Developing an Integrated Teaching Module for the Topic of Smart Industry in the Museum

Jian-Liang Lin*, Fang-Yi Su, Chieh-Ya Lin, and Kuo-Hung Hsiao

***Abstract*—The teaching of innovative technology in primary education in Taiwan is not enough at present. The National Science and Technology Museum cooperated with the university and the vocational high school to deliver the smart industry knowledge to senior high school students. Here, this research presented a 5-step design procedure to systematically develop an integrated teaching module for various issues. It is a demonstration example that the research generated an integrated teaching module for the smart industry's issues by the design procedure. The knowledge database of module content was built and applied multiple teaching ways to enhance students' attention. The module developed an e-book, one augmented reality (AR) game, one board game, and one package of teaching aids for maker education to introduce the historical developments of industrial revolutions, the internet of things, the smart vehicles, and the industrial robots. Furthermore, the learning outcome and the generic learning outcomes (GLOs) are the evaluation index and the evaluation method, respectively. By the framework of the GLOs, the questionnaire with a 5-level Likert scaling was designed for evaluating the module. By the experiment of demonstration teaching, the statistical analysis revealed that either students from the engineering or non-engineering departments have positive learning outcomes. A slight difference is in the category of "Activity, Behavior, and Progression". The research inferred that the culture of the tested school and the students' background could affect the learning outcomes. The result indicated that the integrated module is useful to science popularization learning of technological issues.**

***Index Terms*—Integrated teaching module, smart industry, generic learning outcomes, museum education**

I. Introduction

"Smart industry" or "Industry 4.0" is regarded as the fourth industrial revolution that is the breakthroughs in the historical developments of science and technology. Several important issues are developed in Industry 4.0, including the smart manufacturing, the Internet of Things (IoT), the artificial intelligence (AI), the big data analytics, and the smart vehicle/transportation. These technological applications are closely related to the life of the public. People should be familiar to the information and the skills of smart industry for their future life. However, the content and the technical terms of the advanced technologies in smart industry are too professional to easily understand for the public though the traditional teaching activity. The unreadable content of smart industry is an obstacle for delivering information of science and technology. And, at present, the teaching issues of smart industry are not sufficient in the basic education of high schools, junior high schools, and elementary schools.

The process of science popularization and the museum education are resolutions to these problems. Here, this paper develops an integrated teaching module based on the design process of integrated learning to contribute to promote technology education for the public. The resulting teaching activities in the museum are regarded as the off-campus teaching to advance the skills and abilities of learners. Then, the paper analyzes the learning outcomes of the integrated teaching module and activities by an evaluation questionnaire designed based on the framework of generic learning outcome. Finally, it is expected that the learners can explore their potential and personal characteristics for choosing their future department of university through the off-campus teaching.

II. Literature Survey

This paper would like to design an integrated teaching module and evaluate the learning outcomes based on the frame of generic learning outcomes (GLOs) for the topic of smart industry. Hence, the following literature survey introduced these three aspects: integrated curriculum, learning outcomes, and GLOs.

A. Research of Integrated Curriculum

An integrated curriculum is to connect different research area in a teaching. The integrated learning encouraged the students to positively engage in the resulting activities that were related to their living. The knowledge learned in the classroom should connect with the practical experiences. Moreover, to cultivate the students' ability by repeatedly skills or implement was the benefit of integrated learning to create a higher effective teaching [1].

In the past years, the educational concept of integrated learning was regarded as the effective way. In 1989, Jacob *et al*. [2]described several a great number options of integration curriculum including existing teaching subjects, fusion of curriculum focus, and residential study about daily living. Also, the design approach for an integrated curriculum was presented and introduced step by step. In 1995, Beane presented that curriculum integration is a way to think about what learning are for, about the sources of curriculum, and about the application of knowledge [3]. In the overview by Wall and Leckie in 2017, the integration curriculum was connected to "This We Believe", which encouraged all participants including teachers and students to generate a positive, purposeful and meaningful learning. The curriculum design should be a tenet of middle level education. And there was not a certain model or a fixed method for

Manuscript received September 12, 2022; revised November 1, 2022; accepted December 12, 2022.

The authors are with National Science and Technology Museum, Taiwan.
*Correspondence: jllin927@mail.nstm.gov.tw (J.L.L.)

doi: 10.18178/ijiet.2023.13.5.1871

integration curriculum. The teachers could integrate curriculum by different ways based on various sources, and they could discuss with students to define the content of curriculum across the boundaries of research [4]. The course design using integrated teaching module was more interesting and effective than the conventional course by the experimental teaching to under graduate medical students [5].

In 2016, Yadav *et al*. applied integrated teaching-learning sessions for medical undergraduates in India to face multiple fields [6]. Through the comparison between the students taught by the traditional method and the ones exposed to the integrated teaching-learning sessions, the students of the integrated group have higher mean scores. Students and faculties highly accept the integrated teaching-learning method. In 2018, Drake and Reid presented that integrated curriculum should be regarded as an effective means to cultivate 21st century capabilities for students [7]. The Know, Do, Be (KDB) framework were applied for designing integrated curriculum. Although curriculum integration was a challenge, it is a possible resolution to the growing need to address the competencies. In 2021, Duggan *et al*. presented a series of integrated teaching modules for middle school (Gr 7–9) students in two rural, underprivileged schools in South Africa's southern Cape coastal region [8]. The module formed by the integrated curriculum design included practical exercises and incorporated data from the surrounding environment. The research revealed that the integrated teaching module made the students have greater capacities and be adaptive to their surroundings.

According to the above literature survey, it is opinioned that the educational concept of curriculum integration is appropriate for designing the teaching module about the topic of smart industry.

B. Research of Learning Outcomes

The available definitions of learning outcomes are diverse. Based on the viewpoints of investigators, the learning outcomes corresponded to different research issues [9]. In the recent years, online learning or E-learning is a trend with the development of the internet. For the type of online learning, the evaluation method of learning effects is different from the one of traditional face-to-face learning. These effects could be categorized into four modes: learning outcomes, learning satisfaction, group learning environment, and individualized learning. Therefore, the process of how to learning should be emphasized more than the learning results [10].

The research summarized the definitions of learning outcomes. Some scholars indicated that the learning outcomes emphasized on the changes in learning abilities or skills after the process of teaching and learning [11–13]. The test was the most common evaluation form of learning results. The scores were used to determine the learning outcomes [9, 14]. Based on the perspective of learning, the learning outcome was an index to simultaneously evaluate the learning results of participants and the teaching quality of teachers. These learning outcomes could be affected by curriculum design, teaching methods, and learning behaviors [15].

In a word, this paper believed that learning outcomes are the changes in learners' abilities and did not constrain in the performance of cognition, affection, and skills. Some characteristics of learners, such as interest, inspiration, joy, creativity, and social interaction, should be emphasized. The learning outcomes resulting from diverse assessment tools are much appropriate for the characteristics of learning in museums. Here, for the teaching activity related to the teaching module, the learning outcomes were defined as the changes in the knowledge, concepts, and values of the learners.

C. Research of Generic Learning Outcome

GLOs developed by the museum, libraries, and archives council (MLA) in Britain. GLOs model presented broad definitions of learning, and it included the benefits of learners from the interaction of culture and arts as well as the learning environment [16]. Generally, the evaluation used the customized questionnaire with points system to get quantitative analysis of learning outcomes. It is useful to investigate the learning outcomes for museums, libraries, and archives.

In 2008, Wang discussed the developing trends of the learning outcomes, including the available problems and the current situations, as well as the impacts on different museums in Western countries [17]. In 2018, Dieck *et al*. [18] studied the visitor's learning experience in the art gallery or the cultural museum by using wearable devices augmented reality, since the investigation of learning experience resulting from the cultural heritage tourisms was limited. By the framework of GLOs and the thematic analysis, the wearable augmented reality application for enhancing visitor's learning experiences in a gallery were assessed.

In 2012, Tsai utilized GLOs model for evaluating the educational program "Welcome to Silk Paradise" in the National Museum of Natural Science in Taiwan [19]. The quantitative and qualitative analyses for the participants' feedback were applied to investigate the learning outcomes in the case study. In 2015, Hsu *et al*. integrated the physical resources with the e-learning at the National Museum of Natural Science in Taiwan to develop a curriculum-based m-learning model for exploring plants [20]. The authors evaluated the learning outcomes of students and the feedback of teachers by GLOs method. Based on the results of the examination, the learning model connected museums and schools, as well as improved the perceptions, the learning performance, and the attitudes of students for learning natural science. In 2017, Liu *et al*. [21] organized three scientific-educational camps. The students could acquire the necessary knowledge in biology, geology, comparative anatomy, as well as collection and conservation to broaden their scientific views in the paleo-biology by the learning activities in museums. According to the summative evaluation of the questionnaire survey designed by GLOs, most students highly confirmed the program and obtained diverse acquirements from the activities.

In 2019, focusing on the VR experiential exhibit in the multimedia area of the special exhibition, Hsieh *et al*. used the GLOs model to design the questionnaire [22]. Through the methods of questionnaire, observation, and interview, the participants' feedback for the VR exhibit was analyzed. The display method can enhance technological literacy and create the exhibit environment. Moreover, it is more famous among young people. In 2020, Wang *et al*. used the GLOs model to investigate the learning outcomes of participants in the Clean Energy Science and Technology Creative Exhibition held in 2019 [23]. The results showed that the knowledge and understanding level is the most effective, and the variations in other levels were not significant. The background factors, including gender, grade, and frequency of visiting a museum, had no significant correlation with each level. In 2020, Chen *et al*. used the GLOs model to study the learning outcomes for the temporary exhibit "Goldfish Festival" in the museum [24]. According to the results, the scores of the levels of "Knowledge & understanding" and "Attitudes & Values" decreased. The biology topic and the display approach are not interesting for the participants.

Whatever visiting the exhibitions of museums or attending the educational activities in museums, GLOs model is a subjective measuring index for learning in museums. The characteristic of GLOs model to emphasize the active learning is appropriate for the learning environment of the museum.

III. Design Procedure of Integrated Teaching Module

The definitions of curriculum integration were wide. Generally, the integrated approaches have four approaches: infusion, multidisciplinary integration, interdisciplinary integration, and transdisciplinary integration [1, 2, 7]. They are appropriate for different teaching issues or themes, respectively. Here, the paper presented a procedure to systematically construct an integrated teaching module. The procedure had five stages, as shown in Fig. 1.

STEP 1 Topic definition. For developing the teaching module, the first step is to define the topic, the targets, and the objectives. The teaching issues related to the topic were determined. And the objectives of teaching module could be developed. Based on the confirmed issues, the target that the module would like to be applied on could be locked. Here, this paper clearly defined the topic of the teaching module as smart industry. Based on the available exhibitions of the museum, four issues were confirmed: the development of industrial revolutions, the IoT, the smart vehicles, and the industrial robots.

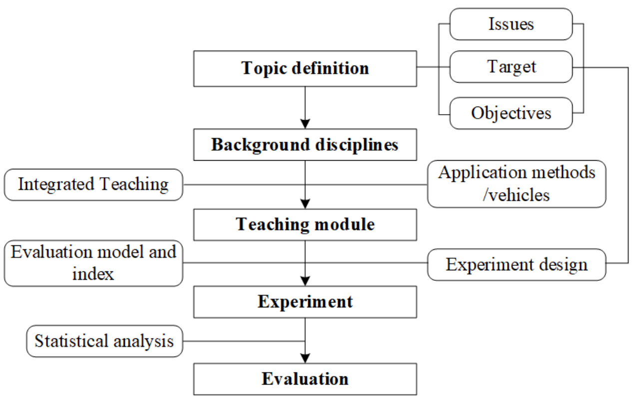


Fig. 1. Design procedure of integrated teaching module.

STEP 2 Fundamental research. The second step is to build the database of fundamental research related to the defined issues or themes. The literature survey and the research results contributed to compile the content of the teaching issues. Therefore, the early research was much important and was regarded as the base of developing the teaching module. This paper studied IoT, smart vehicles, and industrial. And, the literature survey of industrial revolutions was supplemented to connect these three issues to provide an overall concept about smart industry.

STEP 3 Teaching module. The third step is to develop the integrated teaching module. The teaching content was compiled focusing on the issues and their corresponding fundamental research. The teaching means how to deliver the knowledge should be considered after concluding the content. It is believed that the innovative technology is helpful to increase the effectiveness of teaching and to attract the attentions of participants, such as AR, VR, board game, maker activity.

Furthermore, the issues could be the interaction between several disciplines or the combination of various subjects. Based on the teaching issues, the appropriate integrated approaches should be determined. Multidisciplinary integration emphasized that a common theme connected to different disciplines by fusing skills, knowledge, or even attitudes into the curriculum. Students could investigate the theme in several subjects. For the interdisciplinary integration, the common learning from different subjects were organized in the integration curriculum. Students got interdisciplinary skills and information by the common learning in various subjects. As to the transdisciplinary integration approach, it is a level integration to conclude the various curriculums related to the questions what students would like to investigate and the skills that they could apply in a real-life.

This paper used the interdisciplinary integration approach to design the integrated teaching module. The four issues came from different subjects, including mechanical engineering (vehicle engineering, manufacturing engineering), computer science and information engineering, technology history…etc. The teaching involved several skills, like coding, sensors control, optimization design, and electronic circuit. E-learning by electronic books, AR mobile game for experience and the board game were the vehicles used to deliver the teaching content. And the maker activity was to train the skills.

STEP 4 Experiment. Experiment is a necessary process to prove the design of teaching module. Demonstration teaching is an efficient experiment method, and it should be consistent with the original issues, targets and objectives. In the process of experiment design, the model and the index to evaluate the teaching results should be clearly defined. The common ways to get the evaluation index are exams or questionnaires. This research applied the GLOs model to define the learning outcomes as the evaluation index and to design the questionnaire with point level contributed to the resulting quantification analysis.

STEP 5 Evaluation. The final step is to scientifically analyze the results of demonstration teaching. The available analysis methods are multiple, such as inferential analysis, descriptive analysis, qualitative analysis, quantitative analysis. The analysis methods are much related to the kind of data collection. Here, the research used the statistical analysis to the quantified results of learning outcomes by the customized questionnaire. The quantification results directly revealed the efficiency of the teaching module in each identified aspect. Further, the quantification results should be explained by inferential analysis based on the teaching environments and the target students.

IV. THE INTEGRATED TEACHING MODULE

Based on the museum's resources, the teaching module developed various products to deliver the technological knowledge, and to cultivate the students to have the abilities of analysis, summarization, creative thinking, and practice simultaneously. In what follows, the integrated module is introduced.

A. *Scopes of Integrated Teaching Module*

The content of smart industry is interdisciplinary and multidisciplinary. According to the existing exhibitions of the museum, the paper concluded four topics: the historical development of industrial revolutions, the IoT, the smart vehicles, and the industrial robots. The first topic talked about the history of industrial revolutions. The technological history as well as the representative inventors or scientists in different periods were introduced. Since 1760, the revolutions started stage by stage and generated the breakthroughs on the application of power and manufacturing process, the electricity and communication technologies, as well as the computing and communication technology in turns. Now, industry 4.0 is regarded as the subset of the fourth industrial revolutions. The mobile network, automated production, artificial intelligence, IoT, and the analysis of big data are developed at this time. The second topic, IoT, introduced the structure, development, techniques, and technological applications of IoT. The third topic is the introduction of industrial robots. The components, mechanical structure, mechanical theory, the applications now and in the future were presented. The final topic is smart vehicles. The power module for transmission, the safe system, and the development of the Internet of Vehicles (IoV) were presented.

B. *Materials of Integrated Teaching Module*

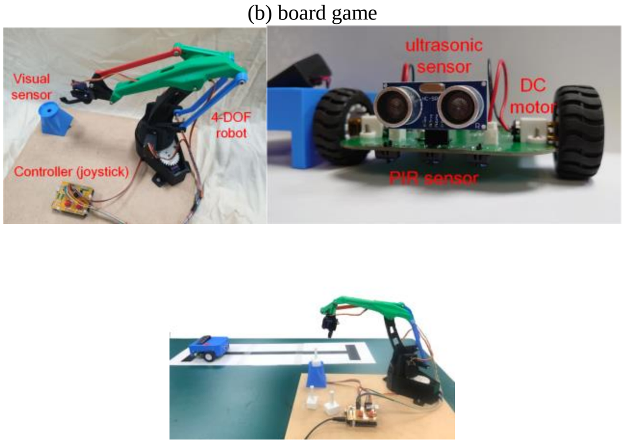
In order to attract the learners' attention and increase the learning enjoyment, the research group especially developed diverse products in this teaching module, including an electronic book, a board game, a mobile game with the technology of augmented reality (AR), and a set of equipment for maker activity.

For E-learning, the research group collected the entire contents of these four topics to form 24 chapters of an online electronic book, as shown in Appendix A1. These chapters are films by the design style of motion graphics, as shown in Fig. 1. The electronic book made the knowledge of science and technology much readable for learners to enhance the learning effectiveness. As far as deep learning is concerned, the teacher supplemented the professional information in cooperation with the watching the electronic book. Even, the students should be encouraged to search the solutions independently.

The development of diverse teaching ways is an effective means to improve the efficiency of teaching and learning. The board game, the AR mobile game and the teaching aids, as shown in Fig. 2. They were the extensive applications of the online electronic book. The stories and rules of these games and the operation of teaching aids combined with the knowledge of the smart industry.

(a) AR mobile game

(b) board game



(c) The combination of the maker teaching aids- 4-DOF robot & self-propelled vehicle

Fig. 2. The integrated teaching module.

The AR game is the APP for the mobile phone or tablet and applied the style of the tower defense game. The image design of challenge at each level is the representative machine or invention in the industrial revolutions, in order to make strong impressions for students. For example, the first level (the 1st revolution) is the steam engine. The player should answer the questions so as to attack the boss and get points.

For the board game, the players must finish the missions in the card to earn various kinds of resources in the rounds that are the industrial revolutions. The students must use the knowledge learning from the electronic book or the exhibition-visiting to play these games, whether the AR mobile game or the board game. The game points or the game levels are the results in another kind of exam.

The teaching aids of the maker activity consisted of a 4-DOF series robot and a self-propelled vehicle with the functions of visual identification and black-line track, as shown in Fig. 2(c). The combination of 4-DOF industrial robots and the automatic mobile vehicle were integrated to simulate the production process or cargo transportation of an automated factory. The coding of the computer program and the techniques of visual cognition and sensors (PIR sensor and ultrasonic sensor) were involved in the maker activity. Also, the activity is teamwork learning, and the students should cooperate in designing more efficient programming for automation. These devices can generate several missions to test the ability of coding and logic and the scheduling of the automatic process.

TABLE I: THE EVALUATION RESULTS OF LEARNING OUTCOMES BY GLOS

Category	Knowledge and Understanding	Skills	Attitudes and Values	Enjoyment, Inspiration, and Creativity	Activity, Behavior, and Progression
Avg. Scores	4.39	4.20	4.15	4.38	4.21

TABLE II: GROUP STATISTICS OF LEARNING OUTCOMES

	Variable	N	Avg.	Std. Deviation	Std. Error Avg.
Knowledge and Understanding	Engineering	36	4.46	0.48	0.08
	Non-Engineering	26	4.31	0.50	0.10
Skills	Engineering	36	4.31	0.64	0.11
	Non-Engineering	26	4.05	0.57	0.11
Attitudes and Values	Engineering	36	4.27	0.64	0.11
	Non-Engineering	26	3.99	0.76	0.15
Enjoyment, Inspiration, and Creativity	Engineering	36	4.47	0.54	0.09
	Non-Engineering	26	4.25	0.56	0.11
Activity, Behavior, and Progression	Engineering	36	4.39	0.58	0.10
	Non-Engineering	26	3.95	0.61	0.12

TABLE III: T-TEST FOR EQUALITY OF MEANS

		Levene's Test for Equality of Variances		T-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference: Lower	Upper
Knowledge and Understanding	equal variances	0.00	0.99	1.17	60	0.25	0.15	0.13	−0.10	0.40
	unequal variances	--	--	1.16	52.42	0.25	0.15	0.13	−0.11	0.40
Skills	equal variances	1.33	0.25	1.69	60	0.10	0.26	0.16	−0.05	0.58
	unequal variances	--	--	1.72	57.22	0.09	0.26	0.15	−0.04	0.57
Attitudes and Values	equal variances	0.00	0.97	1.54	60	0.13	0.27	0.18	−0.08	0.63
	unequal variances	--	--	1.50	48.51	0.14	0.27	0.18	−0.09	0.64
Enjoyment, Inspiration, and Creativity	equal variances	0.05	0.82	1.55	60	0.13	0.22	0.14	−0.06	0.50
	unequal variances	--	--	1.55	53.03	0.13	0.22	0.14	−0.06	0.50
Activity, Behavior, and Progression	equal variances	0.19	0.67	2.89	60	0.005*	0.44	0.15	0.14	0.75
	unequal variances	--	--	2.87	52.28	0.01	0.44	0.15	0.13	0.75

Note: * means the null hypothesis is rejected, and the opposite hypothesis is accepted, which shows that non-engineering subjects and engineering subjects have inconsistencies in the aspect of "action, action, and progress." In the table, the P value determined by the Levene test is 0.67. Because $P > 0.05$ represents that the variances between the two groups are the same, the result depends on the assumption of "equal variances." The analysis showed that the T-test statistic was 2.89, the degree of freedom was 60, the P value of the two-tailed test was 0.005, and $\alpha=0.01$.

V. ANALYSIS OF LEARNING OUTCOME

This research applies the GLOs model for analyzing the teaching module applied on the demonstration teaching. According to the model, the questionnaire is designed in five categories: "Knowledge and Understanding," "Skills," "Attitudes and Values," "Enjoyment, Inspiration and Creativity," as well as "Behavior and Progression." Each category has five questions. This questionnaire used a 5-level Likert scale. The results of Likert scaling are bipolar, evaluating either positive or negative response for the learning.

There are 62 students (testing samples) in total in these two courses of demonstration teaching. The evaluation results of learning outcomes are summarized in Table I. Regardless of the students' learning background, the average of "Knowledge and Understanding" is 4.39 points and is the highest scoring. The average point of "Attitudes & Values" is 4.15, the lowest scoring. According to the averages of categories, it is affirmed that the students positively identified the teaching module for the popularization of science and technology in the museum. The teaching module is successful to deliver the knowledge and improve students' abilities about the topic of smart industry.

In order to investigate the effects between the learning background and the learning outcomes, the statistical analysis of the learning outcomes respectively for the students with engineering and non-engineering background is shown in Tables II and III. The learning outcomes of the students with different background are much close in each one of GLOs five categories. Following the evaluation results in Table II, three reasons are inferred as follows: (1) The science popularization of the teaching module is successful. The students without the engineering background can accept and realize the designed teaching content of smart industry. (2) The tested school, Kaohsiung Advanced Industrial Vocational School, is a technical school. The school culture ordinarily over-emphasized the industrial education. The students imperceptibly receive the information related to the industry. Therefore, the non-engineering students can generate the good learning outcome in this evaluation of demonstration teaching. (3) In the tested school, the department of chemical engineering is classified to the non-engineering group, and many chemical engineering students participated the demonstration teaching. These students actually affect the evaluation results.

Further, there is a small difference between the two groups of students in the evaluation of "Activity, Behavior and Progression" shown in Table II. As far as the non-engineering students are concerned, their learning effects following by the teaching module are slightly lower than the engineering students. Based on the statistics analysis in Table III, the evaluation of this category is significant, i.e., the learning outcomes of these two groups of students are different. It is possible that the non-engineering students considered the smart industry is out of their major subjects, interests, and the career development in the future, even they understood the topic is much related to their daily life.

VI. Conclusion

Education is one of the museum missions. The teaching activity in the museum positively engages the technological subjects in the national primary education. The museum that possessed multiple exhibitions and abundant resources from various industries is an advantage of the teaching field. Focusing on the topic of smart industry, this paper contributed to developing the integrated teaching module with interactive ways and blended materials and investigated the effect of the module through the demonstration teaching and the evaluation of GLOs model. Here, the paper contributions were summarized as follows:

1) A systematic design procedure for developing an integrated teaching module was presented. The design procedure was generalized and should be appropriate for various teaching issues. The steps of experiment and evaluation analysis were presented to investigate the effects of the developed module and to revise the module based on the feedback from students and teachers. Furthermore, the evaluation indexes are consistent with the evaluation models, but they were unconstrained by the teaching issues. The module designer could determine the evaluation means according to the schedule of teaching activity and the space field of teaching.
2) An integrated teaching module to deliver the historical development of industrial development, IoT, smart vehicles, and industrial robots was generated. The teaching module included the e-learning, the practice, and gameplay learning. An electronic book with 24 chapters was compiled for e-learning. The teachers could discuss the content of the electronic book with the students in the class. After the course, the students were inspired to investigate the professional knowledge further to train the literature survey's ability. Furthermore, the students had the chance to practice. The teaching aids of maker activity included the training of practice and research. The maker activity combined with smart vehicles and industrial robots. And, the identified missions of maker activity could be varied by applying different sensors. Finally, two teaching games (the AR game APP, and the board game) were generated based on the educational concepts of interactive learning. The game content customized by the teaching issues. The knowledge of teaching content (the electronic book) could be completely used to finish these games.
3) The effects of the integrated teaching module were investigated based on the evaluation of the GLOs model. The experiments were executed by the demonstration teaching. The quantitative learning outcomes in different aspects of GLOs model indicated the positive learning results. The learning outcomes of the engineering and the non-engineering students are not apparent in the demonstration teaching. The qualitative analysis introduced that the school culture of subjects (students) and the science popularization of the teaching module could be the impact factors for the unobvious differences.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Jian-Liang Lin and Fang-Yi Su conducted the research. Jian-Liang Lin and Kuo-Hung Hsiao collected the research of industrial robots and smart vehicles. Chieh-Ya Lin and Fang-Yi Su analyzed the learning outcomes. Jian-Liang Lin and Chieh-Ya Lin wrote the paper. All authors had approved the final version.

Funding

This research was supported in Ministry of Education. The authors are grateful to the National Science and Technology Council (Taiwan R.O.C.) for the financial support of publication (MOST 110-2511-H-359 -002 - of this work).

Acknowledgment

The authors thanks for the financial support from Ministry of Education, and the technological support from Department of Animation and Game Design, Shu-Te University and Kaohsiung Municipal Industrial High School.

References

[1] T. Barton. (2019). Integrated curriculum: Changing the future of teaching. [Online]. Available: https://www.artscouncil.org.uk/measuring-outcomes/generic-learning-outcomes#section-1

[2] H. H. Jacobs, *Interdisciplinary Curriculum: Design and Implementation*, Association for Supervision and Curriculum Development, Alexandria, VA, 1989.

[3] J. A. Beane, "Curriculum integration and the disciplines of knowledge," *The Phi Delta Kappan*, vol. 76, pp. 616–622, 1995.

[4] A. Wall and A. Leckie, "Curriculum integration: An overview," *Current Issues in Middle Level Education*, vol. 22, pp. 36–40, 2017.

[5] N. A. Toppo, M. Lazarus, R. J. Seth, O. P. Bhargava, K. S. Yadav, and P. K. Kasar, "Introduction of integrated teaching learning module in second M.B.B.S. curriculum," *International Journal of Contemporary Medical Research*, vol. 3, pp. 1275–1279, 2016.

[6] P. P. Yadav *et al*., "Effectiveness of integrated teaching module in pharmacology among medical undergraduates," *International Journal of Applied and Basic Medical Research*, Vol. 6, no. 3, pp. 215–215, 2016.

[7] S. M. Drake and J. Reid, "Integrated curriculum as an effective way to teach 21st century capabilities," *Asia Pacific Journal of Educational Research*, vol. 1, no. 1, pp. 31–50, 2018.

[8] "Learning for change: Integrated teaching modules and situated learning for marine social-ecological systems change," *The Journal of Environmental Education*, vol. 52, no. 2, pp. 118–132, 2021.

[9] S. Y. Guo, *Psychological and Educational Testing*, Jing-Hua Publisher (in Chinese): Taipei, 1999.

[10] S. W. Chou, "Impact of internet technology on education-learning environment, learning method, Teacher-Student Interactions, Teaching content," *Web Journal of Chinese Management Review*, vol. 2, pp. 89–96, 1999.

[11] G. Piccoli, R. Ahmad, and B. Lves, "Web-based virtual learning environments: a research framework and a preliminary assessment of effectiveness in basic IT skills training," *MIS Quarterly: Management Information Systems*, vol. 25, pp. 401–426, 2001.

[12] M. Young, B. Klemz, and J. Murphy, "Enhancing learning outcomes: The effects of instructional technology, learning styles, instructional methods, and student behavior," *Journal of Marketing Education*, vol. 25, pp. 130–142, 2003.

[13] S. T. Hsu, C. S. Hsu, and Y. W. Wang, "The relationship between teachers' instructional attitudes and students' learning results," *Journal of Leader University*, vol. 5, pp. 62–77, 2008.

[14] H. H. Tsai and Y. P. Chang, "The impact of learning motivation on learning effect—the moderator of perceived leadership," *Chung Hua Journal of Management*, vol. 8, pp. 1–17, 2007.

[15] F. Guay, C. F. Ratelle, and J. Chanal, "Optimal learning in optimal contexts: The role of self-determination in education," *Canadian Psychology/Psychologie Canadienne*, vol. 49, pp. 233–240, 2008.

[16] Generic Learning Outcome. [Online]. Available: https://servelearn.co/blog/integrated-curriculum-changing-the-future-of-teaching/

[17] C. H. Wang, "The development and implication of research on museum visitor learning outcomes and impact," *Museology Quarterly*, vol. 22, pp. 91–107, 2008.

[18] M. C. Dieck, T. H. Jun, and D. Dieck, "Enhancing art gallery visitors' learning experience using wearable augmented reality: Generic learning outcomes perspective," *Journal of Current Issues in Tourism*, vol. 21, no. 17, pp. 2014–2034, 2018.

[19] H. K. Tsai, "A case study of the effectiveness of applying generic learning outcomes to the planning of educational programs: Take "welcome to silk paradise" at the national museum of natural science as an example," *Technology Museum Review*, vol. 17, pp. 87–116, 2012.

[20] T. Y. Hsu, Y. H. Wang, and F. J. Kuo, "Virtual and physical blended learning applications and service model for popular science education in museums: Curriculum-based Virtual and Physical Mobile Learning as an Example," *Museology Quarterly*, vol. 29, pp. 99–115, 2015.

[21] K. J. Liu, C. M. Chang, and J. H. Chang, "The evaluation of the educational activities on tracing mammalian fossils in Taiwan for science museum," *Technology Museum Review*, vol. 21, pp. 51–79, 2017.

[22] Y. L. Hsieh, C.H. Chen, and Y. H. Lai, "Inspiration and creativity: visitor study of virtual reality-based museum exhibition," *Museology Quarterly*, vol. 33, no. 2, pp. 79–73, 2019.

[23] L. S. Chen, T. C. Sung, and S. Y. Chen, "Generic learning outcomes in museums: A case study of the temporary exhibition 'goldfish festival' in the national museum of marine science and technology," *Journal of Museum & Culture*, vol. 19, pp. 3–33, 2020.

[24] Y. H. Wang, J. R. Liu, and Y. X. Chen, "A study on assessing the effectiveness of museum education activities with generic learning outcomes (GLOs)—take "clean energy technology creative exhibition" as an example," *Journal of Industrial Technology Education*, vol. 13, pp. 130–150, 2022.