Exploration of knowledge graphs to support teaching in curriculum of live foods cultivation within discipline of aquaculture

Shixi Chen[1, 2], Li Ao[1], Xueting Xiao[1], Bin Li[1], Taishuo Chen[1]*

[1]College of Fisheries, Neijiang Normal University, Neijiang, 641004, China
[2]Conservation and Utilization of Fishes Resources in the Upper Reaches of the Yangtze River, Key Laboratory of Sichuan Province, Neijiang, 641000, China

Keywords:

Live foods cultivation;
Artificial intelligence;
Knowledge graphs;
Teaching reform
and innovation

ABSTRACT

Live foods cultivation is a core course for the discipline of aquaculture, covering knowledge from multiple discipline such as microbiology, aquatic biology, ecology, and engineering. The traditional teaching model is lacking in addressing the rapid update of knowledge, the abundance of knowledge points, and the increasing individualized learning needs of students. To address these issues, an exploration has been conducted to build a knowledge graph centered on "data-driven, human-machine collaboration, and personalized empowerment" to assist teaching, guided by the main problem of the complex theoretical knowledge existing in the traditional teaching model. This has initiated an innovative approach for AI technology to assist the teaching of live foods cultivation courses, providing a case for AI used in the education of cultivating higher-level agricultural, forestry, and aquatic science. In the future, these knowledge graphs will continue to be evaluated for their effectiveness in real classroom settings by student test scores and feedback surveys.

CONTACT:

[1]Author: shixi_chen@163.com

*Corresponding Author: 281294296@qq.com

Note: Authors designated with "†" are recognised as co-first authors.

DOI.10.64549/jaai-ii.v1i2.119

This work is licensed under the CC BY 4.0 HTTPS://CREATIVECOMMONS.ORG/LICENSES/BY/4.0/

1.Introduction

Aquaculture is one of the fastest-growing foods production sectors globally. As a major component in ensuring global foods security and quality protein for consumption, it has evolved and continues to grow. Live foods are required for the breeding of various economic species of aquatic animals. These live foods are cultivated and grown for feeding the fish larvae and other aquatic animals in the aquaculture facilities. The cultivation of these live foods is a complex process that requires quality feed, efficient system for growth and production, as well as effective management for maximum production. Hence, the course of live foods Cultivation is important for the students studying Aquaculture Science and other related fields of study such as Fisheries Technology. This professional course aims to equip the students with sufficient knowledge and practical skills on the different live foods used for feeding the various aquatic animals, particularly during their breeding stage. Live foods are mainly composed of rotifers, brine shrimp, and copepods. The students also learn how to cultivate and grow these live foods by constructing various systems for their growth and production. They are also expected to learn on how to manage and regulate the environmental factors that affect the growth of these live foods. Nutrition of the live foods, as well as control of pests and diseases that attack these live foods are also part of the topics that are being covered in this professional course. However, most of the concepts in the course are abstract and difficult to understand using traditional teaching methods such as textbook and pictures. New technologies such as Artificial Intelligence or AI are changing fast and affecting most industries today, including education. There are many ways that AI can be used in order to support the learning process of the students. One of the supports that AI can provide is by recommending learning path that is suitable for each learner. Another support that can be provided by AI is by generating intelligent content. There are also simulations that can be provided by using AI. These simulations can be used by the students in order to practice what they have learned. Data mining and analysis of the teaching process is also another support that can be provided by using AI. There are many applications of AI in education. One of the applications of AI in education is the use of knowledge graphs. The knowledge graphs are forms of AI technology that are being used in many fields today. Knowledge graphs are being used in many industries and are being applied in order to solve many complex problems in various fields. Knowledge graphs are also being applied in order to support learning in education. This paper aims to present and explain the application of knowledge graphs in the teaching framework of live foods Cultivation.

2.Analysis of Existing Teaching Problems in Live foods Culture Course

Although many universities have started teaching reforms and have shown great progress, the effectiveness of teaching live foods Culture is still low and there are many big and fundamental problems in teaching this subject. These problems are related to the knowledge framework of this subject. The knowledge framework of live foods Culture is very complex, dynamic and integrated with practice. This subject's knowledge cannot be delivered, students' thinking cannot be guided, and students' skills cannot be developed through the existing teaching models. The following are the main problems of teaching live foods Culture. (1) Complex knowledge framework with interdisciplinary and process-oriented characteristics: Live foods Culture is not only a subject of professional knowledge, but also a complex system with various factors, processes and interactions. The subject matter integrates various discipline including microbiology, aquatic biology, ecology, biochemistry, and environmental engineering. The key concepts and processes include algal classification and photosynthetic products, the logistic growth curve of microalga single-batch cultivation, the effects of nitrogen-phosphorus cycling on eutrophication and the succession of live foods microbial communities. These professional knowledge are not mere static knowledge but a complex, dynamic, non-linear system with various interactions and processes. The existing teaching models mostly adopt a linear approach to deliver knowledge by following

the chapters in textbooks and PowerPoint slides, failing to present the knowledge in a multi-dimensional, dynamic and interactive manner. Students therefore can only learn a series of isolated knowledge, such as memorizing the names of various algae, without establishing a dynamic model to understand their growth interactions with the environmental factors such as light, temperature and nutrients in real time. As a result, the students are unable to establish in-depth systematic understanding and mechanistic knowledge of the subject. Moreover, traditional teaching models cannot fully support students' cognitive construction and knowledge transfer. A core teaching objective is to help students establish well-structured knowledge schemata. Nevertheless, current teaching practices present two major disconnections. First, the disconnection between theory and phenomenon. Complex cultivation mechanisms, including nutrient competition and population effects, lack intuitive dynamic visualization, forcing students to rely on subjective imagination and thereby resulting in cognitive misunderstandings and knowledge gaps. Second, the disconnection between knowledge learning and technical application. Although students master standardized cultivation procedures, they lack in-depth comprehension of the underlying ecological and physiological principles. When confronted with variable production conditions, such as water source replacement and climate anomalies, students fail to flexibly adjust operational strategies, leading to a prominent gap between theoretical learning and practical implementation. The large amounts of information provided in class, the complex and abstract concepts, and the technical procedures for implementation all place a heavy burden on students. The unified teaching pace is not conducive to taking into account the prior knowledge that students bring to class as well as their individual learning styles. This is particularly true for students with a weak microbiology background who may struggle to grasp key aspects of algal metabolism. On the other hand, some students may lack interest in the implementation of parameters and associated procedures. The traditional one-size-fits-all teaching approach does not offer enough scope for differentiated and flexible learning paths. As a result, some students are left behind while others are not given the opportunity for in-depth study. This has a negative impact on the overall effectiveness of teaching live foods Culture. On the other hand, there are gaps in the process of verification-oriented practical teaching, which are critical for connection of theoretical knowledge with practical applications. However, various constraints in terms of facility, time and cost of practical training have led to the isolation of the various formulae for verification through experiments. The typical practice of single inoculation and subsequent counting of algae after cultivation is far from covering the entire scope of the technical procedures for cultivation of microalgae, i.e. activation of the algal seeds, scale-up of the cultivation, control and management of the pollution, and enhancement of the nutritional values, etc. Thus, the various fragmented practical training could not enable the students to gain comprehensive engineering thoughts and skills for systematic management and for the operations on a continuing basis with dynamic changes and optimizations in the aquaculture production. Evaluation methods of conventional teaching of live foods Culture courses primarily focus on memorization and the mere recitation of certain knowledge. In the framework of the curriculum aiming to foster professional talent in aquaculture production, able to continuously operate and optimize production, in reality, however, such systems of evaluation are unable to ascertain whether students possess a systematic causal understanding and higher-order thinking capabilities necessary to analyze given situations, make decisions, and optimize production in complex situations. Such a system of evaluation exerts the baton effect to encourage mere memorization. The problems mentioned above are deep-rooted for the live foods Culture course, as they stem from the contradiction between its complex knowledge structure and the instructional paradigms that are mostly traditional. Overcoming these problems will be possible only through the curriculum reformation of the live foods Culture teaching in terms of its contents, concepts and tools. For this end, it is necessary to establish an innovative teaching support system that can help implement the following functions: displaying students' knowledge frameworks, supporting students' learning in individualized ways, linking up learning with practice,

and linking up evaluation with learning. Knowledge graphs and intelligent technologies in general shall be the methodologies and toolkits that will enable teachers to overcome the numerous and complex problems that teaching Live foods Culture courses present.

3.Construction and Application of Intelligent Knowledge Graphs

The knowledge outline in Fig. 1 for the five core modules of the “curriculum of Live foods Cultivation within discipline of aquaculture” course—Introduction and Basic Concepts, Plant-based live foods—Microalgae, Microalgae Cultivation, Animal-based live foods, and Experimental Skills Training—gives students an overview of the course content and its logical structure and helps them in particular to trace the course from theoretical foundations to practical applications in detail. Incorporating core concepts, key principles, key technical methods and key species attributes of “curriculum of Live foods Cultivation within discipline of aquaculture” into a knowledge graph using AI, allows for dynamic, highly interactive learning using a core set of nodes which are highly interconnected (Figure 3). Students are able to explore the connections between individual concepts rather than memorizing them in isolation. When studying a particular species, for example the brine shrimp, the system will automatically connect them to related nodes such as the characteristics of the species, methods of reproduction, and applications for live foods cultivation (Figure 5). This facilitates the integration of knowledge across chapters, highlighting key and challenging concepts in a point-to-surface approach to build a complete knowledge framework for each chapter and course in turn. Thus, the knowledge outline of the entire course is provided on a macro-level.

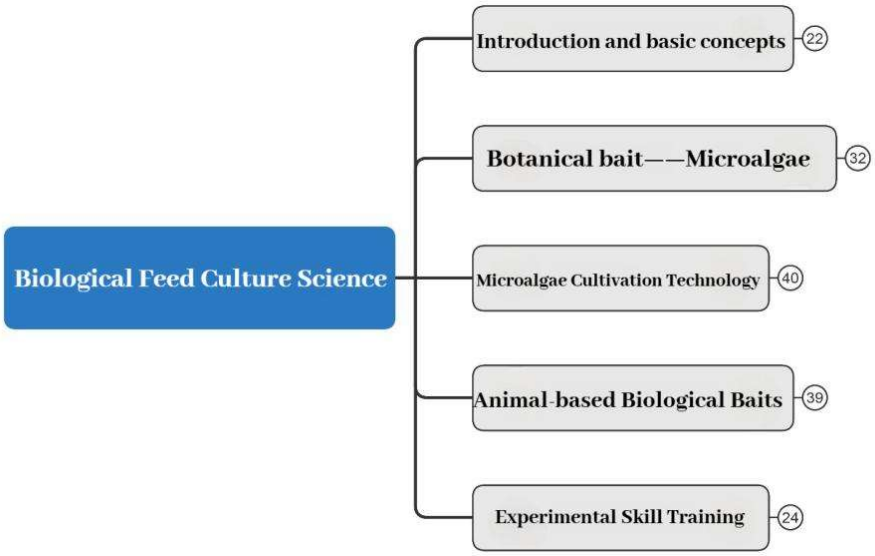


Figure 1 Knowledge graph of the overall course structure (the root node, Biological Feed Culture Science, branches into five core modules, the edges signify a strict "Part-Of" semantic relationship, illustrating that mastery of the entire discipline requires sequential, yet interconnected, coverage of these five foundational pillars.)

Through the introduction and foundational conceptual knowledge map, readers can grasp the core definitional framework of live foods cultivation science, understand the relationships between live foods organisms and live foods, as well as the disciplinary strengths and research scope; clarify the intrinsic connections among fundamental concepts, thereby establishing a solid theoretical foundation for subsequent chapters and addressing the issues of fragmented concepts and weak interconnections prevalent in traditional teaching approaches (Figure 2).

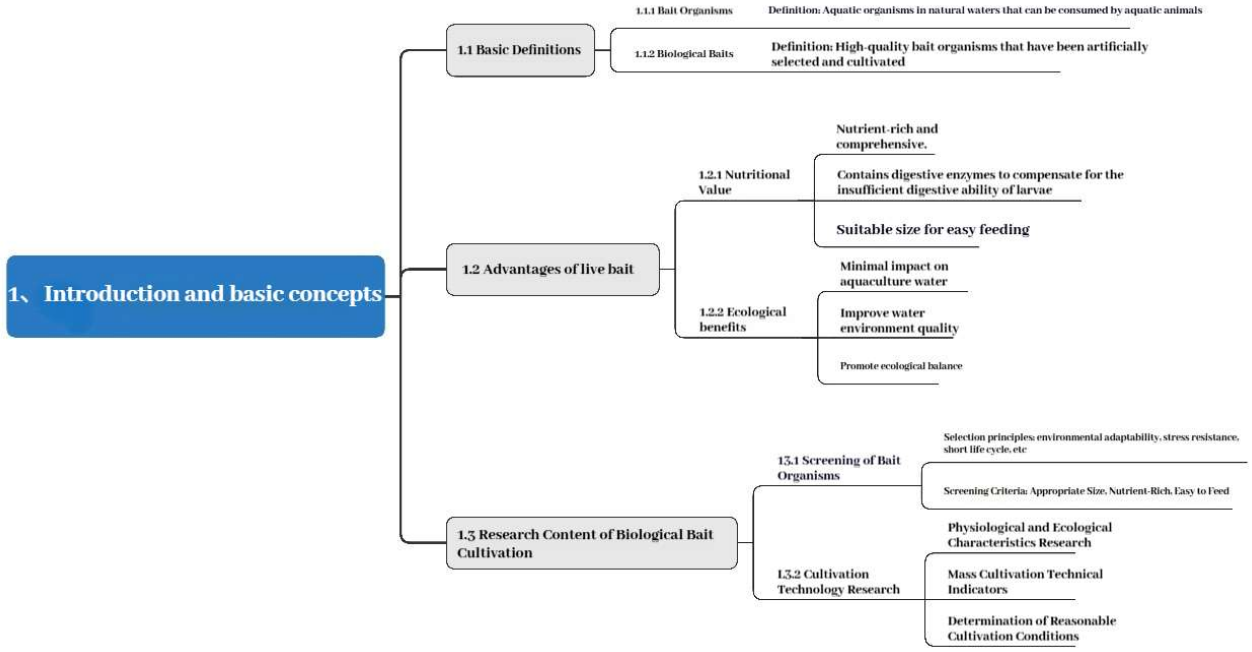
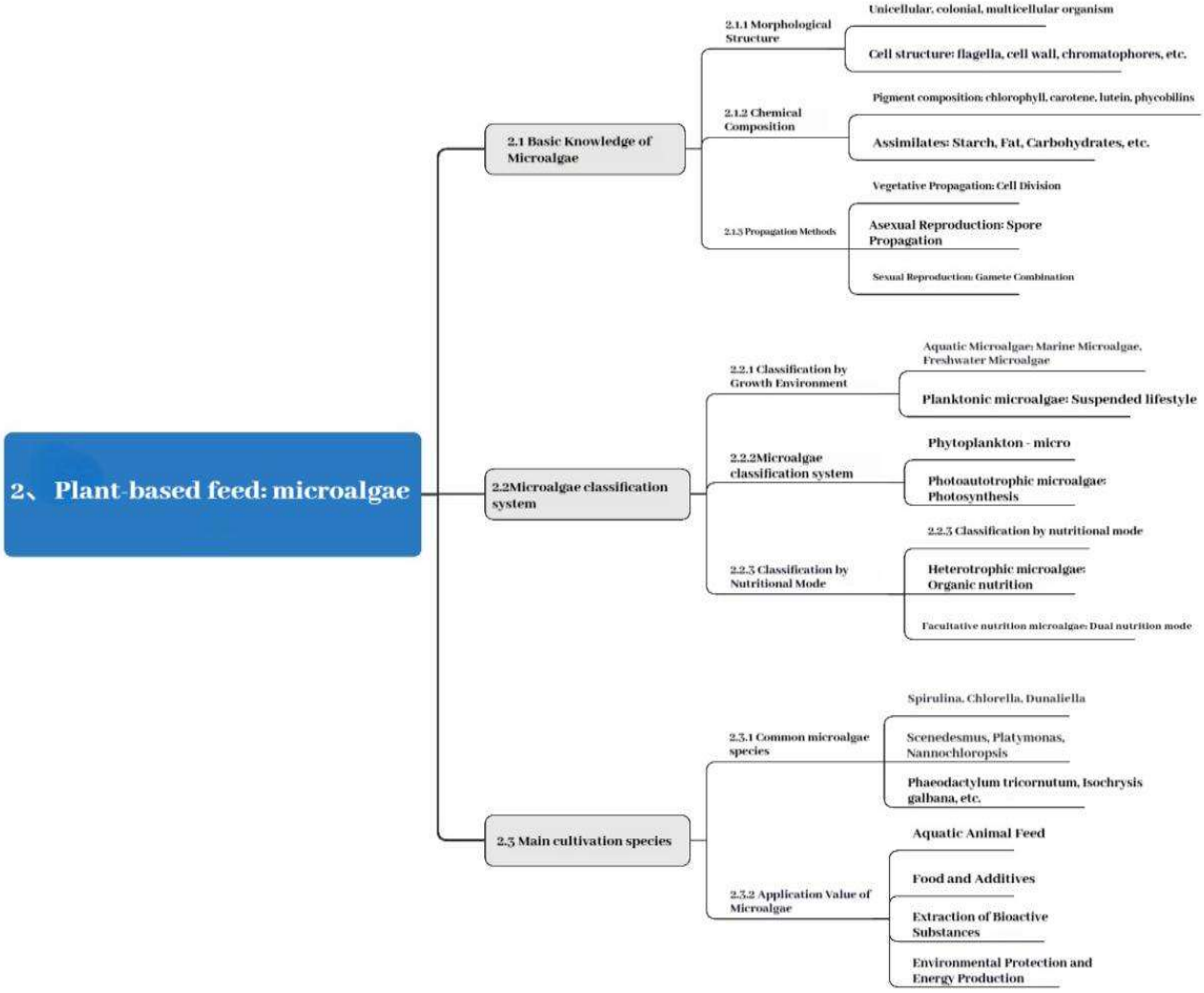


Figure 2 Knowledge graph of the introduction and basic concepts (the directed edges follow a "Concept → Attribute → Sub-attribute" branching logic, enabling students to trace specific practical advantages back to core definitions and overarching research scopes.)

The knowledge graph on plant-based live foods enables students to gain a clear understanding of microalgae as the core component of plant-based live foods—including their morphological structure, chemical composition, reproductive methods—along with their classification system and application value. It highlights the central role and research dimensions of microalgae in aquaculture live foods systems, overcoming the fragmented teaching approach commonly seen in traditional instruction and establishing a systematic framework for plant-based live foods knowledge (Figure 3).

Figure 3 Knowledge graph of plant-based live foods (The data structure employs a "Cellular Data → Taxonomic Data → Application Data" flow, explicitly mapping specific algal species (e.g., Spirulina, Chlorella) to their industrial uses in feed, foods additives, and environmental protection, thus bridging biological theory with industrial utility.)



The knowledge graph of algae cultivation clearly outlines the methods, steps, growth characteristics and influencing factors of microalgae farming (Figure 4).

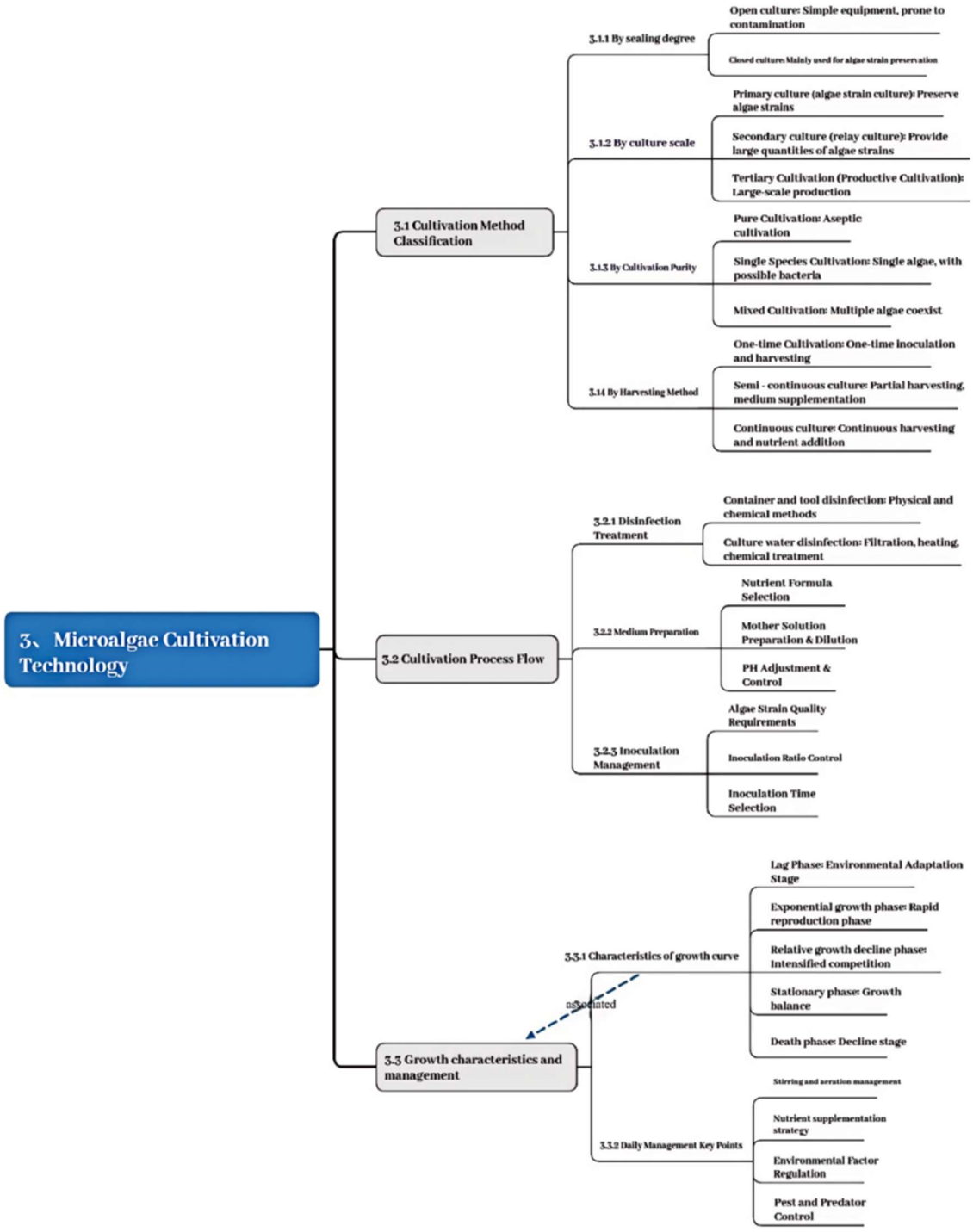


Figure 4 Knowledge graph of algae cultivation (the graph establishes bidirectional cause-and-effect edges between these growth phases and external environmental controls)

The knowledge graph on animal-based live foods provides a clear overview of the research and cultivation systems for three major categories: rotifers, crustaceans, and brine shrimp. It covers species types, reproductive characteristics, key cultivation, and practical applications, clarifies the cultivation patterns and application differences among these live foods types, and establishes a systematic knowledge network for animal-based live foods, addressing the shortcomings of traditional teaching methods characterized by fragmented species knowledge and weak connections between cultivation (Figure 5).

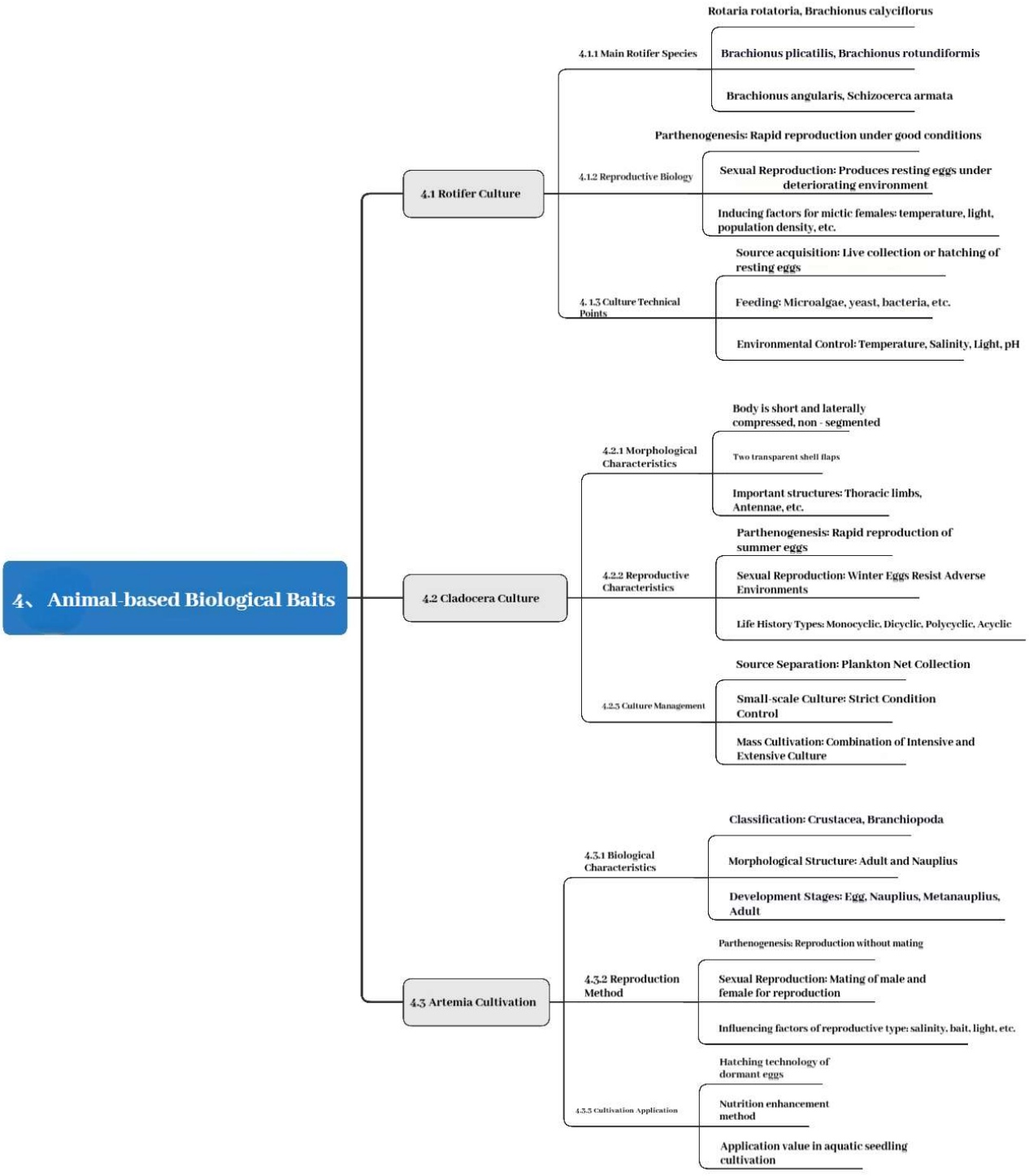


Figure 5 Knowledge graph of animal-based live foods (the graph explicitly connects the "Microalgae Cultivation

Quality" (from Figure 4) to the "Nutrition Enhancement" of Artemia, demonstrating that the nutritional value of the animal bait is directly contingent on the quality of the plant-based feed.)

Through the knowledge graph of experimental skills training, students can master the technical principles, operational procedures, and evaluation systems of the three core experimental modules in live foods cultivation (single-cell algal isolation, cultivation, and zooplankton culture optimization). They will acquire a comprehensive practical framework spanning from experimental design to result analysis, deeply integrating theoretical knowledge with hands-on experimentation. This approach addresses the issues of ambiguous workflows and disconnect between theory and practice prevalent in traditional experimental teaching, thereby enhancing students' practical innovation capabilities (Figure 6).

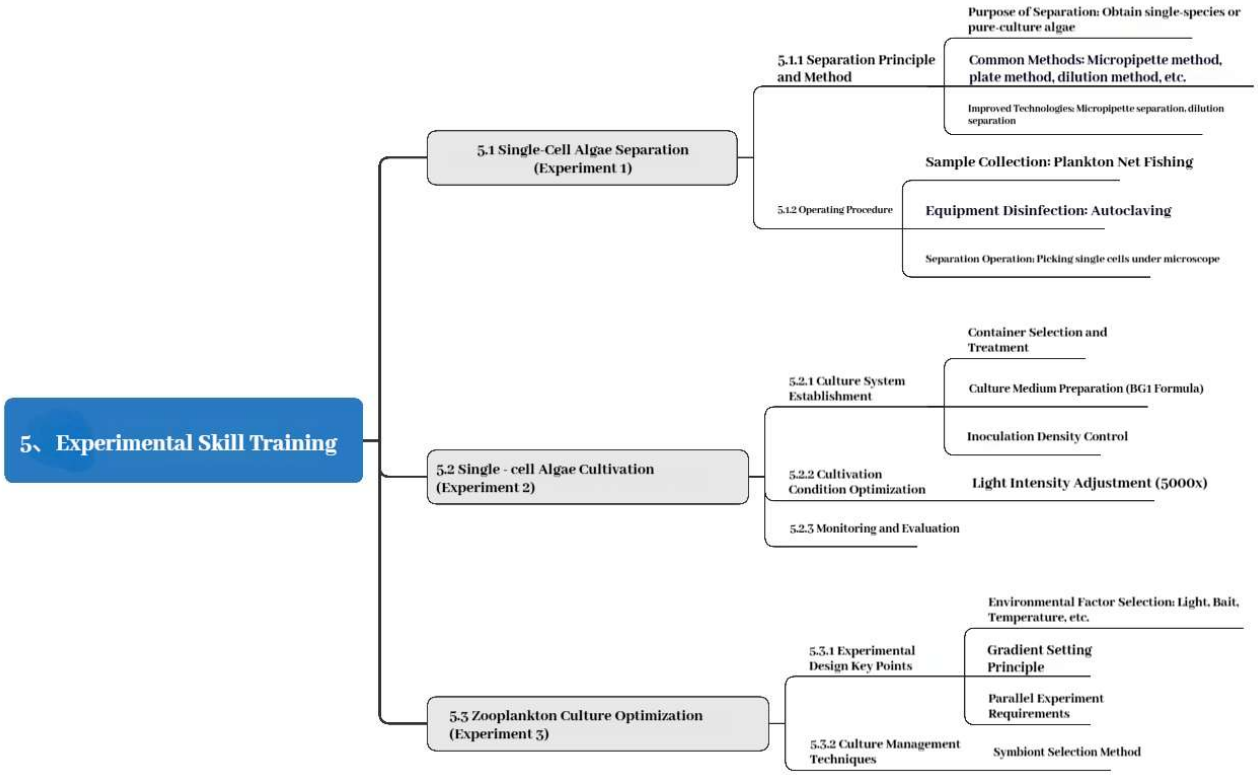


Figure 6 Knowledge graph of live foods cultivation experimental skills training (the graph represent action-oriented procedural workflows (e.g., Sample Collection → Equipment Disinfection → Microscopic Separation). This data structure explicitly integrates theoretical principles with operational steps, ensuring students grasp the sequential dependencies and engineering thinking required for practical applications.)

The five major modules of the course are interrelated and follow a sequence of “theoretical foundation—species research—technical adaptation—practical validation” (introduction and definitions of basic terms / screening criteria for plant-based live foods sources — characteristics of selected species — design of cultivation / choice of cultivation methods / environmental variable control / processing steps optimization — cultivation quality and its impact on the cultivation of other animal-based live foods components as well as their enrichment effects — experimental practices / practical feedback — microalgae cultivation technical details improvement). The characteristics of microalgae as potential live foods sources for animals determine the design of cultivation, the choice of cultivation methods and the control of variable environmental parameters as well

as the optimization of processing steps. As the primary foods source for animal-based live foods, the cultivation quality of microalgae is closely related to the growth and reproduction of other animal-based live foods components such as rotifers, copepods and brine shrimp as well as to their nutritional enrichment effects. Together they form a complete supply system for live foods. The theoretical frameworks thus directly determine the experimental practices, while the practical feedback successively refines the technical details of the cultivation of microalgae, thus completing a closed loop. This loop allows students to acquire a systematic and complete knowledge framework in the course of study.

4.Summary

With higher education evolving with the deep integration of AI, “curriculum of live foods Cultivation within discipline of aquaculture”, as a unique specialized subject, will find increasing applications of AI in the future. As large language models and embodied intelligence continue to advance, their integration into this subject education will become deeper and more seamless.

At the present stage, this study has merely finished the theoretical construction of a knowledge graph-based teaching framework customized for the course "Live Foods Cultivation", without carrying out offline comparative experiments or obtaining empirical data to verify the practical value of the teaching method. To tackle these limitations, future research will enhance empirical investigations. Aquaculture majors will be divided into an experimental group and a control group, which will respectively receive intelligent knowledge graph-based teaching and traditional offline teaching. After the teaching cycle is completed, multi-dimensional evaluations will be carried out. The unit test results, final assessment scores and practical project achievements of the two groups will be compared to analyze the influence of intelligent teaching on students' theoretical comprehension and practical skills. Questionnaires and interview outlines will be designed to collect students' feedback and teachers' evaluations on teaching adaptability and tool usability. Finally, integrated data analysis will be conducted to identify the advantages and disadvantages of the teaching framework, so as to iteratively optimize the knowledge graph structure and teaching process. This will further improve the intelligent teaching system and provide data-driven support and practical references for the digital education reform of aquaculture-related courses.

Acknowledgments

Thank all the authors for their efforts, and support of the Neijiang Normal University.

Funding

This research was funded by the Education Reform Project of NEIJIANG NORMAL UNIVERSITY (grant number JG202523 to Shixi Chen; grant number JG202526 to Li Ao.)

References

Conroy, C.A. and Walker, N.J., 2000. *An examination of integration of academic and vocational subject matter in the aquaculture classroom*. *Journal of agricultural education*, *41(2)*, pp.54-64.

Halfhide, T., 2014. Algae: *Opportunities for biomass feedstock production, wastewater treatment and educational outreach*. University of South Florida.

Kagali, R.N., Ogello, E.O., Kiama, C.W., Kim, H.J., Wullur, S., Sakakura, Y. and Hagiwara, A., 2022. *Culturing live foods for fish larviculture using non-microalgal diet: The role of waste-generated bacteria and selected commercial probiotics—A review. Aquaculture, Fish and Fisheries, 2(2)*, pp.71-81.

Conceição, L.E.C., Yúfera, M., Makridis, P., Morais, S. and Dinis, M.T., 2010. *Live feeds for early stages of fish rearing*. *Aquaculture Research*, *41*, pp.613-640.

Gong, R. and Li, X., 2025. *The application progress and research trends of knowledge graphs and large language models in agriculture*. *Computers and electronics in agriculture*, *235*, pp.110396.

Qu, K., Li, K. C., Wong, B. T. M., Wu, M. M. F., and Liu, M., 2024. *A Survey of Knowledge Graph Approaches and Applications in Education*. *Electronics*, *13(13)*, pp.2537.