The Process of Constructing the Concept Map of Autonomous Learning Mapping in the Permanent Exhibition Area of the National Taiwan Science Education Center in Taiwan

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ABSTRACT

In order to strengthen the effectiveness of the permanent exhibition area of the National Science Education Center (NTSEC) in science education and guide learners to learn independently, this study is based on the construction of scientific concept maps, and the construction of autonomous learning maps for the three permanent exhibits and understand its application. It can not only enrich teachers' teaching, but also serve as a guide for autonomous learners, improve their understanding of scientific concepts, and master the learning status of personal scientific concepts, as an important resource for autonomous learning in the field of science. This research consists of three teams of editors, reviewers and working groups to complete the scientific concept map of each educational stage (G1 to G9), and develop the learning routes, learning sheets and assessment based on the contents of these exhibits and concept maps., and build it into an autonomous learning map. To grasps the learners' ideas, experience activities are planned, including 420 people's actual experience and feedback. Through the feedback survey, it can be found that students can learn scientific concepts under the guidance of the learning map. The relevant research results will be provided to NTSEC staffs, self-study groups and teachers in primary and secondary schools.

CCS CONCEPTS

• **Applied computing** → Education; Learning management systems.

KEYWORDS

Autonomous Learning Mapping, Concept Map, Self-directed learning sheet

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1 INTRODUCTION

With the rapid development of the knowledge economy and society, expanding the field of lifelong learning and multiple education, and establishing a learning network inside and outside the school has become a major goal of education. There is also a common sense in museums that the function of "education" is more important than other function such as exhibitions, research, or collection [1].

However, according to the studies of Chang and Chen [2], they found that teachers actually use the National Taiwan Science Education Center (NTSEC) for educational activities or related resources, most teachers agree that teachers can use the resources of the science and education center to develop their curriculum. But they do not use it much because they think they are not familiar with these resources and have not participated in the training related to the science and education center. It is also believed that the resources or activities of NTSEC cannot be sometimes matched with the school curriculum, so the motivation for using it is often to cooperate with off-campus teaching or when some themes can be matched with the school curriculum, and tend to be guided by interpreters. Therefore, it is expected that through the cooperation, teachers can be more capable and willing to take the initiative to lead students to study in the science and education center, and effectively enhance the significance of both sides in science education.

In order to improve the effectiveness of science learning for teachers, students and members visiting the NTSEC, this study uses the construction of scientific concept maps as a reference to assist primary and junior high school teachers in properly planning meaningful science and education learning activities. First, we build a scientific concept map in the three exhibition areas of "Mysteries of the Human Body", "Exploring the Physical World" and "Exploring the Chemical World"; then analyzes the curriculum guidelines and textbooks in the natural science field as the connection of students' scientific literacy at different educational levels. connect it with

the existing permanent exhibits and stratify them according to the difficulty of different grades; and then connect the exhibits according to the logical sequence of concept development to form a learning map of different routes. Finally, related learning sheets and assessment questions are developed as a test of self-directed learning.

On the whole, by systematically integrating and classifying scientific concepts in the permanent exhibits of the Science and Education Center, it can not only enrich teachers' teaching, but also serve as a guide for autonomous learners to improve their understanding of scientific concepts. Through the learning sheets and assessment questions designed by NTSEC, we can grasp the learning status of personal scientific concepts. The visiting process will no longer be just whether you have visited the exhibits or not, but the process of understanding the meaning of scientific concept. In addition, when constructing a concept map, we can also understand which scientific concepts covered by the exhibits can be used as a reference for extended learning. If it is not linked to the content of textbooks or other exhibits, it can be used as a reference for future adjustments. According to the research background, the research goals as follows:

- (1) Rearrange the conceptual knowledge conveyed in the permanent exhibitions of biology, physics and chemistry of NTSEC, and form a systematic knowledge context through concept maps, and form a learning route in series.
- (2) Develop the learning sheets of permanent exhibition content to assist the study, and organize the exhibits that can be used as extended study to form an aid for subsequent study, and strengthen the educational significance of NTSEC.
- (3) Design assessment questions with concept maps of various fields and related learning bigideas, as a reference for students' learning achievement assessment, and as the direction for setting a long-term learning platform, and designed as a learning map.
- (4) Invite primary and junior high school students to experience and give feedback as a reference for revision.

2 LITERATURE REVIEW: BASIC RELATIONSHIP OF LEARNING, CONCEPT FORMATION AND CONCEPT MAPPING

In the 1960s, with the rise of cognitive development theory, Piaget proposed that learners will actively construct knowledge and develop a set of personal models for adapting to the environment, which are then used to learn and interpret new stimuli and experiences [3]. Concept is an important unit of cognition. It is established through induction and sorting through cognitive processes. It is also a construction of a logical relationship to express or represent certain meanings, and is connected through abstract forms. In addition, concepts are also related to naming, defining, and language using, so the output of concepts has its importance in the knowledge system.

From the analysis of cognitive development, individuals combine, classify and integrate their own experience with the knowledge they have come into contact with in the process of cognitive learning to form an important concept, and in the continuous expansion and learning of knowledge, form their own knowledge systems, which are particularly important for the construction of scientific concepts and knowledge.

In order for students to build their own cognitive structure, meaningful and in-depth learning is necessary. In-depth learning can guide students to seek meaning, find relationships between concepts, and integrate newly learned knowledge into their own knowledge structure and experience. middle. Through deep learning, students' learning outcomes are better preserved and learn how to apply knowledge [4]. Among them, American scholars Novak and Gowin put forward the concept of concept mapping [5], in which learners can carry out hierarchical classification in the learning of concepts, and connect and name the relationship between two concepts, among which the most important or most general concepts are placed on the top of the map, while the less generalized concepts are placed on the bottom. There are parallel hierarchical relationships between concepts, so that there are up-down and left-right relationships between the concept maps, forming a meaningful network structure. This structure can help students to constantly clarify their personal thoughts under the discussion between teachers and students, and can also promote their metacognitive thinking, which can be effectively used in teaching and evaluation [6].

For the teaching of science, concept map is a very important teaching design and teaching strategy. It connects concepts with appropriate and meaningful words in the form of propositions to form a framework that is conducive to learning, including organizing a teaching activity or a teaching plan for a unit, including not only teaching design content, but also teaching. The content of the activity and related teaching experiments also found that the students' high-level thinking ability and affection attitude were improved [7]. It is used in the construction of scientific concepts in NTSEC. The permanent exhibitions on the 3rd to 5th floors include three exhibition areas: life science, physics, and chemistry. The exhibits have many different design concepts and display goals. The same theme concept can be extended to many different activities. Concepts and sub-activity concepts are even connected across different fields of knowledge, so the scientific concept maps constructed by the same theme concepts are not the same. Taking the exhibition area "Mysteries of the Human Body" on the 3rd floor of the permanent exhibition in NTSEC as an example, each exhibit introduced by different systems of the human body can be classified into themes and fields, and the difficulty of learning can be analyzed to construct a framework for contextual teaching and learning.

Based on the construction of scientific concept maps, the learning routes and learning maps are developed, and then through the examination of learning sheets and assessment questions, it helps visitors to deepen scientific concepts and improve their learning experience in NTSEC. The scientific concept map enables NTSEC's staffs to unify and understand concepts, and also allows the audience to clearly understand the hierarchical relationship and connection of concepts. When planning theme tours and event design, NTSEC's staffs can generate new horizontal lines through the cross-connection of scientific concept maps. Thinking is an important part of generating new knowledge. Combined with extended reading, the concept can be extended to digital resources such as a

series of themed videos in NTSEC, science exhibitions' prize papers, monthly scientific magazines, etc., to construct your own scientific concepts.

In terms of future long-term development, learners' self-learning process is helpful for personalized learning results, cross-domain learning and customized service recommendations. In the future, with the membership system, members can record their personal learning process and can customize the areas of knowledge content you are interested in, and conduct diversified learning. The system can also collect the relevant behavior records of individual participation in exhibition activities, digital learning or browsing on the service integration system to establish a more complete social education service system.

3 RESEARCH METHOD

According to the overall structure of the "Construction and Application of Autonomous Learning Maps in the Permanent Exhibition Area" of NTSEC, the description is as follows [8]:

3.1 Concepts and principles of scientific knowledge

The texts of all the exhibits in the three areas of the permanent exhibition on the 3F "Mysteries of the Human Body" in life sciences and "Exploring the Physical World" and "Exploring the World of Chemistry" in the 5F permanent exhibitions of physics are organized, linking the existing curriculum syllabus and textbooks in the field of nature. The content of each exhibit is suitable for the learning content of the lower grade of elementary school, the middle grade of elementary school, the upper grade of elementary school and the junior high school, or it can be used as a

3.2 Concept map

Based on the scientific knowledge contained in the copywriting of the exhibits in the three districts, a concept map is drawn and linked with the current scientific concepts of primary and junior high school students to construct a scientific concept map centered on the permanent exhibits of NTSEC.

3.3 Recommended study route

According to the fields of life sciences, physics, chemistry, etc., four recommended study routes have been developed (G1 to G2, G3 to G4, G5 to G6, and G7 to G9). There will be links between exhibits and extended learning exhibits. 12 recommended study routes are included totally. The experience time of each route is mainly less than 1 hour, according to the needs of the experiencer, the recommended learning routes of different hours can also be combined.

3.4 The autonomous learning map

According to the learning routes of the four learning levels (G1 to G2, G3 to G4, G5 to G6, and G7 to G9), four autonomous learning maps are drawn, exhibit projects or cross-linking routes across disciplines.

3.5 Science learning route learning sheet

According to the scientific concepts contained in the copy of the exhibits provided in this case, open-ended problem study sheets covering different fields or cross-fields such as life sciences, chemistry and physics are designed to be used in conjunction with the learning route, as a student or as a visitor Records of people's learning journey.

3.6 Science concept assessment questions

After analyzing the contents of the exhibits in the permanent exhibition area, write assessment questions for four different learning levels (G1 to G2, G3 to G4, G5 to G6, and G7 to G9), and each exhibit can be evaluated according to its content, which is a reference for the follow-up inspection of the self-learning effect of those who visit the permanent exhibition area.

3.7 Collection of feedback data from experiencers

After the learning route and learning map are established, primary and junior high school students are invited to experience and provide feedback. After obtaining their consent, use questionnaires and other methods to collect the experiencers' opinions on the recommended learning route and learning map, and the scientific route learning sheet, and make subsequent corrections accordingly.

3.8 Extended learning exhibits

After explaining the reasons or basis for the exhibits not included in the recommended learning route, select exhibits that can be used as extended learning, and link relevant future activities, lectures and courses in the museum.

3.9 Publish or share the construction process

After completing the entire project construction project of this case and collecting feedback from experiencers, write an article about the construction process of this case, and publish it in the scientific research monthly journal or scientific education forum, exchange or sharing session.

4 RESEARCH PROCESS

(1) Composition of the research team: Three teams are invited, including 15 editorial team members composed of scholars, experts and on-site senior teachers, 6 internal reviewers and 4staffs. a total of 12 editorial meetings and 4 review meetings will be held.

(2) Conceptual analysis and concept mapping

- a. Analyze the guidelines and textbooks in the field of natural sciences as the mastery and connection of students' scientific literacy at different educational levels.
- b. Develop a scientific concept map of the permanent exhibition.
- c. According to the logical sequence of concept development, various exhibits are connected, and 16 learning routes suitable for students at different educational levels are developed
- d. A total of 16 problem-oriented open-ended learning sheets are developed to guide students to think at a higher level in accordance with different learning routes.

Table 1: The relationship of scientific knowledge in the Permanent Exhibition area of NTSEC and curriculum guidelines (as the example of life science)

Elementary School	Junior High School
Grade 1 and 2 A-I-1 Understanding of life growth Grade 3 and 4 INb-II-4 The structure and function of the organisms are coordinated with each other. INd-II-3 Organisms have a certain lifespan from birth and growth to death. Organisms reproduce the next generation through reproduction. Grade 5 and 6 INb-III-5 Organisms are composed of cells, and can be formed in different levels of organization from cell, to organ, to individual.	Grade 7, 8, and 9 Structure and function of cells (Da) Da-IV-2 A cell is the basic unit of all organisms. Da-IV-3 Multicellular organisms have levels of organization including cells, tissues, organs, and organ systems. Structure and function of plants and animals (Db) Db-IV-1 Animals (in the case of humans) obtain required nutrients through ingesting, digestion, and absorption. Db-IV-2 The circulatory system of animals (in the case of humans) transports substances to various cells in the body and exchanges' substances. Understanding the operation of the circulatory system through examining heartbeats, heart sounds, and pulse. Db-IV-3 Animals (in the case of humans) exchange gas through the respiratory system. Db-IV-4 The reproductive system (in the case of humans) produces gametes for sexual reproduction. It has the function of secreting hormones. Homeostasis and regulation of living organisms (Dc) Dc-IV-1 The nervous system of the human body can detect and react to changes in the environment. Dc-IV-2 The endocrine system regulates metabolism and maintains homeostasis.

- e. Develop study sheets for each subject and cross-field for each group, and submit it to the overall design of the art group.
- f. Write the explanatory form and the number of extended learning exhibits that are not included in the learning route/map.
- g. Design assessment questions for various subjects.
- h. Organize the experience event and collect their experience
- i. Analyze assessment results and their feedback
- j. Adjust the learning map suggested to be revised.

5 RESULTS

5.1 The analysis of guidelines in the field of science and the knowledge of scientific concepts in the permanent exhibition

In order to understand the relationship between the scientific knowledge concepts covered by the exhibits in the three permanent exhibition areas and the school nature or related fields, the research team first analyzed the content of the 12-year national basic education curriculum guidelines (referred to as the 108 syllabus) of the natural science and life field syllabus. It is used as the basis for subsequent planning and distinguishing students' elementary, middle, and upper grades and junior high school education levels (or called the first to fourth learning levels).

Among them, the life science exhibition area covers the Grade 1 and 2 students in life field and the learning content for Grade 3 to 9 students in natural science field (see Table 1), and the corresponding life field of the lower elementary school is A-I-1 In the understanding of the phenomenon of life growth, for Grade 3 to 6 students include the structure of organisms, and for Grade 7 to 9 students is further divided into the structure and function of cells, the structure and function of animals and plants, and the constancy and regulation in organisms. Through the above analysis, it can be used as a basis for mastering the students' prior knowledge when formulating learning routes and learning maps.

5.2 Construction of scientific concept map

In the first and second educational levels of nearly three months of discussion and revision, completed four learning levels of physics, chemistry, and life sciences, a total of 12 scientific concept maps. Among them, the higher the learning stage, the denser the concept map (see Figure 1). In addition, in conjunction with cross-disciplinary design, there are also plans for Grade 1 to 4 students in physics and life sciences "sound and hearing", Grade 5 and 6 students in chemistry and life sciences "digestive system", and Grade 7 to 9 students in physics and chemistry "nanometer". Four cross-disciplinary scientific concept maps, including "carbon family" and "three primary colors of light" for Grade 7 to 9 students in physic, chemistry, and life sciences, are used as a collection of scientific concepts contained in the permanent exhibition of NTSEC.

5.3 Construction of autonomous learning map

After nine months of discussions and revisions in the last three educational levels, 12 study routes, 12 learning sheets (see Figure 2) and 12 autonomous learning maps (see Figure 3) were completed. There are 4 cross-field study routes, study sheets, study maps, etc. for reference.

In order to provide learners with self-assessment, a total of 550 assessment questions are designed according to different levels

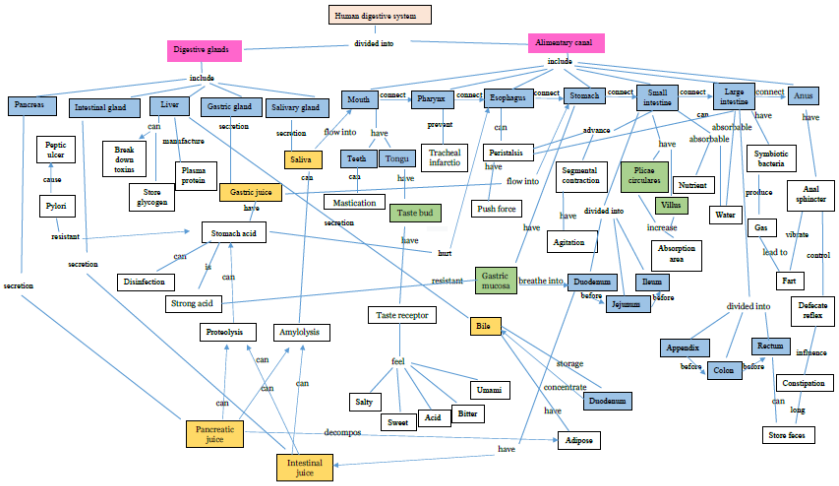

Figure 1: Concept map for Grade 5 and 6 in life science

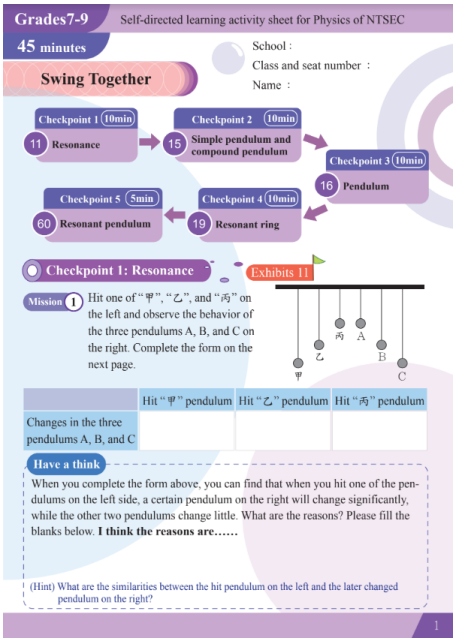

Figure 2: Learning sheet for Grade 7, 8, and 9 students in physics

of difficulty, recommendation, educational levels, and subjects, including 220 questions in physics, 180 questions in life science, 150 questions in chemistry for elementary and middle school students. The assessment questions are marked with phonetic symbols (same for the study sheet and feedback form), which is convenient for students to read.

5.4 Experience activities

In order to get more detailed feedback and suggestions for the planning of the autonomous learning map, a total of 537 students from 12 elementary and high schools in Taipei, New Taipei City, Taoyuan City and Taichung City, as well as self-study groups, were invited to participate in the experience, including accompanying visits. A total of 35 teachers and parents participated, assisting in the experience of the learning map and assisting in filling out the study sheet (see Figure 4), feedback form and assessment questions, etc. The other accompanying teachers and parents also assisted in filling out the feedback form to understand their thoughts. Experienced students and teachers have provided many valuable comments for the research team.

Comments on the overall student feedback form can be found, most students felt that the guidance of the learning sheets and learning maps can help them learn more systematically and think deeply, and the assessment questions can also check their learning results. In addition, 20 accompanying parents from the parents of the self-study group, 15 leading teachers also gave the feedback. Through the guidance of the learning sheet, they found the students can pay more attention to the learning of the relevant key concepts in the exhibition board, and they can also master their own learning through the assessment. It is more helpful for the systematic study of its scientific concepts than before.

6 CONCLUSIONS

Build the conceptual knowledge in the permanent exhibitions of life science/biology, physics and chemistry in NTSEC through the scientific concept map, and combine the connotation analysis of the curriculum guidelines to confirm the students' educational level, which can form a systematic knowledge context.

The autonomous learning map system is formulated through the cooperation of the research team, combined with the design of recommended learning routes, learning sheets, and assessment questions, which can be used as an aid for students' autonomous

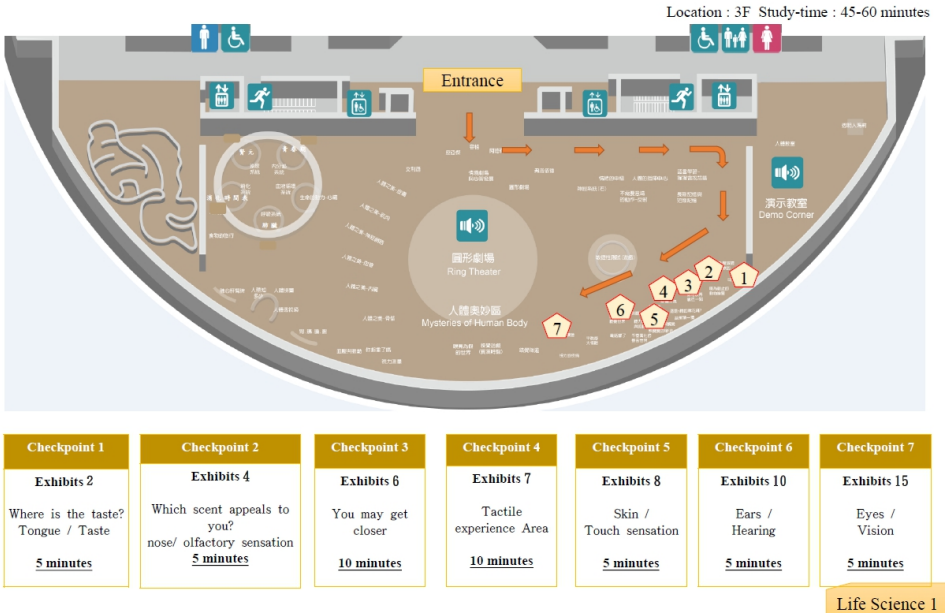

Figure 3: Autonomous Learning map for Grade 1 and 2 in life sciences

Figure 4: Students study earnestly by referring to the study sheet guide during the experience activity

learning and strengthen the educational significance of the science and education museum/center.

After inviting primary and secondary school students to experience and give feedback, the feedback form filled out by students mostly affirms the planning of the overall learning map. Most students are very engaged in learning during the process, and they also make good use of the guidance of the study sheet to think about problems, and the final assessment question. It can help them check the learning effect. In addition, the students also put forward some corrections in the feedback as a reference for subsequent corrections.

7 RECOMMENDATIONS

The autonomous learning map can be displayed digitally, and the public can view the map of each district on the interactive digital platform. As for the people who have completed the route and want to self-check their learning status after the experience, they can click on the interactive digital platform to log in as a member and then click on the route they have experienced, take the assessment test, and get immediate feedback.

In the future, a combination of learning routes and IoT (Internet of Things) game machines can also be held to allow visitors to learn through games. In terms of evaluation, it can be matched with the theme and destiny level of the IoT game, and evaluation questions of different difficulty can be also placed in the game. Through the correctness of the answers, the public can be recommended to visit the learning route of the permanent exhibition.

As for the development of the concept map, it can be revised when the exhibits in the permanent exhibition are adjusted or added or deleted, so as to serve as a reference for the scientific concepts contained in the permanent exhibition area in the related research in future.

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