group and within group. Additionally, all of these samples are non-science and technology educated people and have no background in agricultural subject.

Table 4.4 Bio data and education background of ten farmers in adaptive organic rice farm level

Name	Name code	Gender	Age	Education	Number of land area (Rai)	Number of training course	Number of year of doing in organic rice farm
Kaewloon	AD1	Male	59	Elementary (Pratom 4)	10	no	1
Duangduen	AD2	Female	58	Elementary (Pratom 4)	7	no	1
Nongyoa	AD3	Female	41	Upper secondary school (Mattayom 6)	15	no	First year
Venus	AD4	Male	45	Upper secondary school (Mattayom 6)	7	no	1
Jadesada	AD5	Male	22	Upper secondary school (Mattayom 6)	6	no	First year
Pitak	AD6	Male	53	Elementary (Pratom 4)	8	no	1
Chumporn	AD7	Female	38	Elementary (Pratom 6)	7	no	First year
Intira	AD8	Female	50	Lower secondary school (Mattayom 3)	15	no	First year
Jumrussri	AD9	Female	40	Diploma in accounting	8	no	First year
Thanapat	AD10	Female	39	Bachelor's degree in general management	7	no	1

Table 4.5 Control and experimental groups of adaptive organic rice farming samples

Group	Name	Name code	Gender	Age	Education	Number of land area (Rai)	Number of training course	Number of doing in organic rice farm
Control Group	Kaewloon	AD1	Male	59	Elementary (Pratom 4)	10	no	1
	Duangduen	AD2	Female	58	Elementary (Pratom 4)	7	no	1
	Nongyoa	AD3	Female	41	Upper secondary school (Mattayom 6)	15	no	First year
	Venus	AD4	Male	45	Upper secondary school (Mattayom 6)	7	no	1
	Jadesada	AD5	Male	20	Upper secondary school (Mattayom 6)	6	no	First year
Experimental Group	Pitak	AD6	Male	53	Elementary (Pratom 4)	8	no	1
	Chumporn	AD7	Female	38	Elementary (Pratom 6)	7	no	First year
	Intira	AD8	Female	50	Lower secondary school (Mattayom 3)	15	no	First year
	Jumrussri	AD9	Female	40	Diploma in accounting	8	no	First year
	Thanapat	AD10	Female	39	Bachelor's degree in general management	7	no	1

4.4 Research Results

This effective tutorial ontology modeling on organic rice farming for non-science and technology educated farmers as learning process improvement technique was proposed to transfer appropriate technology effectively and close gap between expert and non-science and technology educated farmers (shown in **Figure 4.2**). There are 7 stages of learning process technique which are stage 1: trainer knowledge capture, stage 2: ontology requirement identification, stage 3: ontology tutorial, stage 4: domain knowledge training, stage 5: learning process, stage 6: knowledge validation and stage

7: ontology adaptation. This knowledge transfer technique of any appropriate technology from sustainable development project was generalized for non-science and technology educated people.

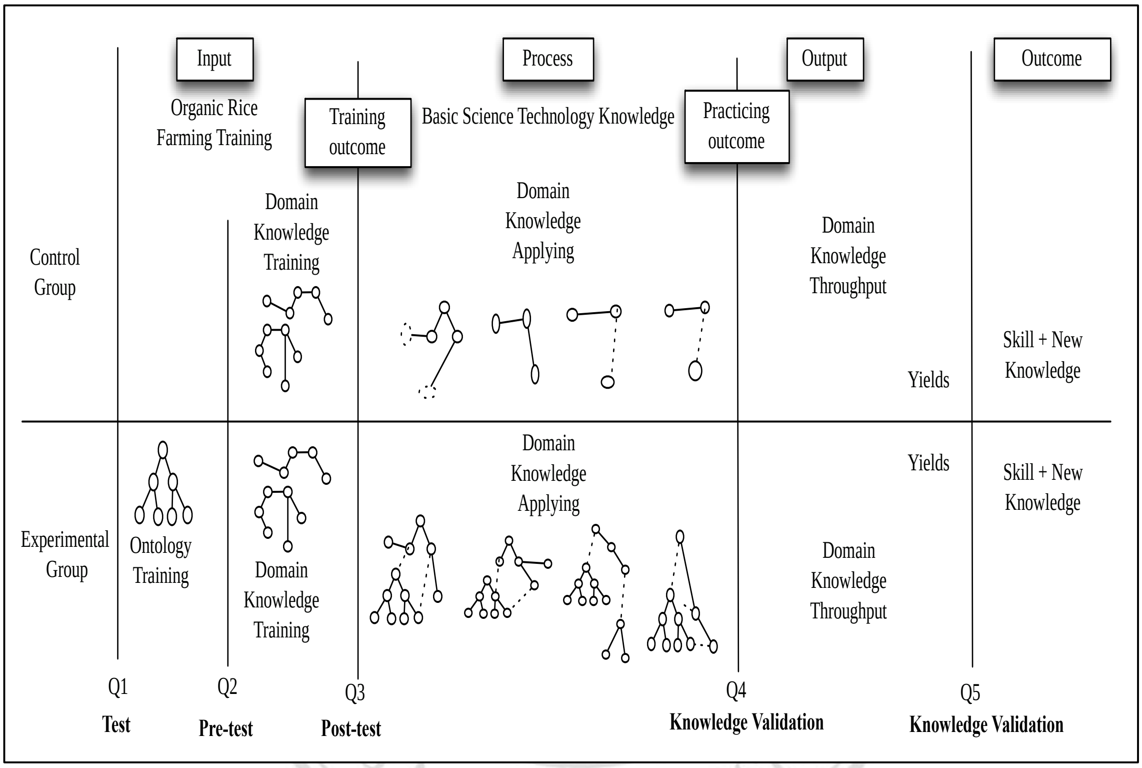

Figure 4.2 The learning process technique framework for non-science and technology educated farmers using knowledge engineering

4.4.1 Trainer Knowledge Capture Using CommonKADS

The social network analysis was used to qualify the chosen experts (academic researchers, practitioners and local experts) in field of appropriate technology knowledge. Social network analysis was appropriate as a strategic tool for expert localization, identification of knowledge communities and analysis of the structure of intra- and inter-organizational knowledge flows. Interviews were used to question researchers, practitioners and local experts in order to identify experts with appropriate technology scientific knowledge. The chosen experts were scientific appropriate technology expertise and utilized knowledge for local issue problem solving related to scientific knowledge. The experts of this research were:

1. Chinakrit Suwanakeree, he is a lecture and researcher at the Faculty of Agriculture, Chiang Mai University. His expertise is organic rice farming, bioextract or biofertilizer, plant disease control, plant pathology and phycology.
2. Vithya Yarnchinda, he is a practitioner in the field of microorganism usage and application for organic farm following sufficient economy for fifteen years from Electricity Government Authority of Thailand (EGAT).
3. Thirasin Jaipa, he is a local expert in organic rice farming in Phrao District community and the leader of organic rice farm group in Phrao. He is also a local researcher of Phrao Model that is the research of Chiang Mai University.

Chinakrit and Vithya were trainers for organic rice farming knowledge in learning process for non-science and technology educated farmers of both control and experimental groups. Thirasin was a mentor of both control and experimental groups.

Both trainers of chosen experts were captured knowledge from interview and their knowledge repository and training document material were collected (shown in **Appendix A**). The knowledge elicitation and capture using knowledge engineering approach into task, inference and domain knowledge that all are shown in **Appendix A**.

The term of expert's domain knowledge refers to knowledge which was specific for a given domain knowledge of practice of organic rice farming knowledge. This knowledge elicitation from experts of this research has nine tasks of organic rice farming knowledge: T1-soil analysis, T2-seed selection, T3-rice seedling, T4-soil preparation, T5-organic rice growing, T6-water management, T7-rice disease, pest, insect protection, T8-harvest and T9- soil development. Each of 9 tasks was modeled into task, inference, domain knowledge from organic rice farming trainer. Trainers of this research designed the training course which is shown in **Appendix A**. **There are 148-domain knowledge of organic rice farming knowledge**, which was captured from experts and combination with all repositories.

Knowledge analysis

This knowledge analysis results came from interviewing experts to elicit organic rice farming knowledge together with reviewing, eliciting and collecting existing scientific knowledge from the sustainable development projects, training material of experts: Chinakrit and Vithaya and academic researches to capture appropriate technology knowledge from them. All researches, repositories and manuals from experts currently available on the sustainable development project websites, National Research Council Thailand: NRCT, Universities in Thailand and workplace were also collected and reviewed prior to capture. Repositories were likely to include manuals, scientific documents, patents and publications.

The CommonKADS modeled nine tasks of the organic rice farming domain knowledge in this study into three corresponding parts, task knowledge, inference knowledge and domain knowledge as shown in **Figure 4.3 – Figure 4.13**. The three main parts are linked to task knowledge which describes the knowledge-intensive tasks of the organic rice growing, inference knowledge which describes using knowledge to carry out the reasoning process and domain knowledge which refers to knowledge of human experts based on their experiences. The domain knowledge was validated by pre-test and post-test and by taught back with experts. The experimental process was verified with experts along this research process.

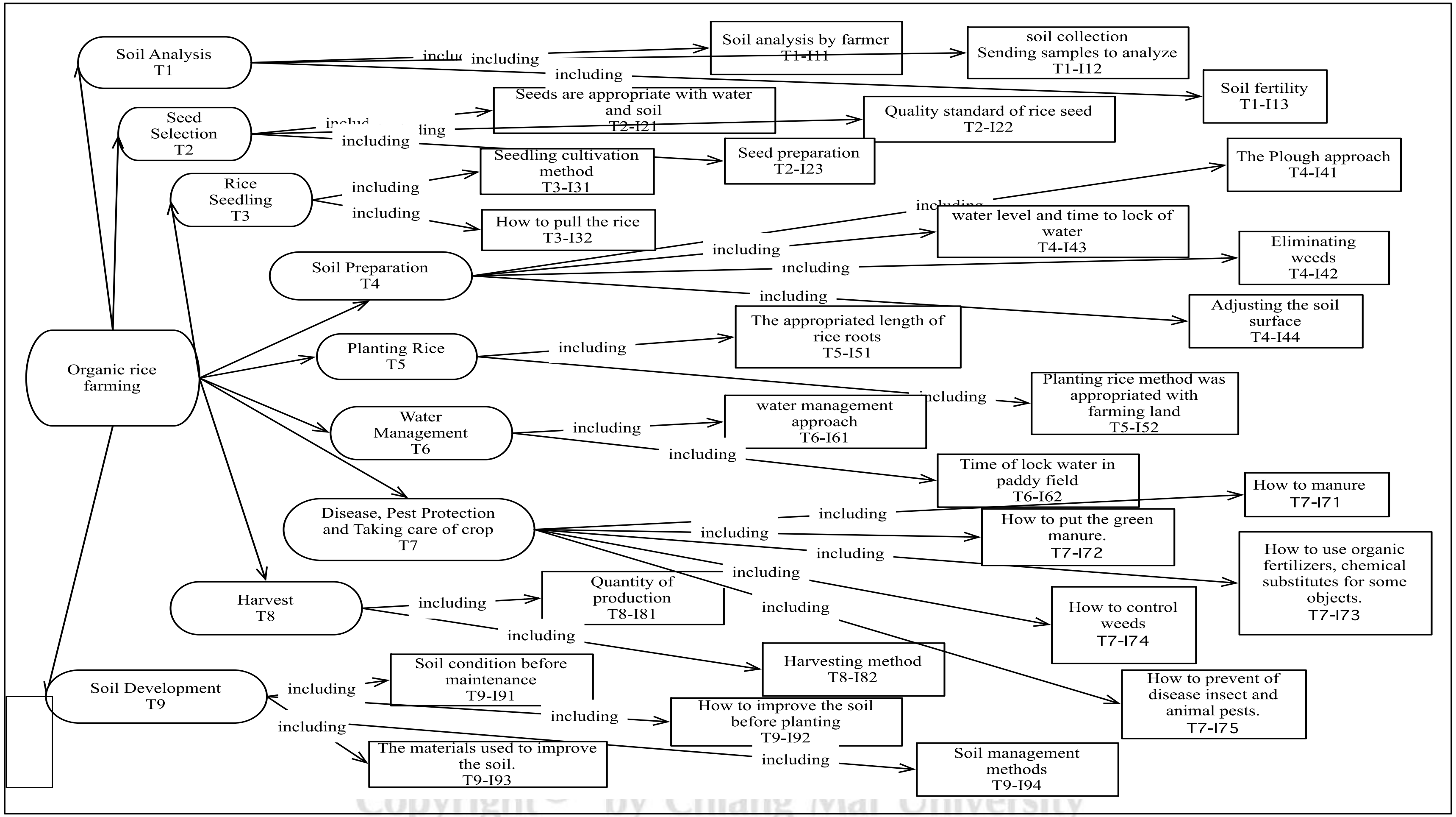

Figure 4.3 The knowledge map on organic rice farming knowledge of tasks and inference

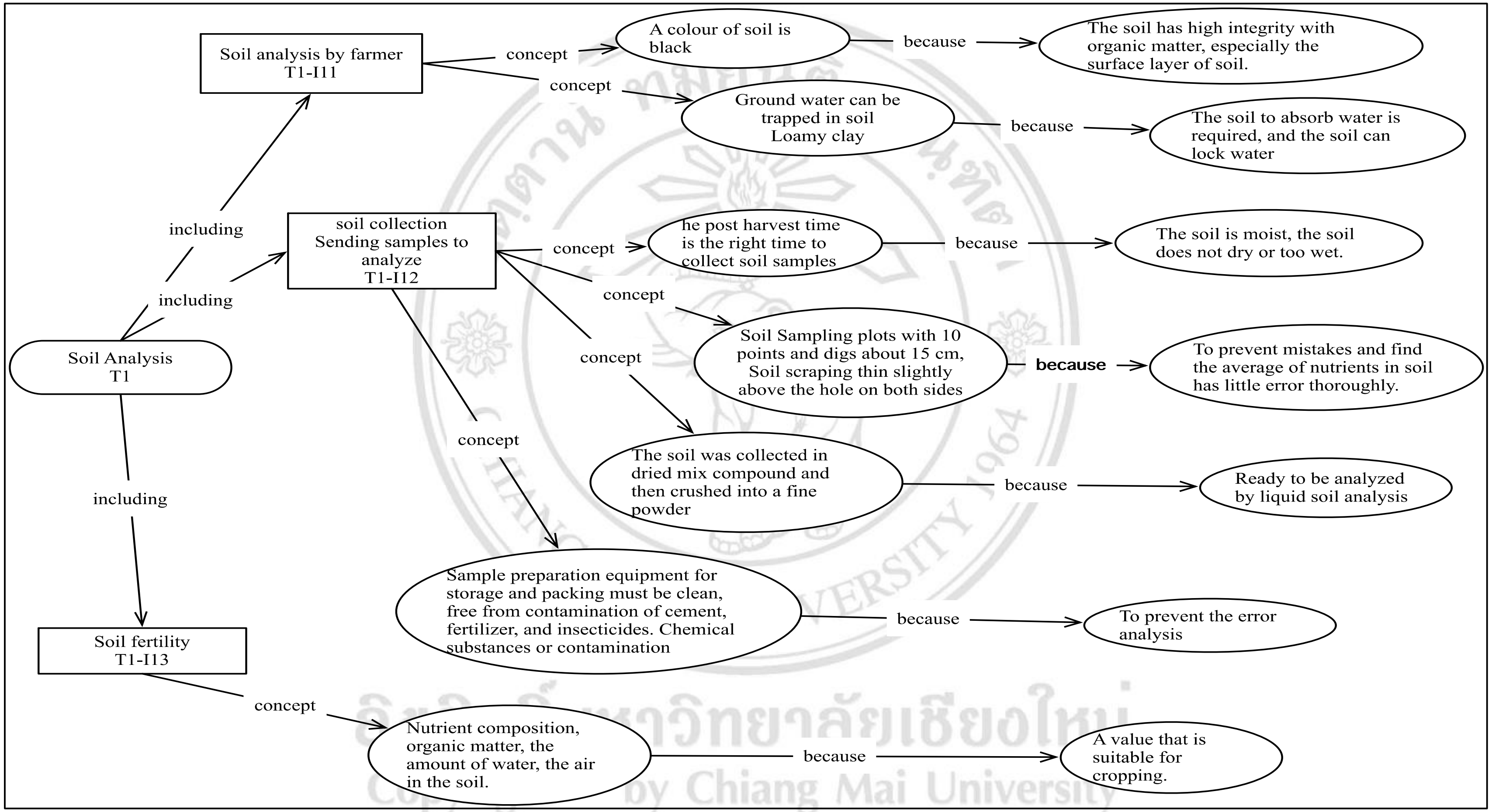

Figure 4.4 The knowledge map of soil analysis task, inferences and domain knowledge

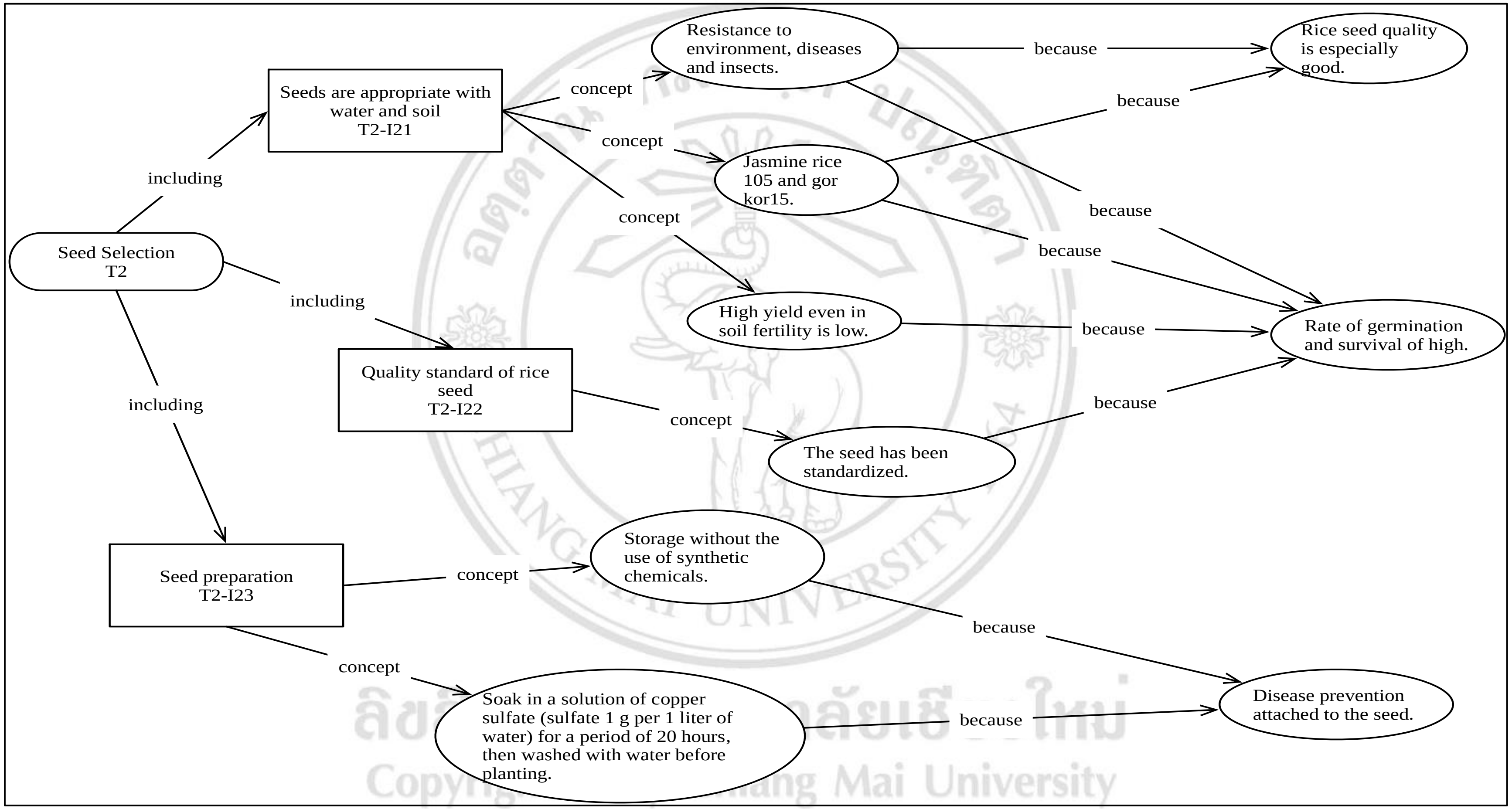

Figure 4.5 The knowledge map of seed selection task, inferences and domain knowledge

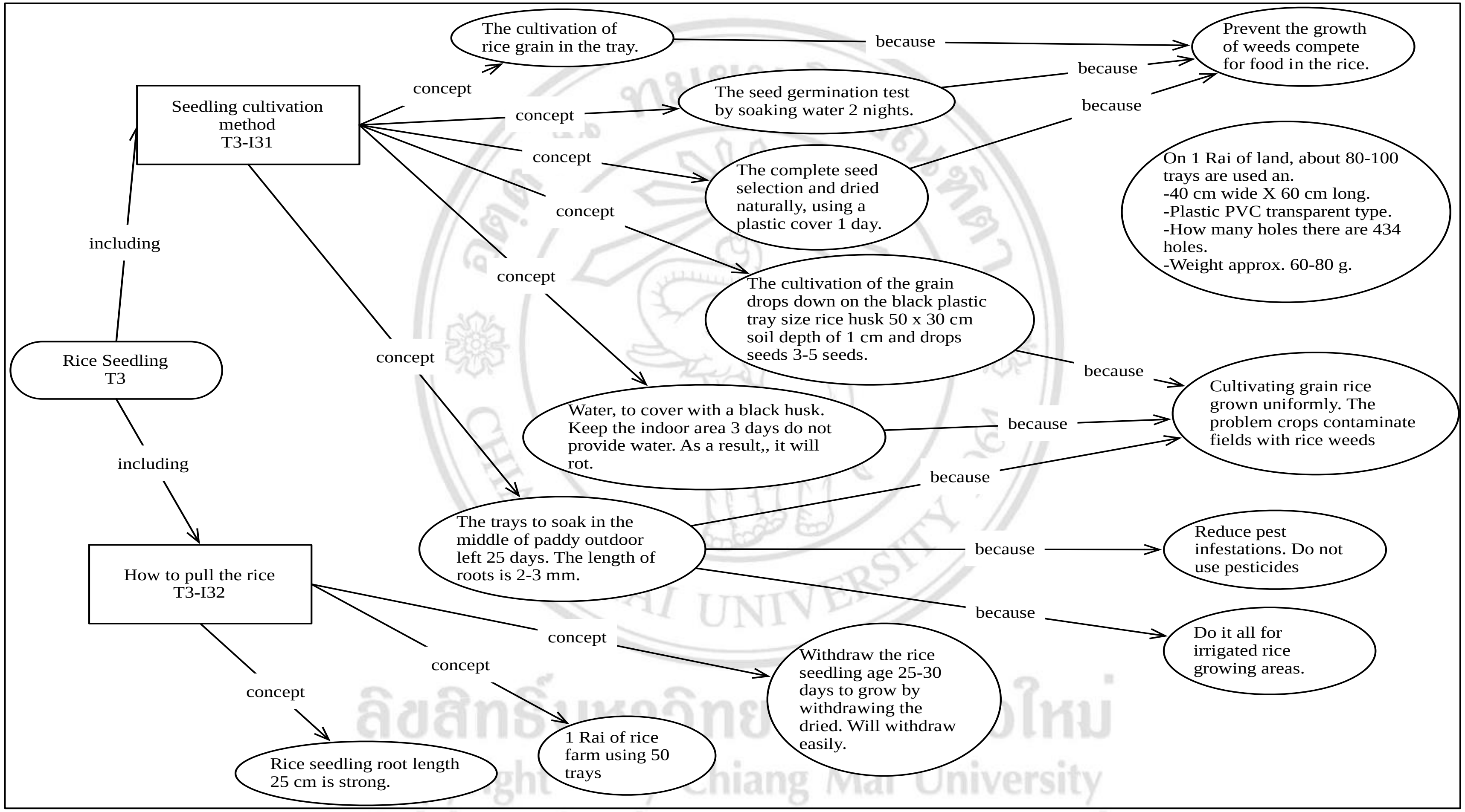

Figure 4.6 The knowledge map of rice seedling task, inferences and domain knowledge

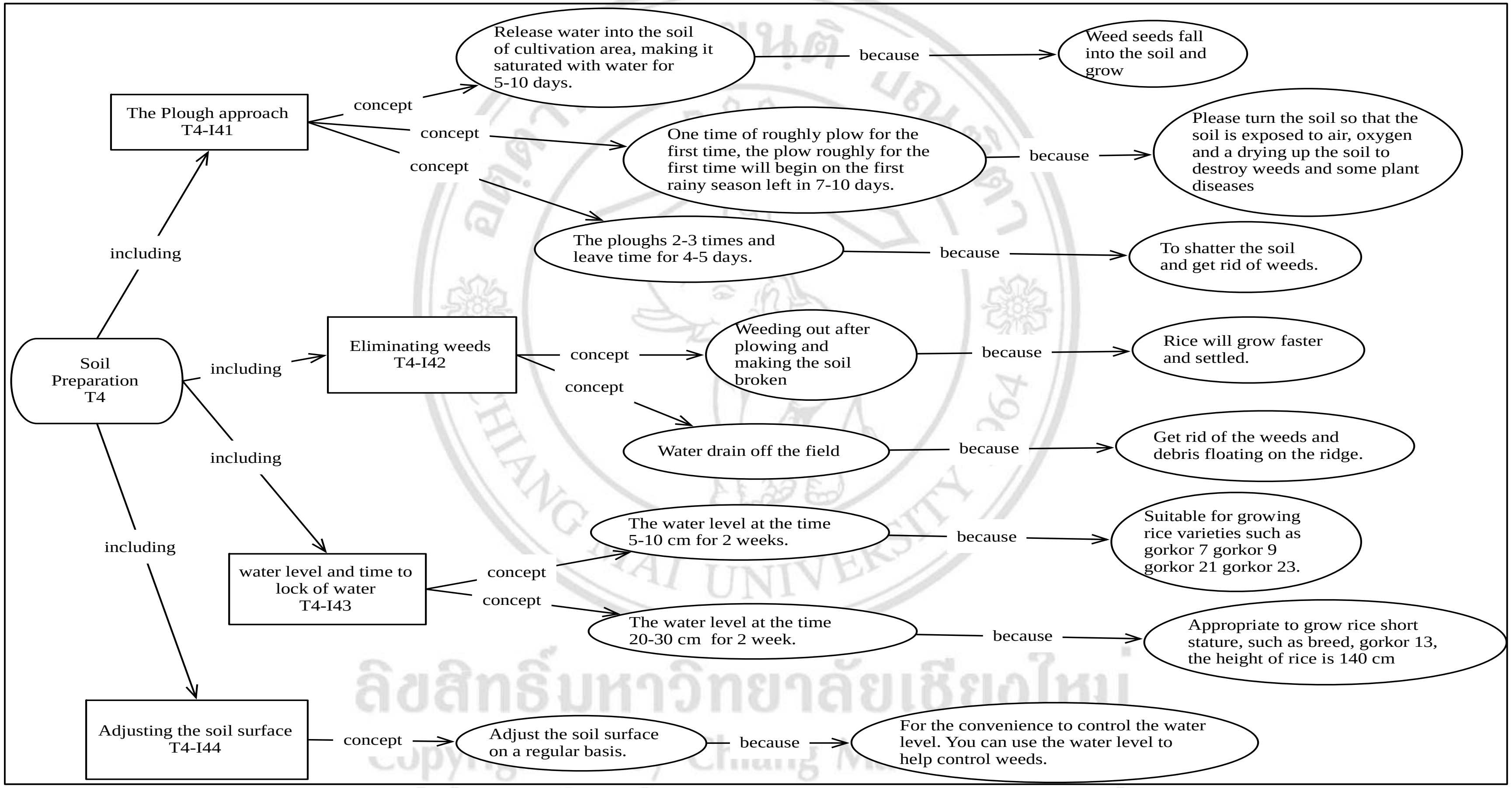

Figure 4.7 The knowledge map of soil preparation task, inferences and domain knowledge

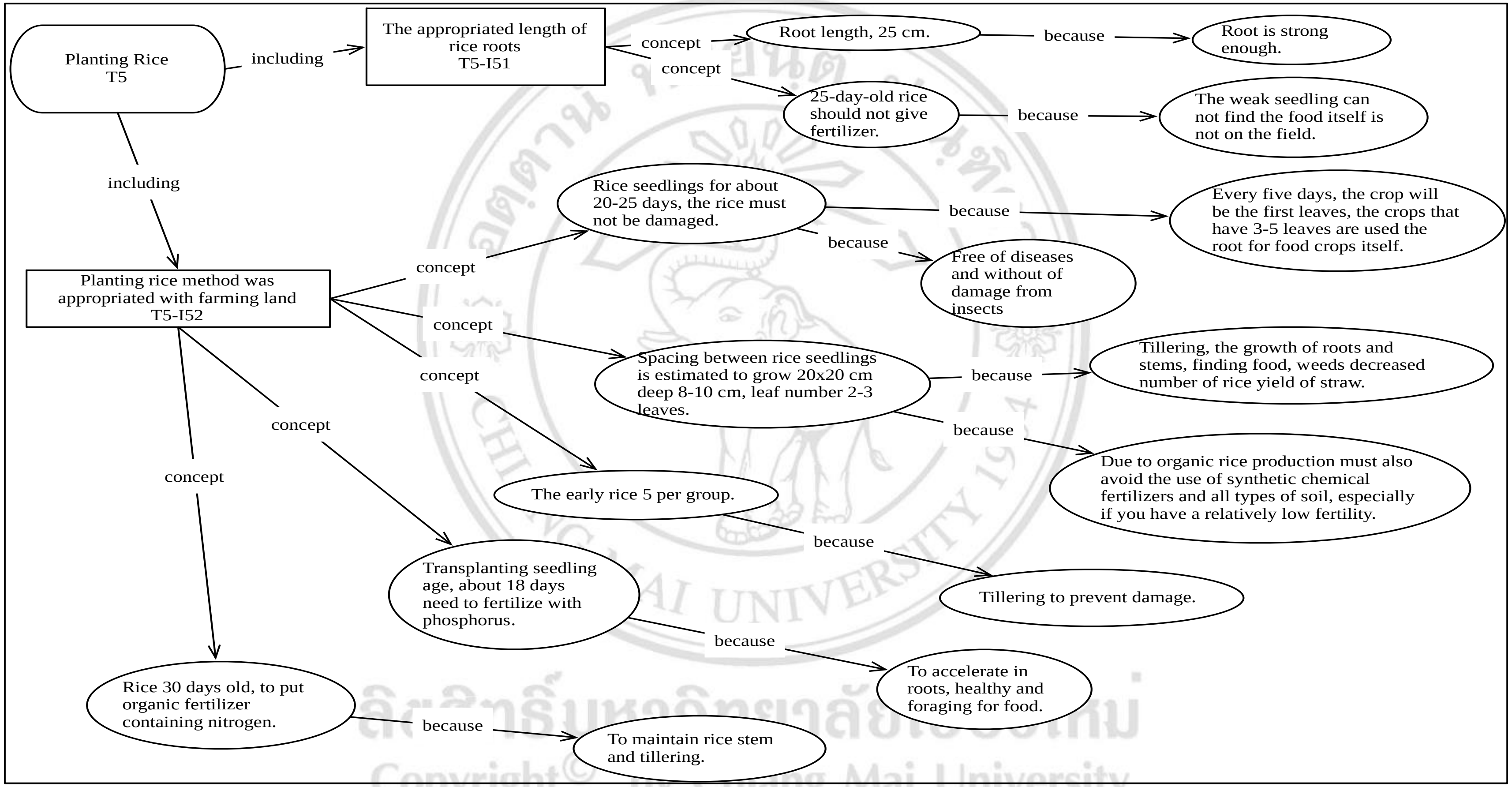

Figure 4.8 The knowledge map of planting rice task, inferences and domain knowledge

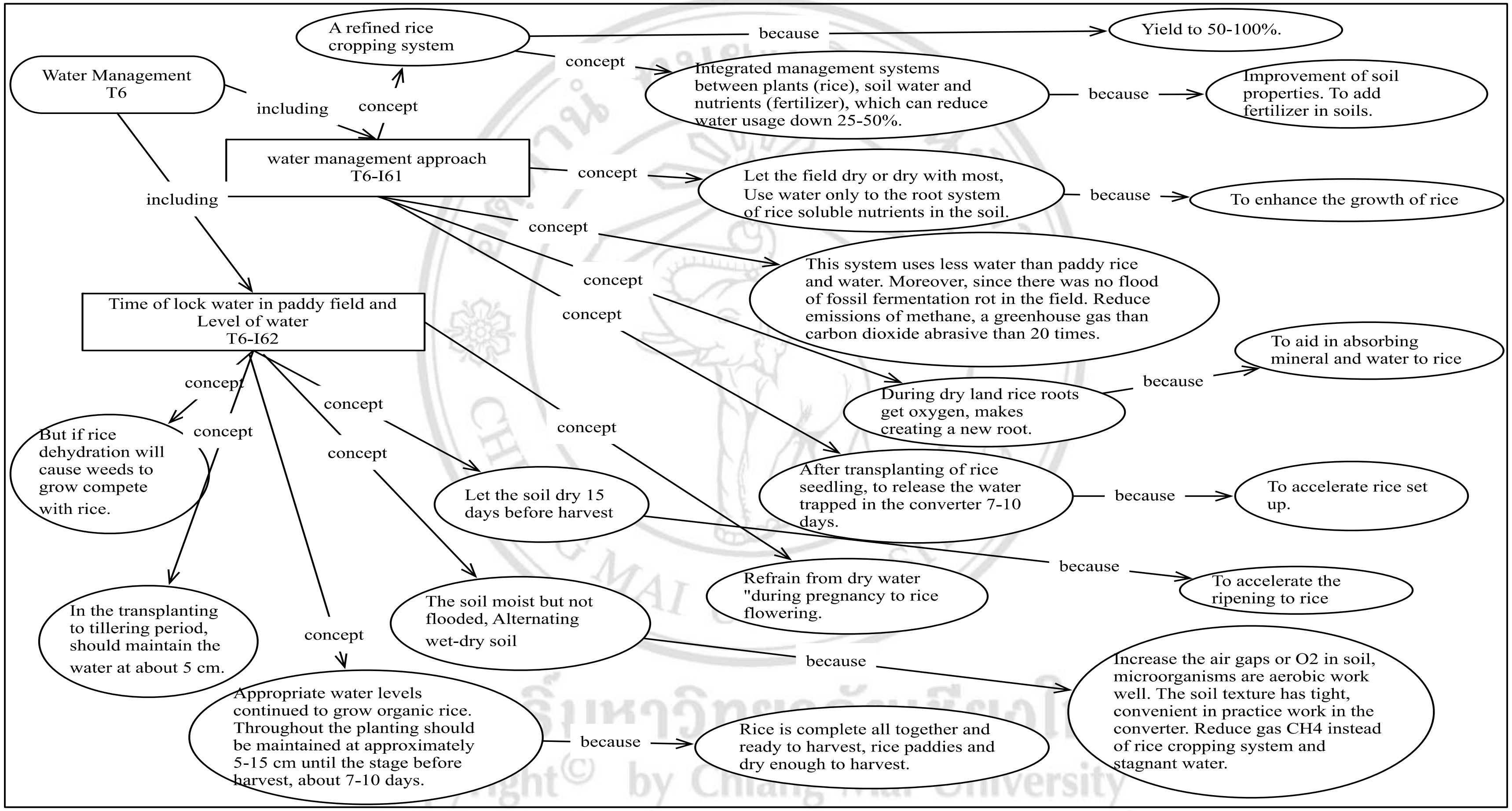

Figure 4.9 The knowledge map of water management task, inferences and domain knowledge

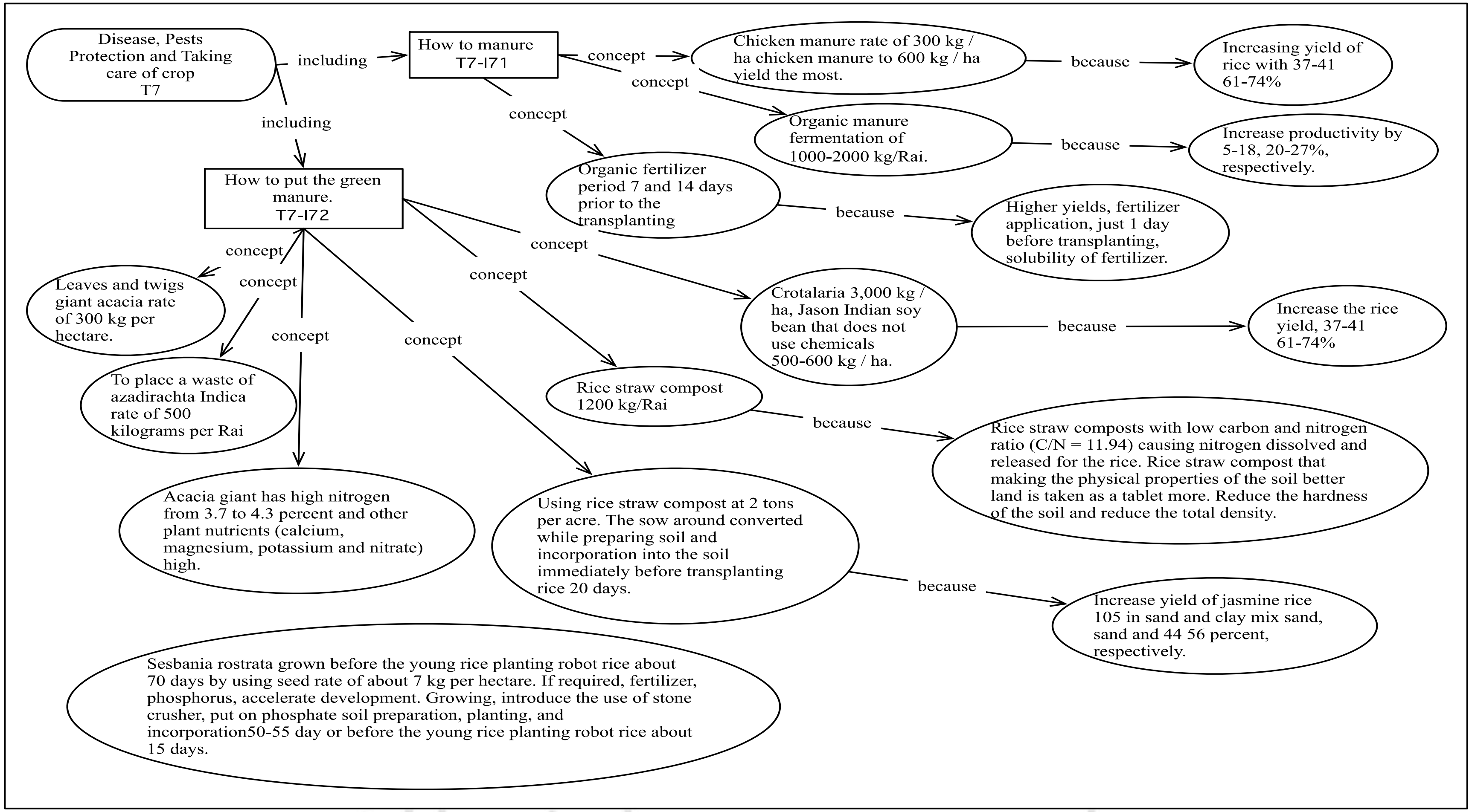

Figure 4.10 The knowledge map of disease, pest protection and taking care of crop task, inferences and domain knowledge

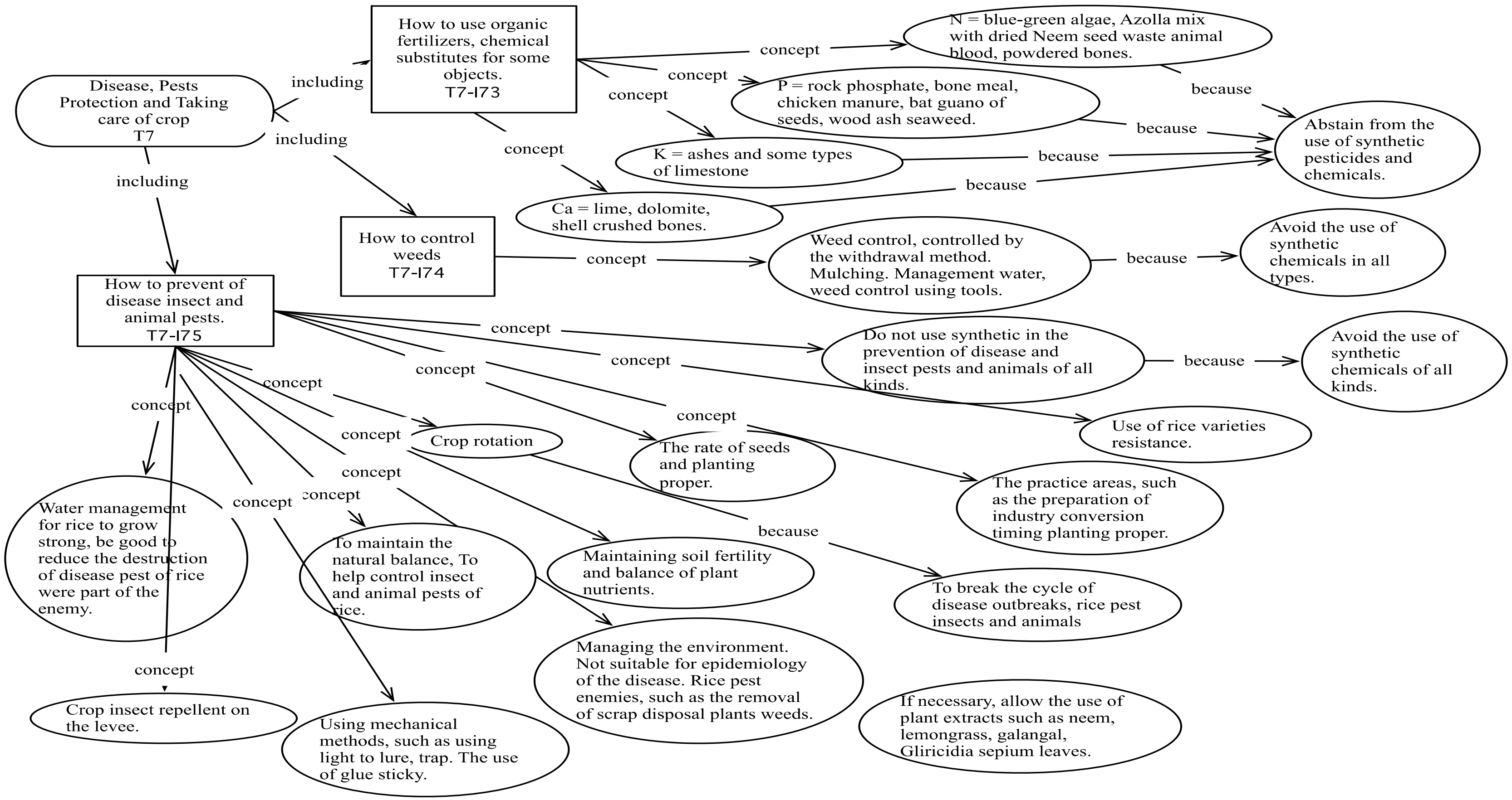

Figure 4.11 The knowledge map of disease, pests protection and taking care of crop task, inferences and domain knowledge (continue)

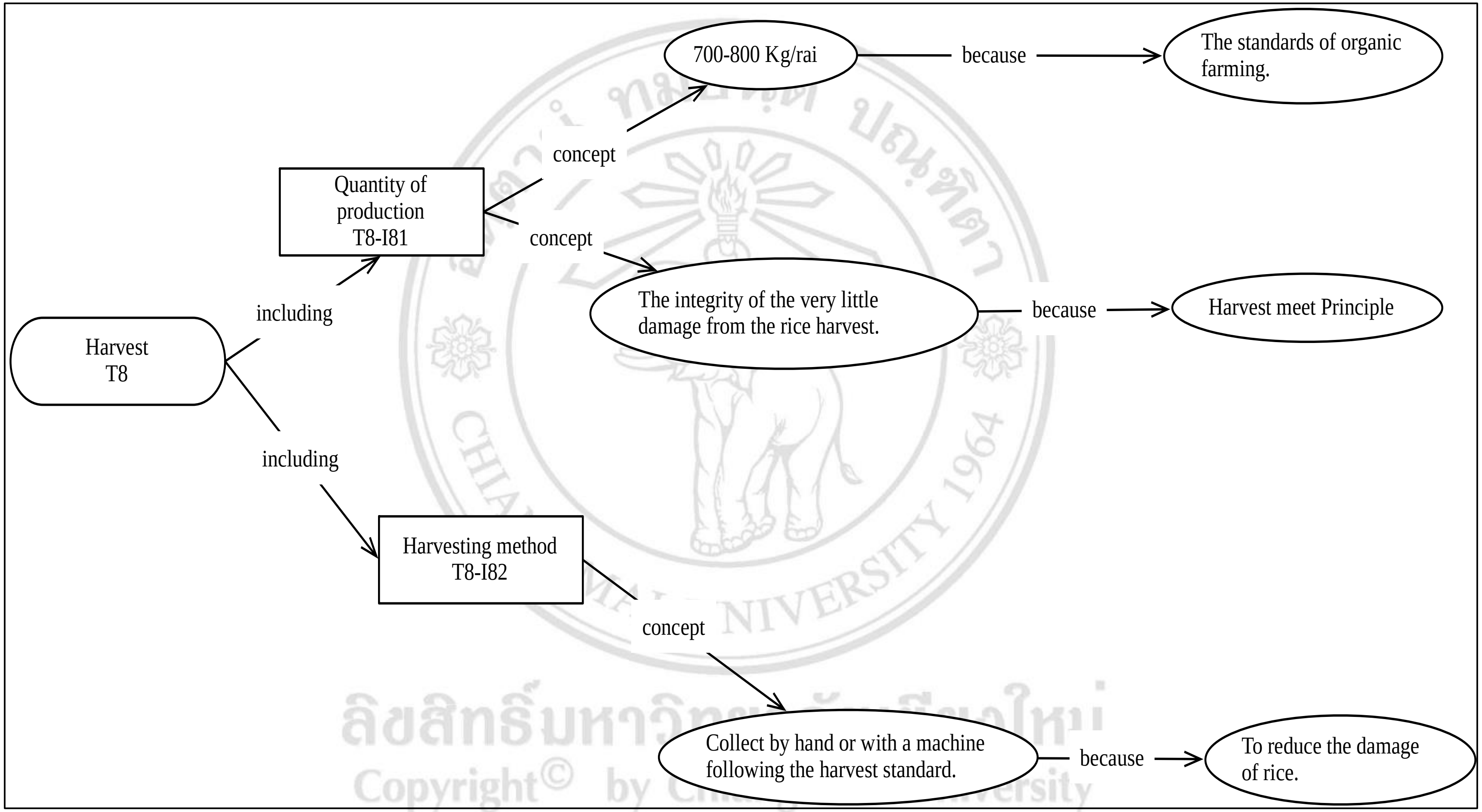

Figure 4.12 The knowledge map of harvest task, inferences and domain knowledge

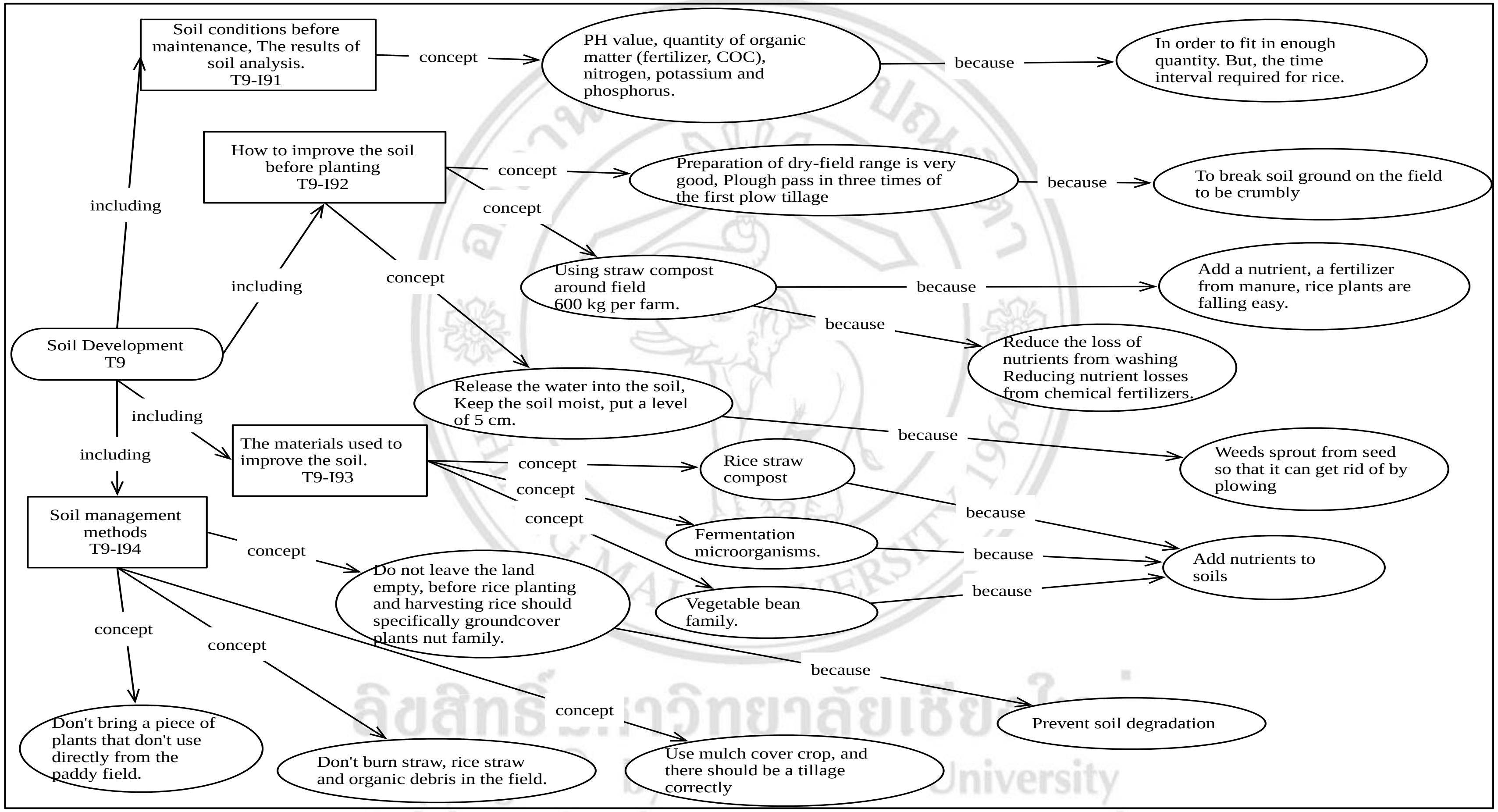

Figure 4.13 The knowledge map of soil development task, inferences and domain knowledge

4.4.2 Ontology Identification and Development

After tacit knowledge of organic rice farming trainer was captured using knowledge engineering, this ontology identification and development step focuses on expert's jargons which are experts' vocabulary in their domain knowledge and then the social science ontology knowledge developed the organic rice farming ontology knowledge related to jargons of experts and based on four main social science ontologies derived from the biology, chemistry, physics and mathematics concepts of Thai's curriculum in lower secondary school. It can be seen in **Figure 4.14 – Figure 4.17** some examples of social science ontology in biology, chemistry, physics and mathematics. This study identified and developed first version of social science ontology into **92 ontologies** which were specification of conceptualization on organic rice farming (shown in **Table 4.6**). All social science ontologies provided for non-science and technology educated farmers to common understanding of organic rice trainer effectively, so that the adaptive organic rice farmers as experimental group in this study could apply and reuse their own ontology, domain knowledge and create their new domain knowledge.

This study emphasizes on knowledge model of CommonKADS model in order to elicit domain knowledge of appropriate technology and academic research in organic rice farming field from experts. When knowledge has been captured to task, inference and domain knowledge, the experts' domain concept knowledge was identified. This research identified experts' jargons in domain knowledge which are experts' vocabulary in their domain knowledge and then the ontology knowledge creation to develop the organic rice farming ontology knowledge based on four main social science ontologies derived from the biology, chemistry, physics and mathematics concepts of Thai's curriculum in lower secondary school which all are references by National Science and Technology Development Agency of Thailand. Consequently, only the experimental group was tutored the social science ontologies on organic rice farming before both control and experimental groups are trained domain knowledge by experts.

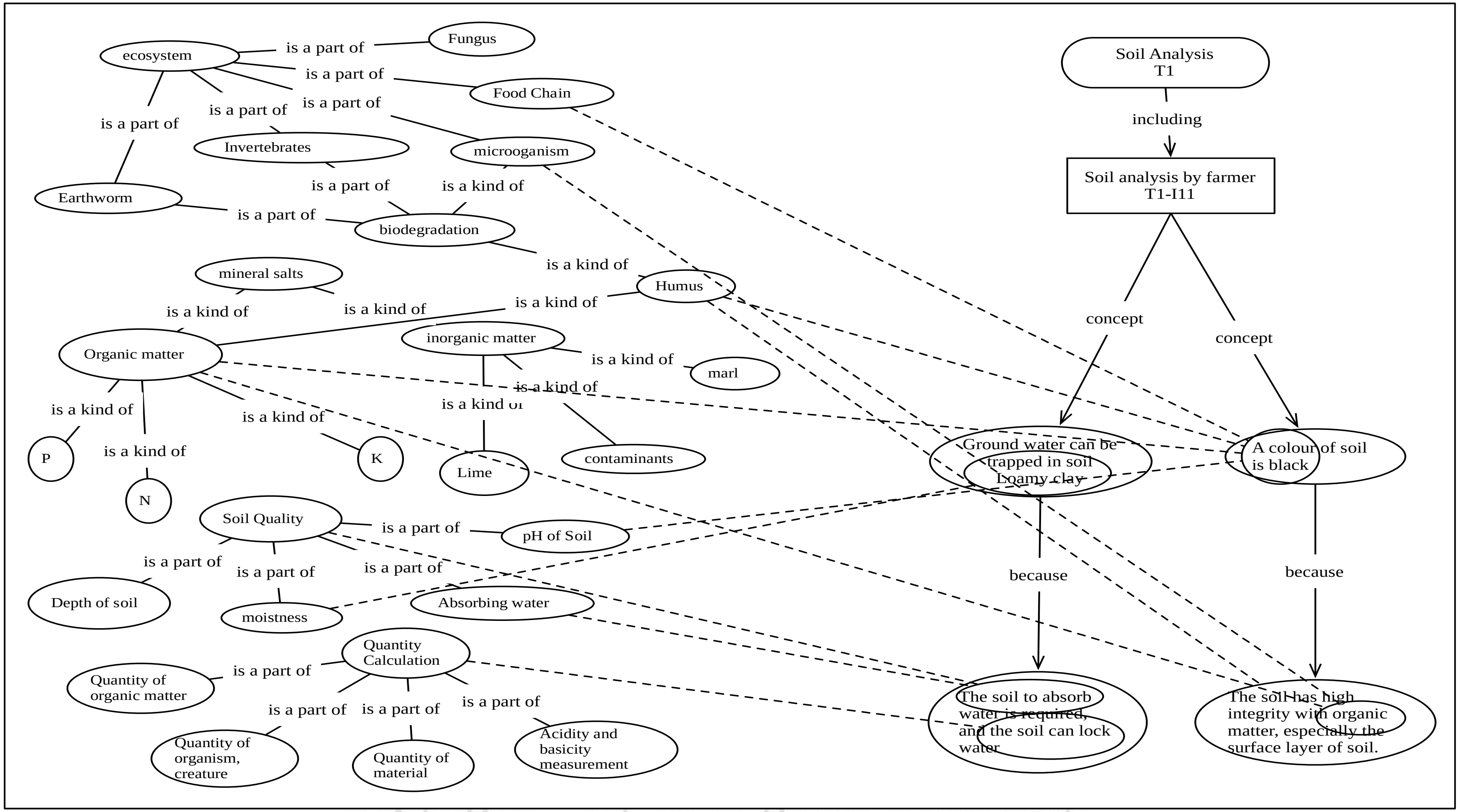

Figure 4.14 Ontologies identification and development of soil analysis task from soil analysis by farmer inference

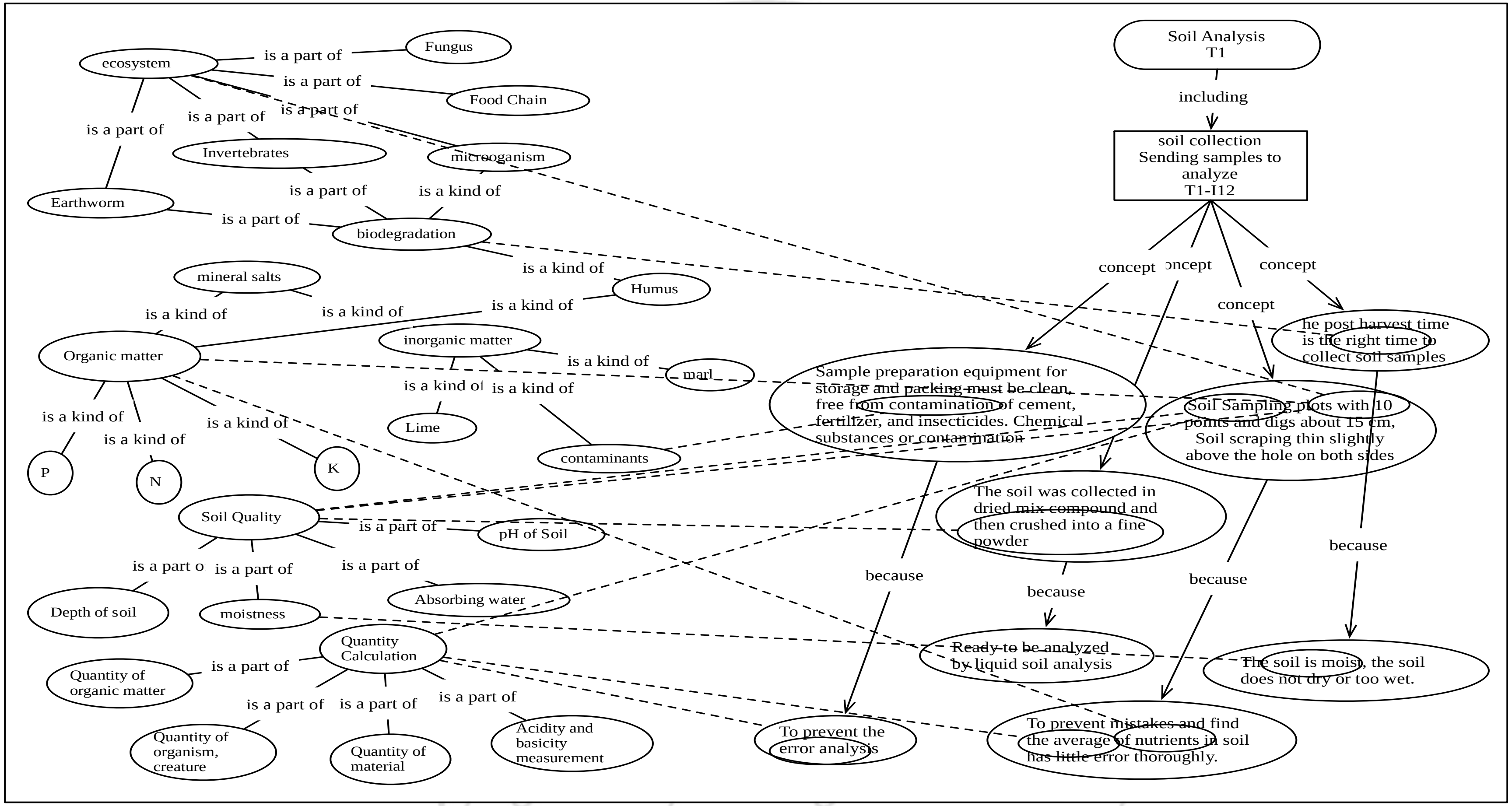

Figure 4.15 Ontologies identification and development of soil analysis task from soil analysis by farmer inference

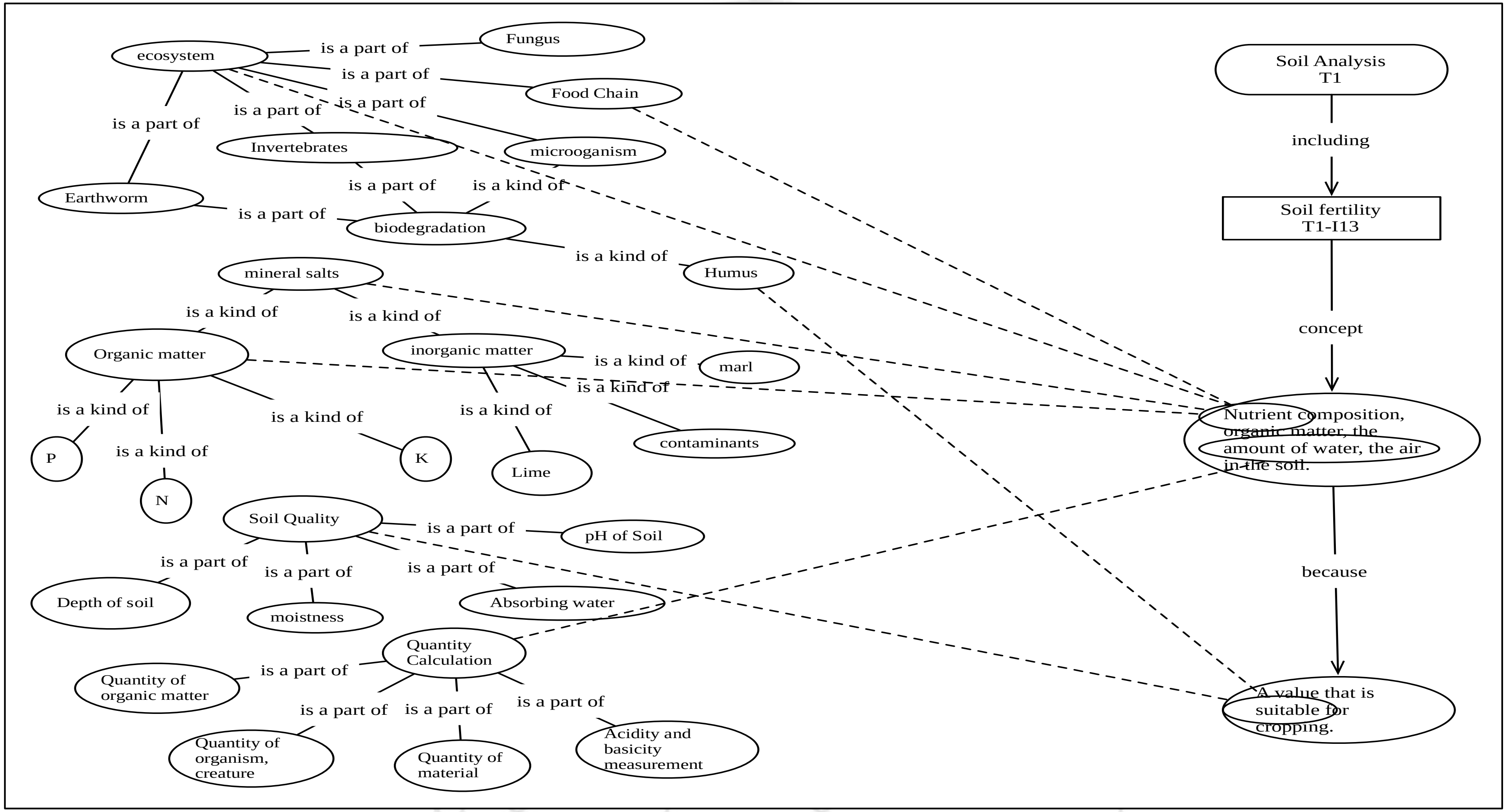

Figure 4.16 Ontologies identification and development of soil analysis task from soil analysis by farmer inference

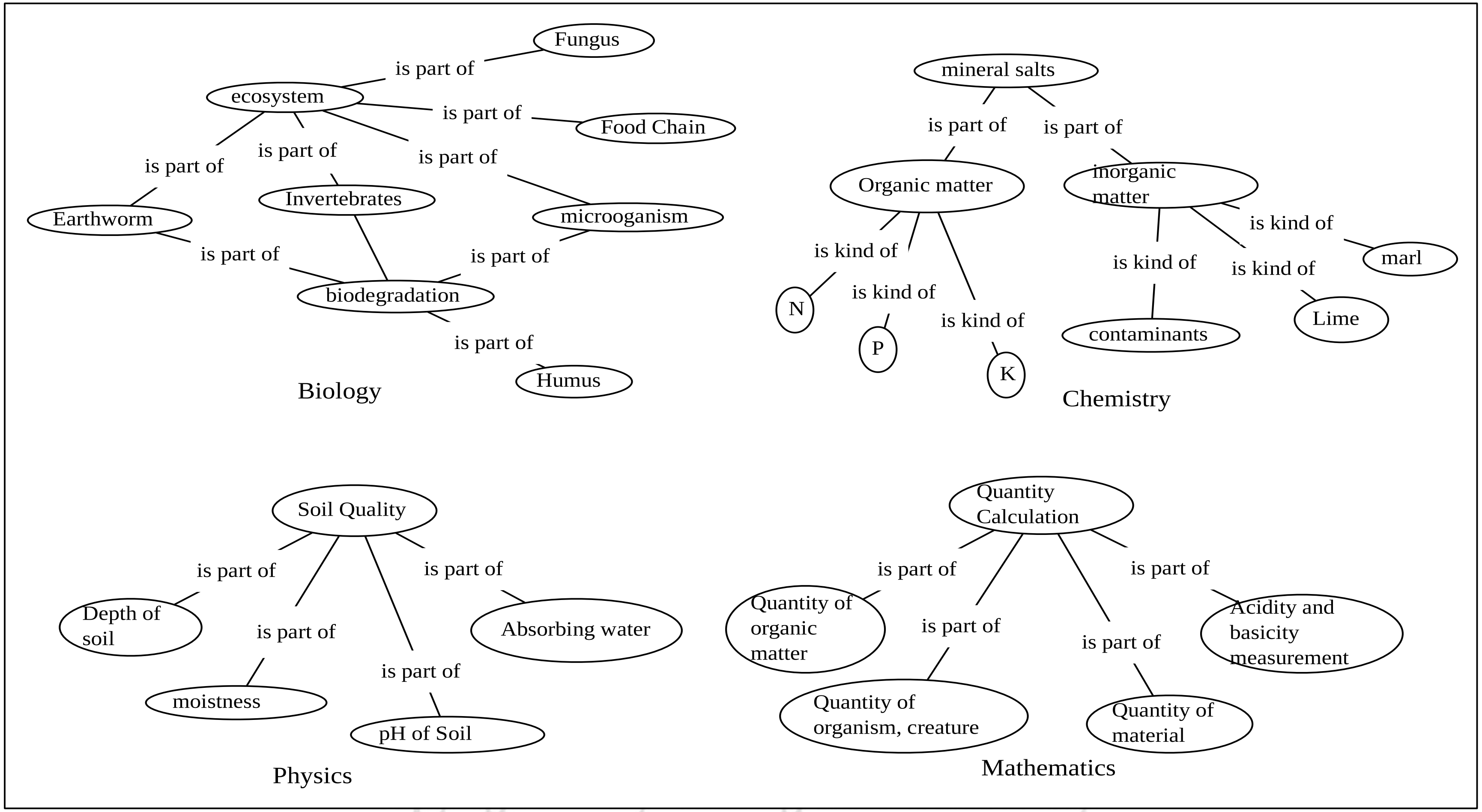

Figure 4.17 Ontology development of each concept

Table 4.6 The minimum of science ontologies based on biology, chemistry, physics and mathematics concepts

Biology	Chemistry	Physics	Mathematics
Microorganism	N nitrogen	Energy	Quantity of organic matter
Fungus	P phosphorus	Fluid motion	Quantity of inorganic matter
Protozoa	K potassium	Solid motion	Quantity of chemical matter
Invertebrates	Ca calcium	Range of motion of matter, Distances	Chemical matter ratio
Earthworm	Mg magnisium	Depth of soil	Quantity of microorganism
Bacteria	S sulphur	Absorbing water	Quantity of organism, creature
Humus	Marl, Lime, Calcium carbonate	Seed fertility	Quantity of material
Ecosystem	Dolomite	Water level control	Quantity of water
Food chain	Mineral salts	Water cleanness	Water level
Nitrogen fixation	pH (acidity or basicity)	Root system	Quantity of holding water
Biodegradation	Starch	Gas drainage	Acidity and basicity measurement
Bioprocess	Glucose	Water system	Dissolution of fertilization
Biomass	Fructose	Saturation point	Quantity of air
Photosynthesis	Organic	Moistness	Water quantity calculation
Biology	Chemistry	Physics	Mathematics

Table 4.6 The minimum of science ontologies based on biology, chemistry, physics and mathematics concepts (Continued)

Cellulose	Inorganic	Specific gravity	Quantity of rice sprouts
Fermentation	Pesticides	Soil fertility	Quantity of Germination
GMO (genetically modified organism)	Contaminants	Rice fertility	Quantity of paddy product
Embryo	Trichoderma		Quantity of damage
Biochemical	Gibberellins		Space of paddy
Biomass	Oxidation		Quantity of bio material
	Reduction		
	Good Agricultural Practice (GAP)		
	Gamma aminobutyric acid (GABA)		

Learning process framework

The learning process was designed to measure the ontology effectiveness and the sample learning method that following only the experts or adopting the domain knowledge by using ontology in reasoning. The control and experimental groups were trained on organic rice farming by experts and were tested for knowledge gained from trainers following Bloom's Taxonomy framework and the science ontology effectiveness and learning process measurement by semantic annotation technique on Bloom's Taxonomy vocabulary (shown in **Figure 4.18**).

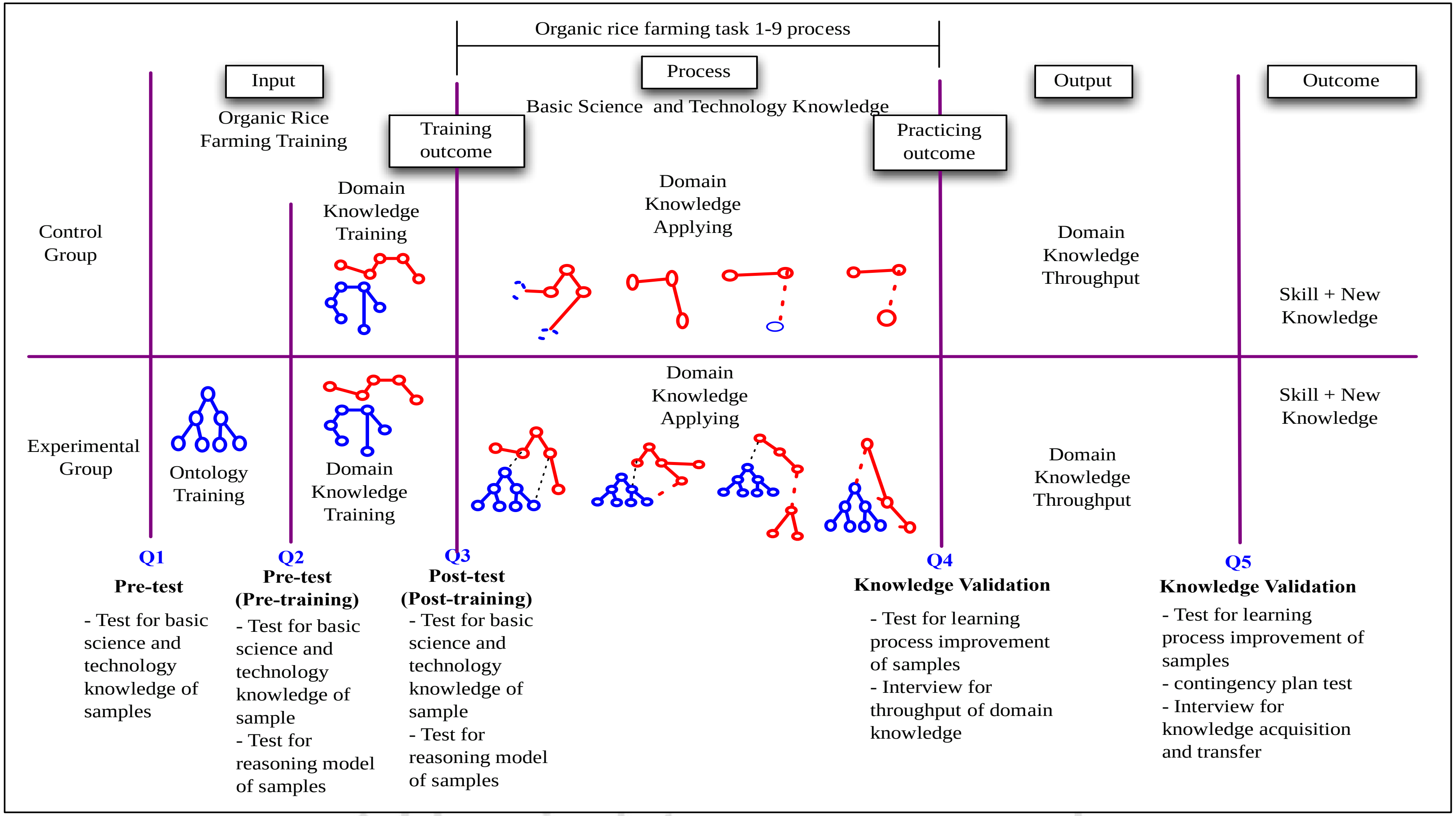

Figure 4.18 The learning process of both sample group

The control and experimental groups were divided equally into two groups and each group has a mentor: Thirasin who is a local expert having an organic rice farming experience. Experts and local expert along this process proving the accuracy verified this learning process implementation and precision of research results and knowledge domain capture. The findings validation was pre-test, post-test and knowledge validation along this process learning at Q1-Q5 that is shown in **Figure 4.18**.

4.4.3 Ontology Tutorial

The additional social science ontologies as shown in **Table 4.6** and in Thai language's version in **Appendix D** were developed for tutoring adaptive organic rice famer samples in order to prove the hypothesis of ontology effectiveness improving learning process. The social scientific ontologies were developed in biology, physics, chemistry and mathematics concepts to enable tutor and reuse of organic farming knowledge derived from the sustainable development projects based on an appropriate technology. The additional ontology model focuses on social science and technology ontologies based on Thai curriculum of lower secondary school in order to effectively represent knowledge of the organic rice farming that ontology defines specification of conceptualization, basic science and social science concepts.

Only five adaptive organic rice farmers of the experimental group were tutored social science ontologies of the organic rice farming ontology knowledge based on four main social science ontologies derived from the biology, chemistry, physics and mathematics concepts of Thai curriculum in lower secondary school by a researcher who has a Master's degree of science. The control group was used as blank to prove ontology effectiveness. The tutorial ontology process for sample in experimental group took place between Q1 and Q2, that was before the organic rice farming training course from experts to both control and experimental groups. The social science ontology knowledge version I based on biology, chemistry, physics and mathematics concepts were training and explaining to experimental group by researcher. All social science ontologies used version I for tutoring an experimental group and a second social science ontology could be adapted in version II when the implementation learning process finished.

4.4.4 Domain Knowledge Training

The adaptive organic rice farmer samples in both control and experimental groups were trained the domain knowledge of intensive organic rice farming tasks by experts who were Chinakrit (an academic researcher in Chiang Mai University) and Vithya (a practitioner in the field of appropriate technology knowledge of organic rice farming). The training course and activities were designed to cover all nine tasks of organic rice farming crop knowledge which was expected that the learners could understand and apply knowledge of appropriate technology for their organic rice farms.

The term of expert's domain knowledge refers to knowledge which was specific for a given domain of practice, both in terms of more abstract knowledge and domain knowledge embedded in the organizational, social and material context of a given practice. This research has nine tasks of organic rice planting knowledge: T1-soil analysis, T2-seed selection, T3-rice seedling, T4-soil preparation, T5-organic rice growing, T6-water management, T7-rice disease, pest, insect protection, T8-harvest and T9- soil development. Each of 9 tasks was modeled into task, inference, domain knowledge from organic rice farming trainer. Trainers of this research designed the training course which it is shown in **Appendix A**.

The training agenda and learning activities were designed by trainers and researcher, divided into three sections which were:

(i) Seed Selection (task 2), Seedling (task 3), Organic Rice Planting (task 5) by Chinakrit
(ii) Soil Preparation (task 4), Soil Development (task 9), Water management (task 6) by Vithya
(iii) Harvest (task 8), Disease, pests and taking care (task 7), Soil Analysis (task 1) by Chinakrit and Vithya

(iv) Making biological substances for organic rice farming activities by Vithya

This training course started July – August in 2014 during rice crop period of Thailand.

4.4.5 Learning Process Measurement

The control and experimental groups were trained in organic rice farming by trainers who had expertise in organic agriculture and organic rice agriculture which are appropriate technology, then both adaptive organic rice farmer samples were tested with post-test after training course finished (step: Q3). Both adaptive organic rice farmer sample groups were cultivated organic rice and applied appropriate technology knowledge, that was trained in organic rice farming process in their own croplands. The scores of Q1-Q3 of both control and experimental group are shown in **Table 4.7**.

The learning process was designed to measure the ontology effectiveness and the sample learning method that followed the experts or adopted the domain knowledge by using ontology in reasoning. The control and experimental groups were trained on organic rice farming by experts and were tested for knowledge gained from trainers following Bloom's Taxonomy framework. The measurement of tutorial social science ontology effectiveness on organic rice farming knowledge in learning process comparison of both control and experimental groups by semantic annotation on domain knowledge with experts' jargon are shown in **Figure 4.19 - Figure 4.21.** There were 148-domain knowledge of nine intensive tasks of organic rice farming which were disseminated to both sample groups. The experimental group only was trained 92 number of social science ontologies on organic rice farming of first version. Consequently, learning process of samples was assessed as step Q4 the training outcome of the learning process that was assessed via capturing organic rice domain knowledge from both sample groups using CommonKADS. The average throughput of organic rice farming domain knowledge in learning process was counted and validated in terms of applying domain knowledge, effectiveness of domain knowledge with their community and acquiring knowledge by themselves in both control and experimental sample groups.

All questions in steps Q1-Q5 used Bloom's Taxonomy vocabulary to design examination and interview question agenda by trainers and a researcher. The results of scores from test Q4 along the learning process arer shown in **Table 4.8.**

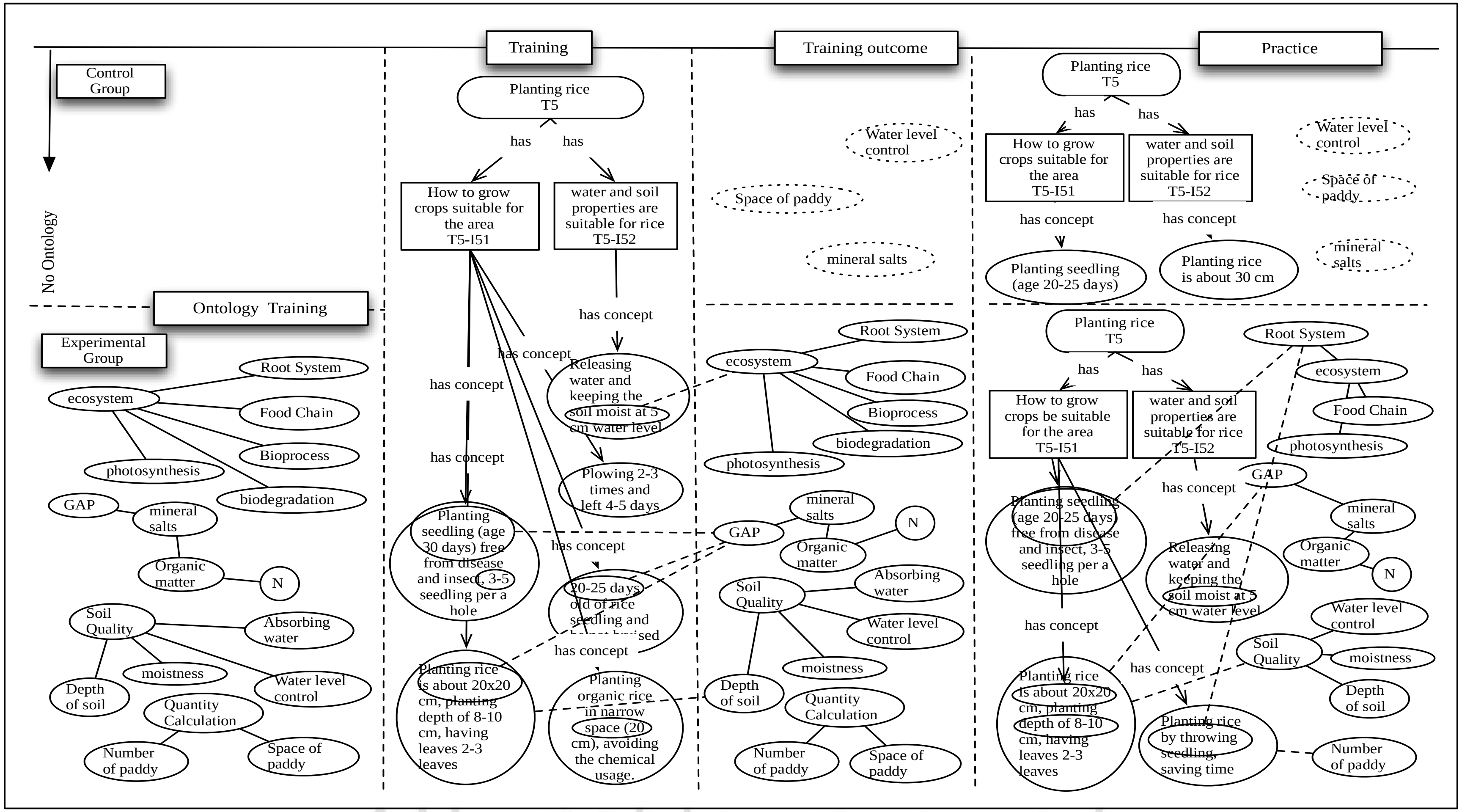

Figure 4.19 Knowledge validation technique of task 5 organic rice planting comparison of AD1 and AD6 samples

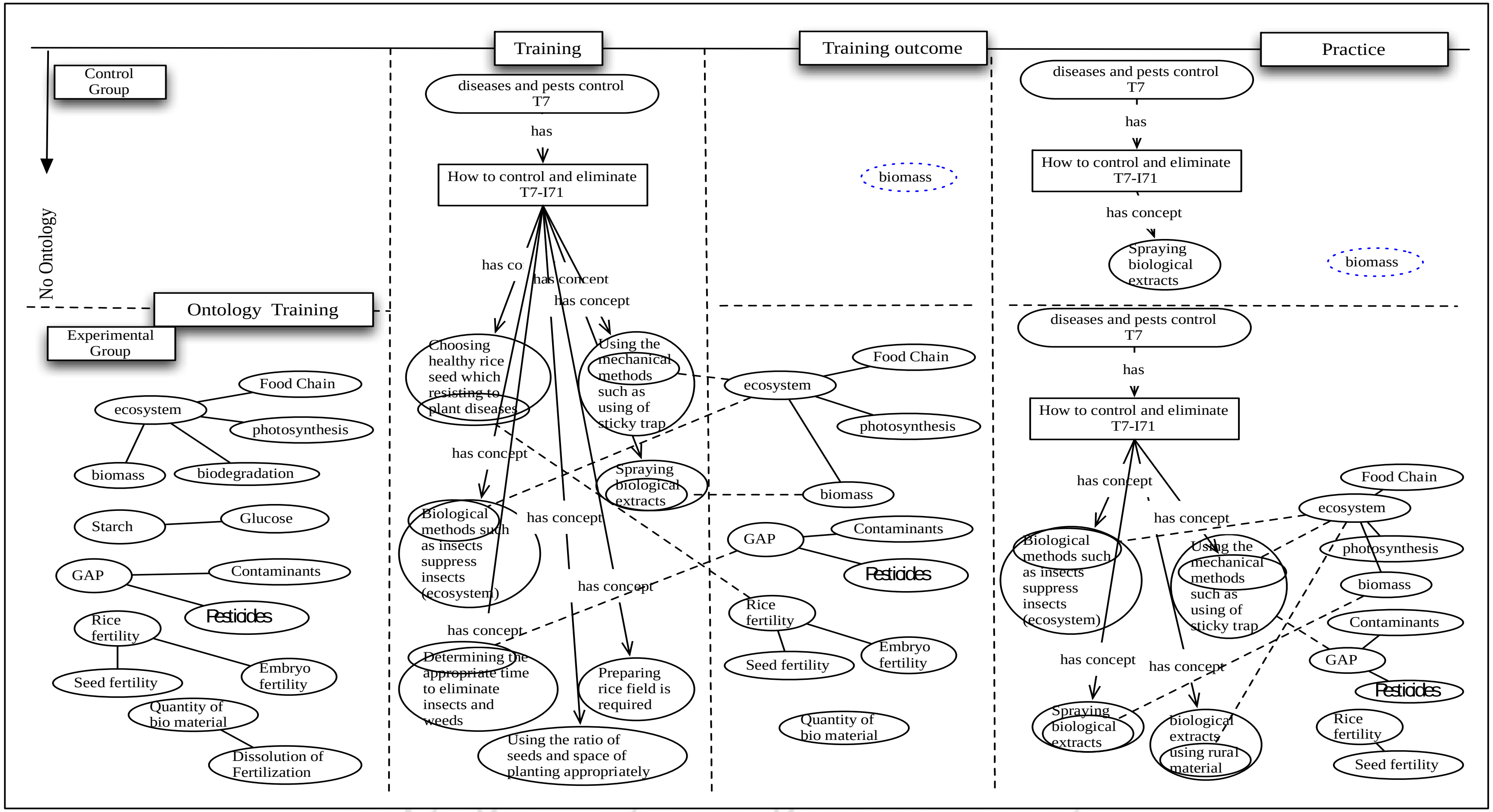

Figure 4.20 Knowledge validation technique of task 7 disease and pests control comparison of AD1 and AD6 samples

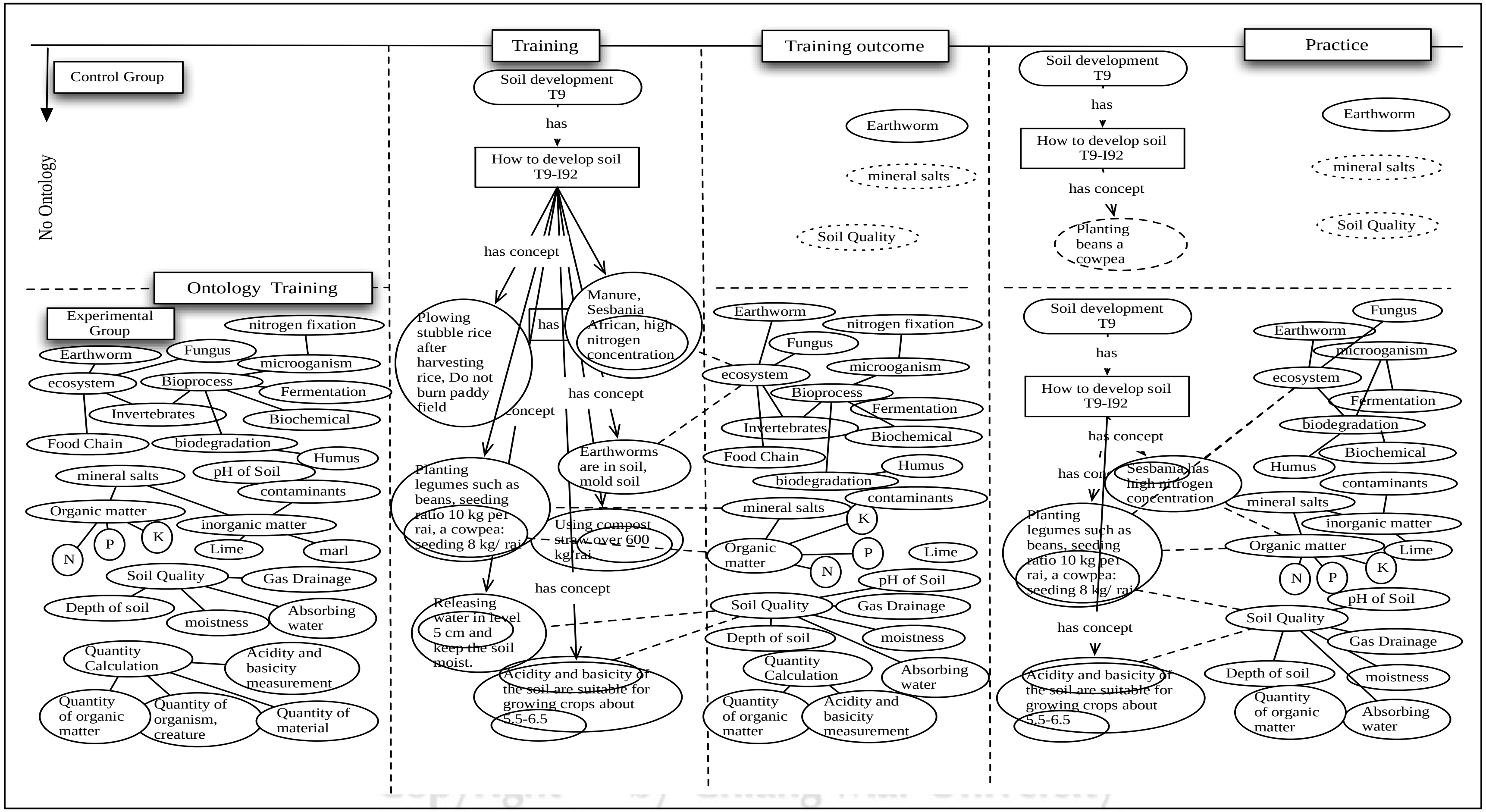

Figure 4.21 Knowledge validation technique of task 9 soil development comparison of AD1 and AD6 samples

Table 4.7 The scores from Q1-Q3 tests of both sample groups

Test	No. of domain knowledge	Score of number of domain knowledge from Control Group					Average	Score of number of domain knowledge from Experimental Group					Average
		AD1	AD2	AD3	AD4	AD5		AD6	AD7	AD8	AD9	AD10	
Pre-test (Q1)	148	49	47	47	49	41	47	49	49	47	47	47	48
Pre-test of Pre-Training (Q2)	148	50	47	47	47	44	47	69	72	63	69	72	69
Post-test (Q3)	148	63	69	64	66	53	64.20	93	95	88	90	89	91
% Pre-test (Q1)	148	33.33	31.48	31.48	33.33	27.78	31.48	33.33	33.33	31.48	31.48	31.48	32.22
% Pre-test of Pre-Training (Q2)	148	34.04	31.91	31.91	31.91	29.79	31.91	46.81	48.94	42.55	46.81	48.94	46.81
%Post-test (Q3)	148	42.27	43.30	43.30	44.33	36.08	42.47	62.89	63.92	59.79	60.82	60.31	61.55

Table 4.8 The scores from Q4 tests of both sample groups

Test	No. of domain knowledge	Score of number of domain knowledge from Control Group					Average	Score of number of domain knowledge from Experimental Group					Average
		AD1	AD2	AD3	AD4	AD5		AD6	AD7	AD8	AD9	AD10	
Number of applying domain knowledge	148	20 (13.51%)	18 (12.16%)	19 (12.84%)	20 (13.51%)	19 (12.84%)	19.2	53 (35.81%)	54 (36.49%)	53 (12.16%)	54 (36.49%)	53 (12.16%)	53.40
Number of effective domain knowledge	148	11 (7.43%)	11 (7.43%)	11 (7.43%)	11 (7.43%)	11 (7.43%)	11	26 (17.57%)	27 (18.24%)	26 (17.57%)	26 (17.57%)	26 (17.57%)	26.20
Number of acquiring domain knowledge	148	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0	7 (4.73%)	10 (6.76%)	8 (5.41%)	9 (6.08%)	7 (4.73%)	8.20

Effectiveness of tutorial social science ontology in learning process

The results of social science ontology effectiveness in learning process of test Q1, Q2 and Q3 showed that the experimental group which was with ontology training could remember, understand and practice knowledge from experts more than the control group which was without tutorial social science ontologies (shown in **Table 4.9**). The average number of organic rice farming domain knowledge in learning process was counted and validated with tests in terms of domain knowledge in both control and experimental groups. Both sample groups took the test Q1 as a pre-test, Q2 as pre-training (experimental group had already been trained ontologies), then Q3 as post-test after training. Consequently, all answers would be captured using knowledge model of CommonKADS into task, inference and domain knowledge and then using semantic annotation technique to annotate domain knowledge from sample's answer with experts' jargons to assess ontology reasoning of samples as shown in **Figures 4.19-4.21**. All domain knowledge of each sample was counted that is shown in **Table 4.8** and the average number of domain knowledge from each group is shown in **Table 4.9.**

Table 4.9 The comparison of average number of domain knowledge in Q1, Q2 and Q3 between control and experimental groups

	Mean of control group	Mean of experimental group	Mean of both groups	Standard deviation	Minimum of both groups	Maximum of both groups
Pre-test Q1	47	48				
Pre-test before training Q2 (Pre-training)	47	69	58.00	11.94	44.00	72.00
Post-test Q3 (Post-training)	64.20	91	77.60	14.92	53.00	95.00

The Wilcoxon Signed Ranks statistic approach was used to compare the mean difference on number of domain knowledge in Q1, Q2 and Q3 between the control and experimental group that tests to prove the tutorial ontology effectiveness hypothesis. The significance of the two-sided test shows in **Table**

4.10 that the median of the differences between Q1 and Q2 of both sample groups is 0.025 at α=0.05 and the median of the differences between Q2 and Q3 of both sample groups is 0.005 at α=0.05, so it can be seen that the mean difference on average domain knowledge between experimental group and control group was totally different and statistically significant. In addition, this statistical approach shows that the tutorial social science ontology effectiveness as a study hypothesis has been proved via the throughput domain knowledge counting in learning process to be statistically significant of domain knowledge which in applying cognitive level on Bloom's Taxonomy.

Table 4.10 Statistical test of the throughput domain knowledge measurement between control and experimental group comparison

	Post-test Q2	Post-test Q3
Exact Sig. [2*(1-tailed Sig.)]	0.025	0.005

The results of social science ontology effectiveness in learning process showed that the experimental group which was with ontology training could understand and practice knowledge from experts more than the control group which was without tutorial social science ontologies (shown in **Table 4.11**). The average throughput of organic rice farming domain knowledge in learning process was counted and validated in terms of practicing domain knowledge, appropriate domain knowledge with their community and acquiring knowledge by themselves in both control and experimental groups.

The average throughput of organic rice farming domain knowledge in learning process was counted and validated in terms of applying domain knowledge, effectiveness domain knowledge with their community and acquiring knowledge by themselves in both control and experimental sample groups. The tutorial science ontologies on organic rice farming knowledge was validated via a count of number of using domain knowledge, using CommonKADS to annotate domain knowledge from both control and experimental groups with experts' jargons (shown in **Figure 4.19- Figure 4.21**).

Table 4.11 The comparison of an average throughput of domain knowledge between control and experimental groups: Q4

	Mean of control group	Mean of experimental group	Mean of both groups	Standard deviation	Minimum of both groups	Maximum of both groups
Number of applying domain knowledge	19.2	53.40	36.30	18.03	18.00	54.00
Number of effective domain knowledge	11	26.20	18.60	8.01	11.00	27.00
Number of acquiring domain knowledge	0	8.20	4.10	4.40	.00	10.00

Some ontology was not used on organic rice appropriately, and some ontology of their adaptive organic rice farmer samples were reasoned and created which was related to expert's domain knowledge to apply for organic rice farming. Furthermore, the new domain knowledge on organic rice farming which is suitable for case study was created from non-science and technology educated farmers in experimental sample group. The results of social science ontology effectiveness in learning process showed that the experimental group which was with ontology training could understand and apply knowledge from trainers more than the control group effectively which was without tutorial social science ontologies (shown in **Table 4.11**). The average throughput of organic rice farming domain knowledge in learning process was counted and validated in terms of applying domain knowledge, effective domain knowledge with their community and acquiring knowledge by themselves in control group and experimental group. The total number domain knowledge from experts was 148 domain knowledge to train in learning process for both control and experimental sample groups. Then, the output of average of organic rice farming domain knowledge of learning process learned by both sample groups were counted as number of throughput domain knowledge (shown in **Figure 4.22**) and calculated as percentage (shown in **Figure 4.23**).

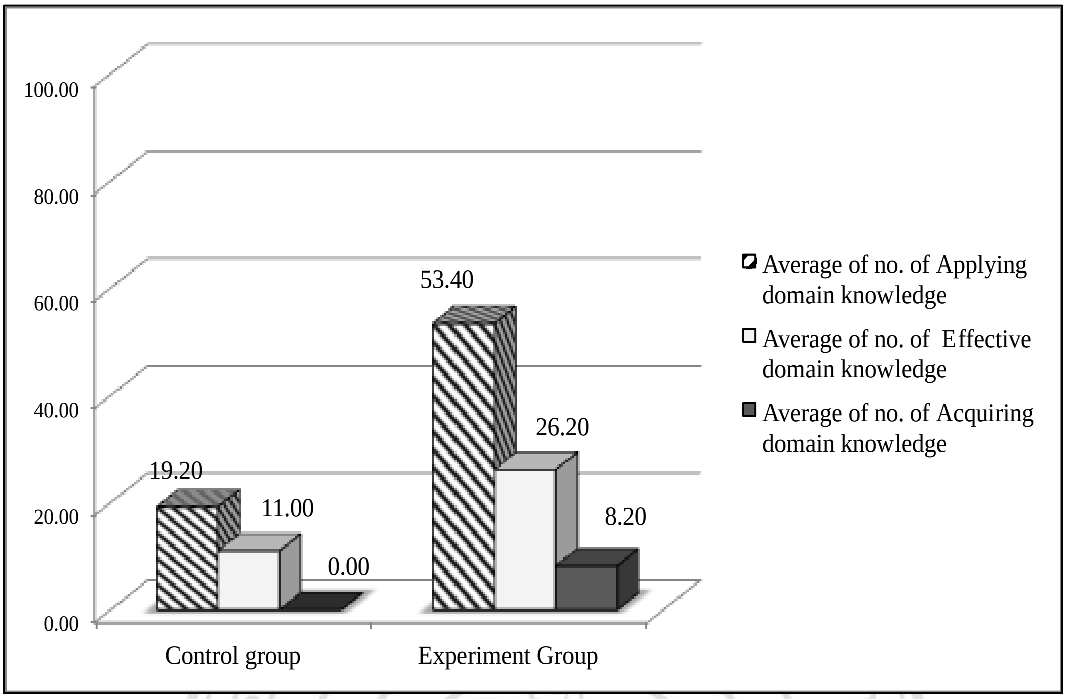

Figure 4.22 Comparison of domain knowledge on organic rice farming of control and experimental groups

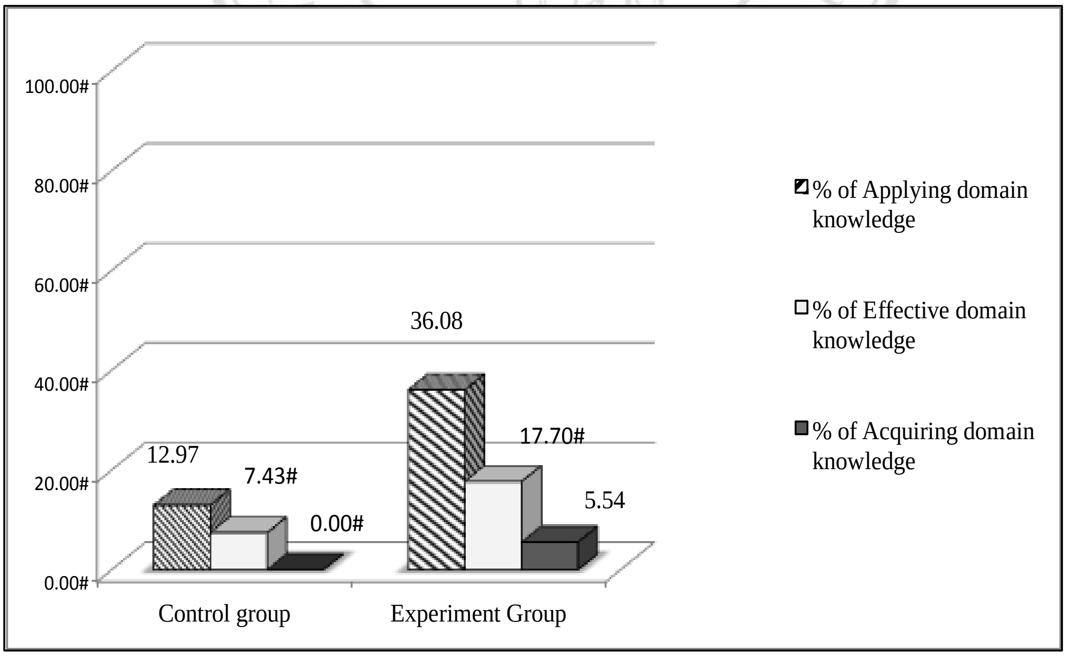

Figure 4.23 Comparison of domain knowledge percentage on organic rice farming between control and experimental group.

Table 4.12 Statistical test of the throughput domain knowledge measurement between control and experimental group comparison

	Number of applying domain knowledge	Number of effective domain knowledge	Number of acquiring domain knowledge
Exact sig. [2*(1-tailed Sig.)]	0.008	0.008	0.008

The Wilcoxon Signed Ranks statistic approach was used to compare the mean difference on number of applying, effective and acquiring domain knowledge between the control and experimental group that tests to prove the tutorial ontology effectiveness hypothesis. The significance of the two-sided test shows in **Table 4.12** that the median of the differences is 0.008 at α=0.05, so it can be seen that the mean difference on average throughput domain knowledge between experimental group and control group is totally different and statistically significant. In addition, this statistical approach shows that the tutorial social science ontology effectiveness as a study hypothesis has been proved via the throughput domain knowledge counting in learning process to be statistically significant of applying, effective and acquiring domain knowledge which in applying cognitive level on Bloom's Taxonomy.

The learning process measurement by semantic annotation technique on Bloom's Taxonomy vocabulary

This research used manual semantic annotation technique on Bloom's Taxonomy vocabulary to measure learning process of non-science and technology educated organic rice farmers. Additionally, learning process of non-science and technology educated samples were measured by semantic annotation technique on Bloom's Taxonomy vocabulary at Q4 assessment stage.

The learning process was measured by semantic annotation on Bloom's Taxonomy vocabulary that it would start with reading learners' answers from the beginning to the end and observing learner's action. The answers and observation of both sample groups would be captured and modeled using CommonKADS, then these knowledge models were manually annotated all annotations in order as they were found to give the most accurate results by semantic annotation measurement on Bloom’s Taxonomy vocabulary. (Shown in **Figure 4.24**)

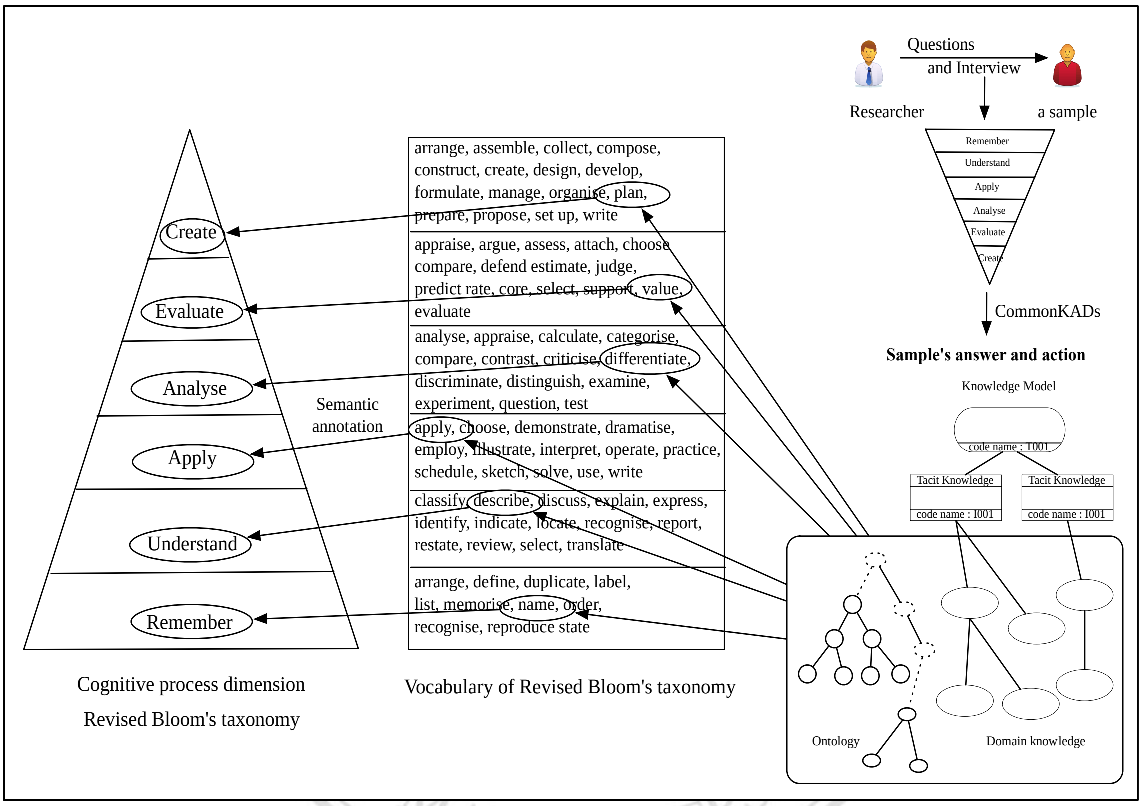

Figure 4.24 The mapping of semantic annotation technique on Bloom’s Taxonomy vocabulary to cognitive level

The questions were designed using the behavior vocabulary of Bloom’s Taxonomy, then tested for both control and experimental groups. The cognitive level of each adaptive organic rice farmer sample was defined from the answers and actions by semantic annotation on revised Bloom’s Taxonomy vocabulary following **Table 4.13** such as if a sample was questioned “Can you describe how to develop organic rice farm soil?” and a sample can describe obviously of organic rice soil development that means the sample was in understanding level of Bloom’s Taxonomy. The example of the learning process measurement by semantic annotation on Bloom’s Taxonomy is shown in **Figure 4.25** and **Figure**

4.26 and the examples of evaluation of cognitive level is shown in **Table 4.14** and **Table 4.15.** The ten samples of both non-science and technology educated organic rice sample groups were assessed by semantic annotation on revised Bloom's Taxonomy vocabulary in order to define the cognitive level of each sample in learning process.

Table 4.13 The revised Bloom's Taxonomy

Cognitive level	Description	Learner's answer and action
Remember	Ability to recognize, arrange trained material, memorize of definitions that without an understanding of the related meaning.	Recall the ontology in the exact content that it was trained on organic rice farming.
Understand	Ability to understand, explain and indicate the trained material.	Restate the trained material in the learner's own vocabulary or can discuss unseen concept of organic rice farming.
Apply	Ability to practice the trained material to apply in new situations.	Apply the appropriate technology of trained material to operate the learner own organic rice farm.
Analyze	Ability to distinguish and examine complex concepts or situations into the learner component portions.	Compare or contrast the performance of the trained organic rice farming to learner component portions and analyze the related component parts to their own situations or another.
Evaluate	Ability to judge and evaluate the worth of trained concepts, knowledge, etc. for specified determination.	Evaluate the business outcome of the learner own organic rice products and making judgments on the quality of their own products.
Create	Ability to propose or rearrange component portions to create new concepts.	Create and develop their own organic rice farming domain knowledge based on appropriate technology concepts.

Reference: Bloom et al (1956), Anderson and Krathwohl (2001)

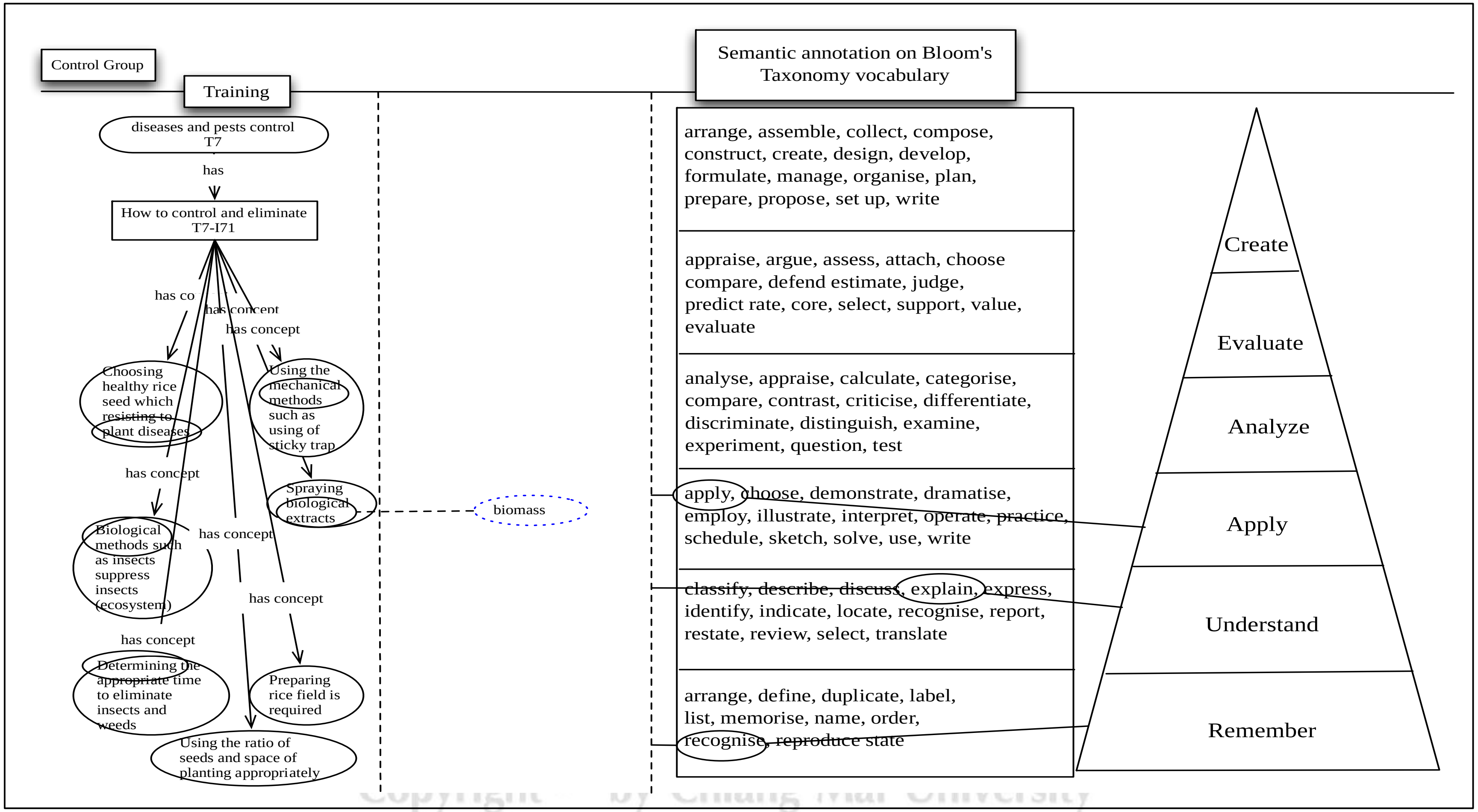

Figure 4.25 The example of mapping of semantic annotation technique on Bloom's Taxonomy vocabulary to cognitive level of the sample code is AD1 on task 7 diseases and pests' control

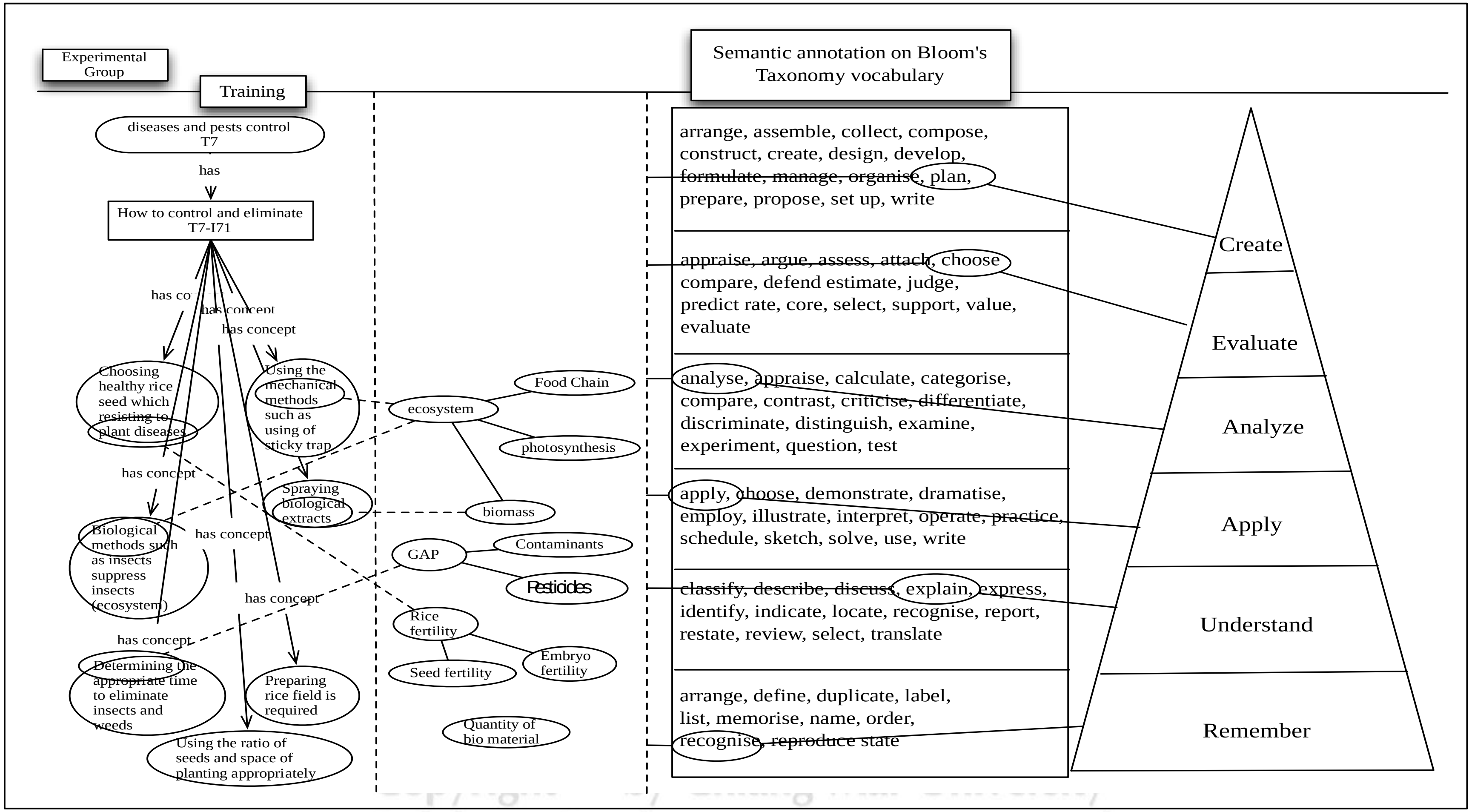

Figure 4.26 The example of mapping of semantic annotation technique on Bloom's Taxonomy vocabulary to cognitive level of the sample code is AD6 on task 7 diseases and pest's control

Table 4.14 An example of cognitive behavior evaluation for non-science and technology educated farmers of organic rice farming learning process improvement: the sample code is AD1 on disease and pest control task 7

Cognitive behavior indicator	Fail (0 point)	Fair (1 point)	Pass (2 points)	Good (3 points)
Remember			Answers get to the points of questions but it is still needed more detail	
Understand		Answers are not clear and get to the key words of correct answers, Confusing answers		
Apply		Answers are not clear and get to the key words of correct answers, Confusing answers		
Analyze	Could not answer all questions			
Evaluate	Could not answer all questions			
Create	Could not answer all questions			

Table 4.15 An example of cognitive behavior evaluation for non-science and technology educated farmers of organic rice farming learning process improvement: the sample code is AD6 on diseases and pest control task 7

Cognitive behavior indicator	Fail (0 point)	Fair (1 point)	Pass (2 points)	Good (3 points)
Remember				Answers are complete and covered all aspects of questions, Clear answer
Understand			Answers get to the points of questions but it is still needed more detail	
Apply			Answers get to the points of questions but it is still needed more detail	
Analyze		Answers are not clear and get to the key words of correct answers, Confusing answers		
Evaluate		Answers are not clear and get to the key words of correct answers, Confusing answers		
Create		Answers are not clear and get to the key words of correct answers, Confusing answers		

The experts and researcher worked and assessed together on the answers from both sample groups in order to verify the accuracy and precision of the learning process measurement technique. The results of semantic annotation on Bloom's Taxonomy vocabulary are shown in **Table 4.16** that total evaluation scores were calculated from all organic rice farming tasks.

Table 4.16 Total evaluation scores of all organic rice farming tasks (Task1-Task 9) were calculated from learning process measurement by semantic annotation on Bloom's Taxonomy vocabulary using assessment form of both sample groups

Cognitive Level	Control Group					Experimental Group				
	AD1	AD2	AD3	AD4	AD5	AD6	AD7	AD8	AD9	AD10
Remember	6	3	0	1	0	14	15	13	15	12
Understand	2	1	0	1	0	10	12	9	9	9
Apply	2	0	0	1	0	7	7	5	7	5
Analyze	0	0	0	0	0	2	4	2	4	2
Evaluate	0	0	0	0	0	2	1	0	1	1
Create	0	0	0	0	0	2	2	0	1	0

Table 4.17 Number of samples in each group reaches the cognitive level

Cognitive Level	Number of sample in control group	Number of sample in experimental group
Remember	3	5
Understand	2	5
Apply	2	5
Analyze	0	5
Evaluate	0	4
Create	0	3

The result in **Table 4.17** and **Figure 4.27** showed that all five samples in experimental group were in analysis cognitive level and just three samples could reach to creating cognitive level. The three samples in control group were in remember cognitive level and no samples in this control group could reach to analysis, evaluating and creating cognitive level.

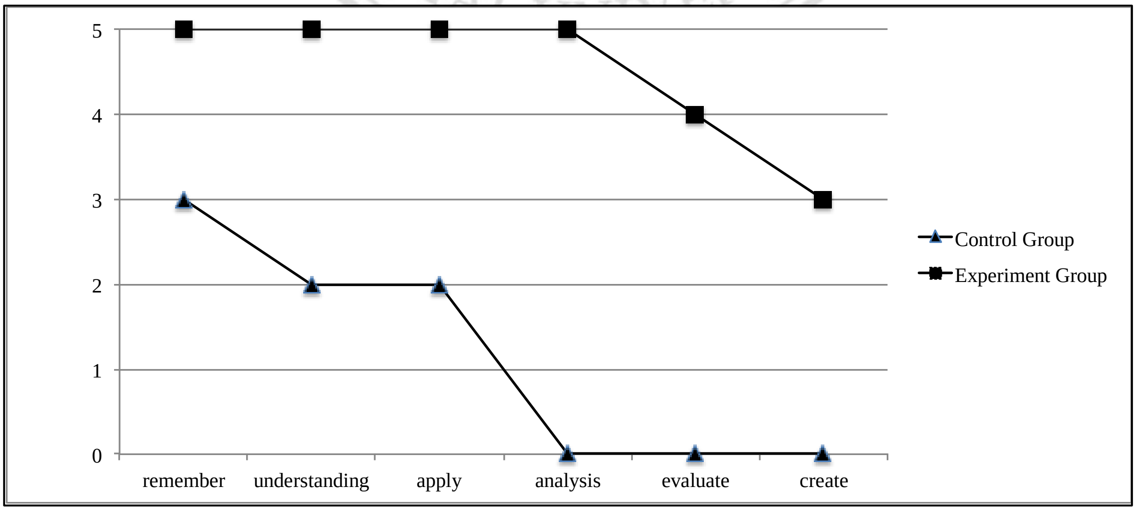

Figure 4.27 Comparison of cognitive level of both control and experimental groups

The learning process measurement by semantic annotation technique on Bloom's Taxonomy Vocabulary using the contingency plan: Q5

Both sample groups were tested by writing their explanations on contingency plan for organic rice farming management in order to test the effectiveness of ontology, the training outcome, outcome stimulation and close gap between experts and knowledge workers. There are six disasters for organic rice farming that were verified by experts. These are chemical exploration, storm, flood, cold weather, drought, diseases; pests and weeds.

The semantic annotation technique on Bloom's Taxonomy vocabulary was used to measure the learning process improvement using contingency plan. The example of semantic annotation on Bloom's Taxonomy vocabulary of contingency plan test (Q5) is shown in **Figure 4.28.** The evaluation form for score measurement is shown in **Table 4.18.**

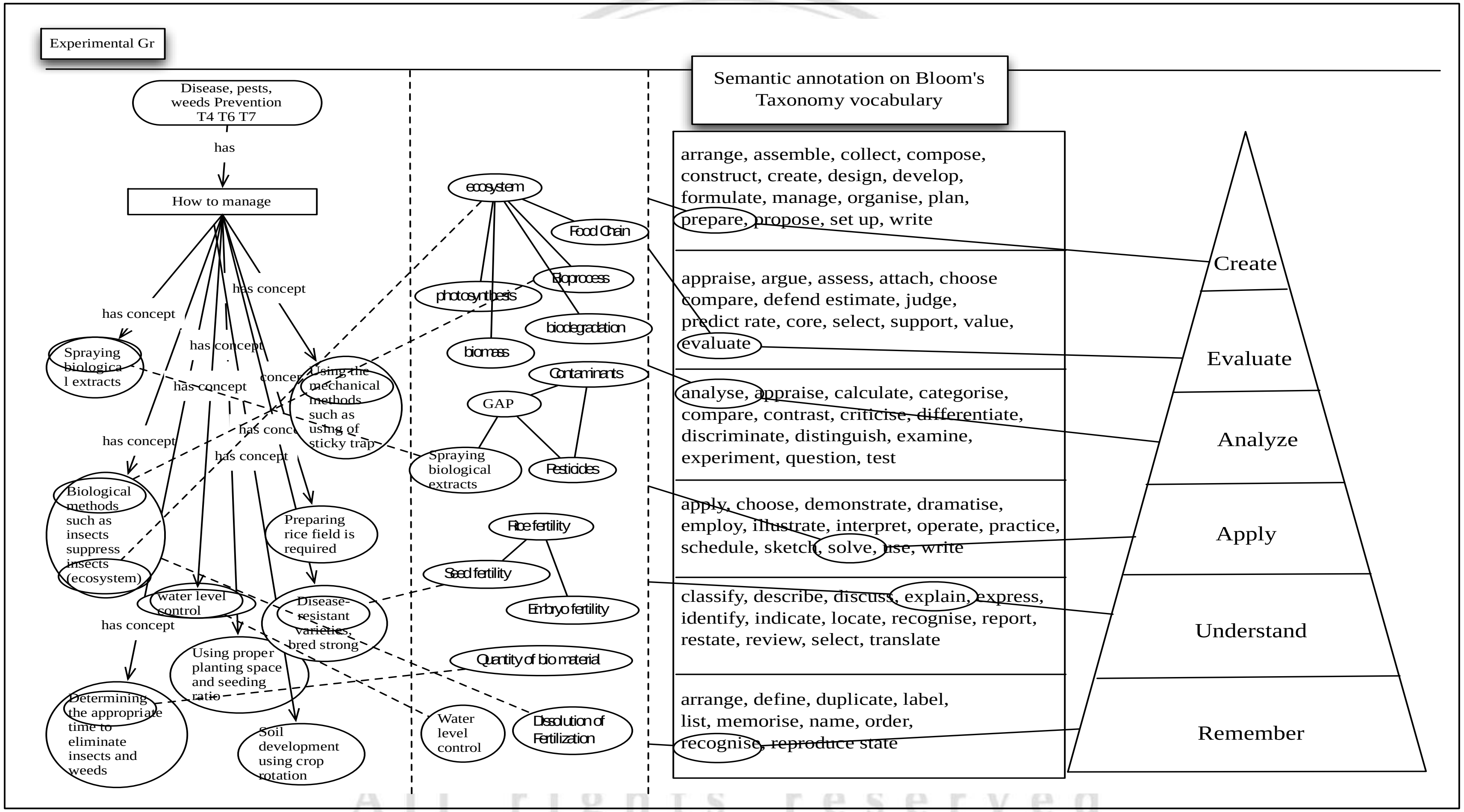

Figure 4.28 The example of mapping of semantic annotation technique on Bloom's Taxonomy vocabulary to cognitive level of the sample code is AD6 on contingency plan of rice diseases, pests and insects outbreak

Table 4.18 An example of cognitive behavior evaluation for non-science and technology educated farmers of organic rice farming learning process improvement: the sample code is AD6 on contingency plan of rice diseases, pests and insects outbreak

Cognitive behavior indicator	Fail (0 points)	Fair (1 points)	Pass (2 points)	Good (3 points)
Remember			Answers get to the points of questions but it is still needed more detail	
Understand			Answers get to the points of questions but it is still needed more detail	
Apply			Answers get to the points of questions but it is still needed more detail	
Analyze			Answers get to the points of questions but it is still needed more detail	
Evaluate		Answers are not clear and get to the key words of correct answers, Confusing answers		
Create		Answers are not clear and get to the key words of correct answers, Confusing answers		

The expert and researcher analyzed and assessed together of individual sample in both sample groups to measure learning process by semantic annotation on Bloom's Taxonomy vocabulary. The total score of individual sample is shown in **Table 4.19** and the number of samples, writing in contingency plan in **Table 4.20**.

Table 4.19 Total evaluation scores of contingency plan were calculated from learning process measurement by semantic annotation on Bloom's Taxonomy vocabulary using assessment form of both sample groups

Cognitive Level	Control Group					Experimental Group				
	AD1	AD2	AD3	AD4	AD5	AD6	AD7	AD8	AD9	AD10
Remember	5	2	1	5	1	12	10	11	12	11
Understand	1	0	0	1	1	10	8	9	11	10
Apply	1	0	0	1	1	9	6	7	9	6
Analyze	0	0	0	0	0	6	5	4	6	4
Evaluate	0	0	0	0	0	5	3	2	4	3
Create	0	0	0	0	0	3	3	2	3	2

Table 4.20 Number of samples writing in contingency plan in each group reaches the cognitive level

Cognitive Level	Number of sample in control group	Number of sample in experimental group
Remember	5	5
Understand	3	5
Apply	3	5
Analyze	0	5
Evaluate	0	5
Create	0	5

The results in **Table 4.20** and **Figure 4.29** showed that all five samples in experimental group were in creating cognitive level. The five samples in control group were in remember cognitive level and no samples in this control group could reach to analysis, evaluating and creating cognitive level.

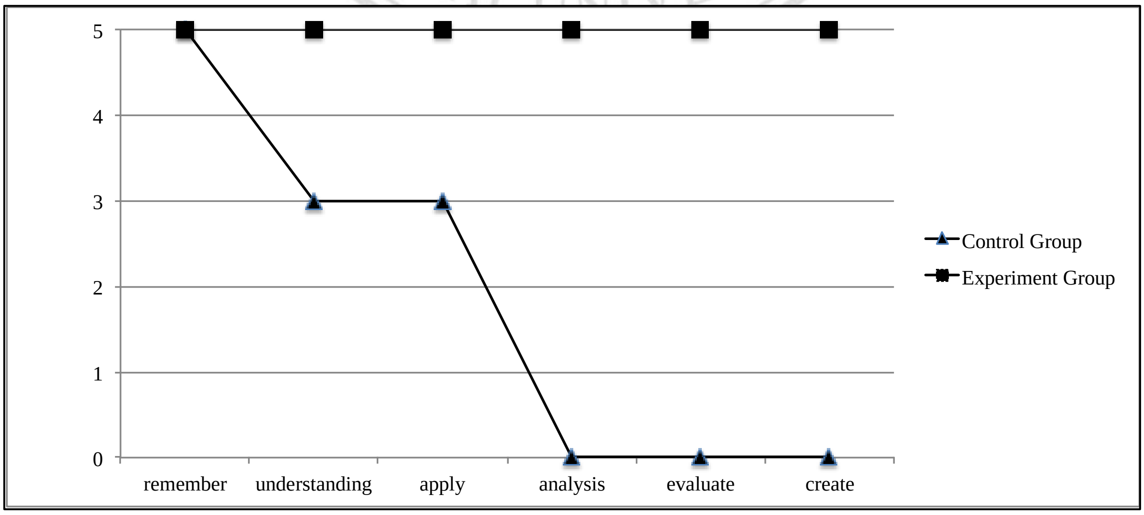

Figure 4.29 Comparison of cognitive level of both control and experimental groups in contingency plan test

For this contingency plan test Q5, both sample groups have written for two weeks that they could search on Internet to find the information, read any books and ask local experts. Then the writing contingency plan answer and in-depth interview took place to complete the answer of both sample groups on contingency plan in order to measure the learning process improvement of samples by semantic annotation on Bloom's Taxonomy vocabulary.

The finding of this contingency plan test was that most of sample in control group could not understand the questions in contingency plan and they could not write the answers on contingency plan test. Then all samples in control group were interviewed with questions in contingency plan by researcher in order to get the answer from them.

The contingency plan that was used to test learning outcome and to stimulate learning outcome on learning process could close gap between experts and non-science and technology educated farmers and prove the effectiveness of additional ontology improving learning process of samples. The non-science and technology educated farmers who had additional ontology could understand and apply appropriate technology knowledge more than samples who lacked of basic education.

4.4.6 Ontology Knowledge Adaptation from Samples: Stage 8

The tutorial social science ontologies on organic rice farming were validated via a count of number of using domain knowledge to organic rice farming effectively from both control and experimental groups by interview (shown in **Figure 4.29**). Some ontology probably was not used on organic rice appropriately, and some ontology of their samples was created and reasoned which was related to expert's domain knowledge to apply for organic rice farming. In this stage result, the new domain knowledge and new ontologies on organic rice farming which was appropriate to a case study community would be created from non-science and technology educated farmers in both sample groups.

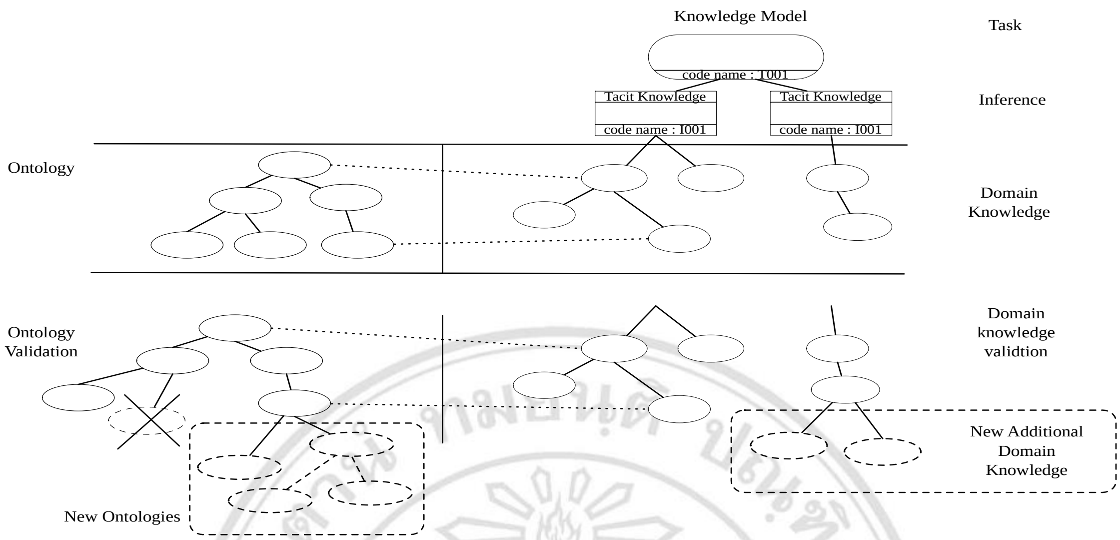

Figure 4.30 Ontology adaptation and knowledge validation and adaptation

The science ontologies of first version were minimized in this stage and improved ontology into appropriate science ontology for non-science and technology educated farmers on organic rice farming to understand experts. Consequently, the minimized and appropriate social science ontology on organic rice farming in this stage would be returned to identify and develop ontology stage to develop a second version of science ontology which was refined in an effective tutorial ontology version for non-science and technology educated farmers. The example of ontology and domain knowledge validation and adaptation is shown in **Figure 4.30,** that is new domain knowledge and new ontology in gray circle. The ontology version 2 would be provided to train non-science and technology educated farmers. Moreover, the ontology could be validated and adapted again and again until reaching the minimized ontology version of research requirement.

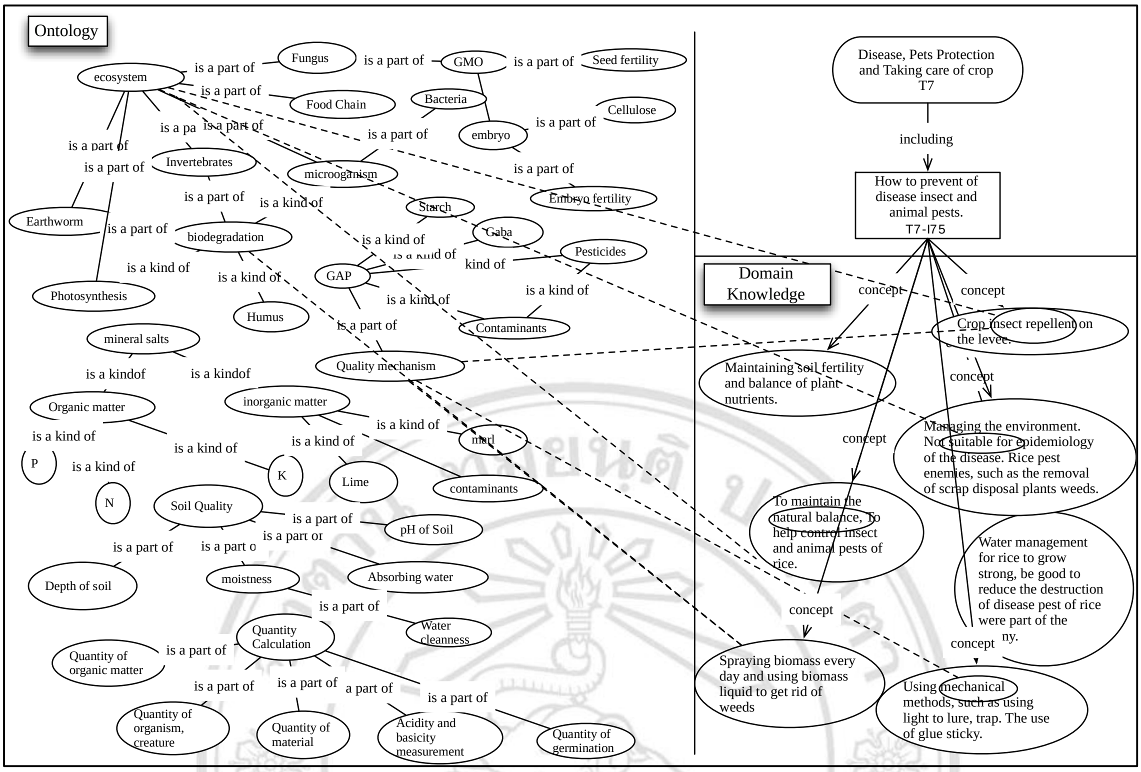

Figure 4.31 Ontology knowledge validation and adaptation

4.4.7 Internal Process Reflection Using Psychomotor Framework

This result showed the learning domain of psychomotor framework that related to movements and motor skills of both sample groups on organic rice farming training knowledge. There are numerous available taxonomies of the psychomotor domain. This study provides taxonomy of Simpson’s taxonomy that has an emphasis toward the progression of mastery from observation to creation. Elizabeth Simpson’s (1966) taxonomy was determined on the progression of a skill from conducted response, i.e., responsibility what you expressed to do in order to response or characteristic reaction (i.e., not having to think about what you’re performance). Moreover, the Simson’s taxonomy includes origination as the highest level that was creation of a new method to perform a task.

Anderson developed revised Bloom’s taxonomy of educational objectives to measure the cognitive domain of individual behavior. The taxonomy for the cognitive domain is definitely the most well-known. These objectives relate to "cognitive levels" of learning. The cognitive level one (remember) is the lowest level, and level six (create) is the highest cognitive level. Learning at the lower levels must be achieved in order to master the higher levels.

This part of this research tests how much cognitive domain level was reached by samples then reflects the internal process to individual behavior. The local experts: Thirasin evaluated both sample groups using psychomotor framework that the assessment form is shown in **Table 4.21.** The psychomotor domain evaluations of examples are shown in **Table 4.22**, **Table 4.23**, **Table 4.24** and **Table 4.25**. All psychomotor domain assessment scores of both sample groups are shown in **Appendix C**.

The cognitive domain and psychomotor domain were analyzed cross domain to reflect how much internal process of tutorial ontology effect to skill performance and learning process behavior of organic rice farming knowledge (shown in **Table 4.26**, **Table 4.27** and **Table 4.28).**

Table 4.21 Performance and competency evaluation form of Psychomotor for sample farmers in both control and experimental groups

Cognitive behavior indicator	Fail/not correct (0 point)	Fair/Correct need to adjust (1 point)	Pass (2 points)	Good (3 points)
Organic Rice Farming Task 1 – Task 9	• Could not answer all questions, • Could not understand experts, • Be not ready to do by their own, • Could not follow correctly experts' guidelines • Could not be origination • Could not respond any complex domain knowledge • Could not apply or modify domain knowledge	• Answers are not clear and get to the key words of correct answers, Confusing answers • Could follow experts' guidelines but need to be adaptive work and output • Could be origination but need to be adaptive work and output • Could respond complex domain knowledge but need to be adaptive work and output • Could apply or modify domain knowledge but need to be adaptive work and output	• Answers get to the points of questions but it is still needed more detail • Could follow experts' guidelines and could respond complex domain knowledge • Could apply or modify domain knowledge	• Answers are complete and covered for all aspect of questions, Clear answers • Could well follow experts' guidelines and could well respond complex domain knowledge • Could well apply or well modify domain knowledge

Table 4.22 An example of authentic assessment using Psychomotor by mentor of sample group: local expert of organic rice farming knowledge.

Sample code	Activity	Practicing Performance			Performance	Process Performance Skill		
		Perception	Set (Readiness)	Guided Response	Mechanism	Complex overt response	Adaptation	Origination
AD1	Organic Rice Farming	1	1	0	0	0	0	0
AD2	Organic Rice Farming	1	1	0	0	0	0	0
AD3	Organic Rice Farming	1	1	0	0	0	0	0
AD4	Organic Rice Farming	1	1	0	0	0	0	0
AD5	Organic Rice Farming	1	1	0	0	0	0	0
AD6	Organic Rice Farming	1	1	1	1	***2***	***2***	1
AD7	Organic Rice Farming	1	1	1	1	***2***	***2***	1
AD8	Organic Rice Farming	1	1	1	1	***2***	***2***	1
AD9	Organic Rice Farming	1	1	1	1	***2***	***2***	1
AD10	Organic Rice Farming	1	1	1	1	***2***	***2***	1

Table 4.23 An example of authentic assessment using Psychomotor by mentor of sample group: local expert of Task 9 soil development of all samples.

Sample code	Activity	Practicing Performance			Performance	Process Performance Skill		
		Perception	Set (Readiness)	Guided Response	Mechanism	Complex overt response	Adaptation	Origination
AD1	T9_Soil Development	**1**	**1**	**1**	**1**	**1**	***2***	0
AD2	T9_Soil Development	**1**	**1**	**1**	**1**	***2***	**1**	0
AD3	T9_Soil Development	**1**	**1**	**1**	**1**	***2***	**1**	0
AD4	T9_Soil Development	**1**	**1**	**1**	**1**	***2***	**1**	0
AD5	T9_Soil Development	**1**	**1**	**1**	**1**	**1**	**1**	0
AD6	T9_Soil Development	**1**	**1**	**1**	**1**	***2***	***2***	**1**
AD7	T9_Soil Development	**1**	**1**	**1**	**1**	***2***	***2***	**1**
AD8	T9_Soil Development	**1**	**1**	**1**	**1**	***2***	***2***	**1**
AD9	T9_Soil Development	**1**	**1**	**1**	**1**	***2***	***2***	**1**
AD10	T9_Soil Development	**1**	**1**	**1**	**1**	***2***	***2***	**1**

Table 4.24 An example of authentic assessment using Psychomotor by mentor of sample group: local expert of sample code AD1.

Sample code	Activity	Practicing Performance			Performance	Process Performance Skill		
		Perception	Set (Readiness)	Guided Response	Mechanism	Complex overt response	Adaptation	Origination
AD1	Organic Rice Farming	1	1	0	0	0	0	0
	T1_Soil Analysis	0	0	0	0	0	0	0
	T2_Seed Selection	1	1	1	1	1	***2***	0
	T3_Seedling	1	1	1	1	1	***2***	0
	T4_Soil Preparation	1	1	1	1	1	***2***	0
	T5_Rice Planting	1	1	1	1	1	***2***	0
	T6_water management	0	0	0	0	0	0	0
	T7_Disease, Pests and Weeds control	1	1	1	0	0	0	0
	T8_Harvest	1	1	1	1	1	***2***	0
	T9_Soil Development	1	1	1	1	1	***2***	0

Table 4.25 An example of authentic assessment using Psychomotor by mentor of sample group: local expert of sample code AD6.

Sample code	Activity	Practicing Performance			Performance	Process Performance Skill		
		Perception	Set (Readiness)	Guided Response	Mechanism	Complex overt response	Adaptation	Origination
AD6	Organic Rice Farming	1	1	1	1	*2*	*2*	1
	T1_Soil Analysis	0	0	1	1	1	1	0
	T2_Seed Selection	1	1	1	1	*2*	*2*	1
	T3_Seedling	1	1	1	1	*2*	*2*	1
	T4_Soil Preparation	1	1	1	1	*2*	*2*	1
	T5_Rice Planting	1	1	1	1	*2*	*2*	1
	T6_water management	1	1	1	1	*2*	*2*	1
	T7_Disease, Pests and Weeds control	1	1	1	1	*2*	*2*	1
	T8_Harvest	1	1	1	1	*2*	*2*	1
	T9_Soil Development	1	1	1	1	*2*	*2*	1

Table 4.26 Comparison cognitive domain level with psychomotor domain

Cognitive level: Revised Bloom's Taxonomy			Psychomotor: Simson's Taxonomy		
Level	Description	Verbs	Level	Description	Verbs
Remember	Ability to recognize, arrange trained material, memorize of definitions that without an understanding of the related meaning.	Arrange, Define, Duplicate, Label, List, Memorize, Name, Order, ***Recognize***, Reproduce, State	Perception	The procedure of appropriate interest of objects, qualities, etc. by technique of senses. Basic in situation, clarification, action chain principle to motor activity. Could include cue, physical inspiration, selection, sensory stimulation and translation.	Associate, Compare, Feel, Hear, Identify, Inspect, Listen, Notice, ***Recognize***, Scan, Select, Smell, Taste
Understand	Ability to understand, explain and indicate the trained material.	Classify, Describe, Discuss, Explain, Express, ***Identify,*** Indicate, Locate, Recognize, Report, Restate, Review, Select, Translate	Set	Readiness for a specific type of experience or achievement. This readiness or preparative modification could be mental, physical or emotional.	Adjust, Arrange, Comprehend, ***Identify,*** Locate, Organize, Recognize, Respond, Select

Table 4.26 Comparison cognitive domain level with psychomotor domain (Continued)

Cognitive level			Psychomotor		
Level	Description	Verbs	Level	Description	Verbs
Apply	Ability to practice the trained material to apply in new situations.	Apply, Choose, Demonstrate Dramatize, Employ, Illustrate, Interpret, Operate, ***Practice,*** Schedule, Sketch, Solve, Use, Write	Guided Response	Obvious behavioral performance of an individual under guidance of a trainer, or following model or set criteria. Might include replication of another person, or trial and error until suitable response obtained.	Adapt, Correct, Imitate, Match, ***Practice***, Repeat, Reproduce, Simulate
Analyze	Ability to distinguish and examine complex concepts or situations into the learner component portions.	Analyze, Appraise, Calculate, Categorize, Compare, Contrast, Criticize, Differentiate, Discriminate, Distinguish, Examine, ***Experiment***, Question, Test	Mechanism	Occurs when a studied response has developed characteristic. At this level the learner has attained certain confidence and skill or performance. The act enhances part of his/her range of possible responses to incentive and requests of situations.	Assemble, Fasten, ***Manipulate,*** Mix, Mold, Set-up, Shape

Table 4.26 Comparison cognitive domain level with psychomotor domain (Continued)

Cognitive level			Psychomotor		
Level	Description	Verbs	Level	Description	Verbs
Evaluate	Ability to judge and evaluate the worth of trained concepts, knowledge, etc. for specified determination.	Appraise, Argue, ***Assess***, ***Attach***, ***Choose***, Compare, Defend ***Estimate***, ***Judge,*** Predict Rate, Core, ***Select***, Support, Value, ***Evaluate***	Complex overt response	Obvious Response Performance of a motor performance that is considered complex because of movement design needed. Could include resolution of improbability, i.e., done without uncertainty; and automatic performance, finely synchronized with great comfort and muscle control.	***Adjust***, ***Combine***, Coordinate, Integrate, Manipulate, ***Regulate***
			Adaptation	Adjusting motor activities to meet requests of problematical situations.	Adapt, ***Adjust***, Alter, Convert, ***Correct***, Integrate, Order, ***Standardize***
Create	Ability to propose or rearrange component portions to create new concepts.	Arrange, Assemble, Collect, Compose, Construct, ***Create,*** ***Design,*** Develop, Formulate, Manage, Organize, Plan, Prepare, Propose, Set up, Write	Origination	Constructing new motor performances or methods of manipulating materials out of skills, capabilities and understandings established in the psychomotor area.	Construct, ***Create***, ***Design,*** Develop, Formulate, Invent

Table 4.27 An example of cognitive level of Bloom's Taxonomy and Psychomotor domain of task 7 of sample AD6 in experimental group.

Sample code AD6	Task 7: Disease and pests control	Psychomotor					
		Practicing Performance			Performance	Process Performance Skill	
		Perception	Set (Readiness)	Guided Response	Mechanism	Complex overt response and Adaptation	Origination
Cognitive level	*Remember*	1 (3)					
	Understand		1 (2)				
	Apply			1 (2)			
	Analyze				1 (1)		
	Evaluate					2 (1)	
	Create						1 (1)

Table 4.28 An example of cognitive level of Bloom’s Taxonomy and Psychomotor domain of task 7 of sample AD1 in control group.

Sample code AD1	Task 7: Disease and pests control	Psychomotor					
		Practicing Performance			Performance	Process Performance Skill	
		Perception	Set (Readiness)	Guided Response	Mechanism	Complex overt response and Adaptation	Origination
Cognitive level	*Remember*	1 *(2)*					
	Understand		1 *(1)*				
	Apply			1 *(1)*			
	Analyze				0 *(0)*		
	Evaluate					*0* *(0)*	
	Create						0 *(0)*

The psychomotor domain is part of Bloom's Taxonomy of learning process that emphasizes on training skills related to motor intensive tasks, comprising physical and manual accomplishments, or other intensive tasks such as those within the medical criteria, communication methods or computer skills. The psychomotor domain is all about "performance" throughout replication, practicing and adjusting new skills whereas the other type of learning in Bloom’s Taxonomy is the cognitive domain focused on knowledge.

The psychomotor domain of control sample group and experimental group are shown performance of organic rice farming skill reflection in accordance with the cognitive level that was internal process. **Table 4.27** showed that sample in experimental group who has additional ontology reflecting cognitive level of Bloom's Taxonomy consistent with psychomotor domain level. The samples in experimental group had learning process and organic rice farming skill improvement that proved hypothesis of ontology effectiveness. The samples in control group who was not tutored ontology reflecting cognitive level of Bloom's Taxonomy consistent with psychomotor domain level. In case of the samples in control group who were doing organic rice agriculture and performed based on their own background in farming that the result is shown in **Table 4.28**.

The most frequently occurring value of data score within control group and experimental group were compared as shown in **Table 4.29**. The results showed that both samples groups reflected cognitive level of Bloom's Taxonomy related to psychomotor domain level. The most samples in experimental group expressed learning process improvement and organic rice farming skill improvement by applying and utilizing domain knowledge from experts more than samples in control group. Most samples in control group could reach cognitive level at understand that is consistent with set level of psychomotor. So, most samples in control group might do organic rice farm based on their old skill and experience that the score of cognitive level related to skill behavior as shown in psychomotor.

Table 4.29 An example of cognitive level of Bloom's Taxonomy and Psychomotor domain of task 7 of sample AD1 in control group.

Sample code AD1	Task 7: Disease and pests control	Psychomotor (Control Group)						Psychomotor (Experimental Group)					
		Practicing Performance			Performance	Process Performance Skill		Practicing Performance			Performance	Process Performance Skill	
		Perception	Set	Guided Response	Mechanism	Complex overt response and Adaptation	Origina tion	Perception	Set	Guided Response	Mechanism	Complex overt response and Adaptation	Origina tion
Cognitive level	*Remember*	1 *(0)*						1 *(3)*					
	Understand		1 *(0)*						1 *(2)*				
	Apply			0 *(0)*						1 *(2)*			
	Analyze				0 *(0)*						2 *(2)*		
	Evaluate					*0* *(0)*						*2* *(1)*	
	Create						0 *(0)*						1 *(0)*