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Research Article

A Framework for Mobile Meaningful Plant Learning to Improve Natural Science Learners' Performance

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ABSTRACT

Plant study is an essential part of the science curriculum; however, many students do not obtain a practical familiarity with plants even though they have engaged in a botany course in school. This study aims to develop a mobile, meaningful plant learning framework to improve students' botanical learning skills. The content validity process, as a method to help validate the proposed framework, is used in this work. Five educational technology specialists with expertise in the study and development of mobile learning and meaningful learning were invited to check and review the criteria for the developed framework, thus increasing the validity of the framework. As all five specialists rated "Agree" or "Strongly Agree" on all the usability framework criteria in the survey, the overall content validity index is 1.00, which means that all the experts agreed with the framework's presentation, task support, and customization. This study will provide valuable insights for researchers, instructors, and instructional designers interested in developing mobile learning and natural science skills.

Keywords: Meaningful learning, Mobile learning, Natural science, Usability evaluation, Students' performance

I. INTRODUCTION

The traditional method for studying plants in Taiwanese elementary schools is limited to print-based textbooks and other dispersed resources that may be used to complete instructors' in-class lectures. Conventionally, natural science courses are offered as a series of lectures the teacher presents, traditionally based on a textbook. Traditional teaching methods are often restricted in their effectiveness due to being formal and teacher-centered, which prevents the presentation of content in more informal learning situations [1].

Presentational approaches are essential in natural science courses. Students' achievements and cognitive development might be compromised if students are only exposed to the basic knowledge of a subject without searching into its deeper levels [2]. Numerous studies have investigated the misconceptions that students might encounter in the process of knowledge construction when completing tasks related to plant observation [3, 4]. In natural science courses, avoiding one-sided knowledge is necessary to prevent a lack of understanding of organizational structure.

To eliminate the limitations of the educational approach, the coordinated utilization of outdoor learning and advanced technologies is a viable means to improve teaching and learning about plants in a more socially engaging and interactive way [5-7]. Online learning has decreased many constraints and barriers that are prevalent in traditional learning environments [8].

Although the theory and practice of online technologies in education environments have been developed dynamically and rapidly, few studies have discussed efficient online instructional methods for students [9, 10]. Due to the lack of face-to-face contact, instructors and students usually encountered a lack of meaningful interactions and active social presence in online learning. The findings recommend that online instructors find effective methods to design and facilitate meaningful interactions and active social presence in online learning. [8].

Educators consider meaningful learning as an effective teaching method. Meaningful learning, which is constructive and active, occurs in online learning environments when people reflect an activity, construct knowledge in reaction to their environment, and articulate what they have learned [11-13]. Understanding, assessing, and evaluating the components of meaningful learning with technology is crucial. Assessment instruments may aid instructors in making more informed decisions about pedagogies and classroom interventions for effectively utilizing technologies for fostering learning [14].

Mobile learning delivers some online learning characteristics but differentiates itself with unique features, such as mobility and context awareness [15]. Mobile learning allows instructors to cultivate online learning solutions for learners, which can be applied anywhere and anytime as required to attain consequences that cannot be accomplished with other existing educational tools [16]. Although many recent studies have focused on mobile learning environments, few researchers have considered using meaningful learning in such educational environments. Despite the advent of mobile and online technologies, learning and teaching in learning institutions have not drastically changed in recent years, and pedagogies often remain the same [17].

This study aimed to apply mobile devices with meaningful learning to establish a new mobile learning system named the Mobile Meaningful Plant Learning System (MMPLS) for plant study. Synthesizing meaningful learning and IT technology can help to enhance learning mobility, context awareness, constructivism, cooperation, and interaction between humans and humans as well as humans and the environment in an outdoor-ecological M-learning system.

II. LITERATURE REVIEW

A. Meaningful Learning

Meaningful learning involves integrating previous knowledge and newly obtained information; learners take long-standing accountability for their own learning [18, 19]. Cadorin et al. (2014) described meaningful learning as an individual's active process of knowledge construction, a long-standing responsibility, and developing skills and knowledge through experience [20]. While mechanical learning merely comprises memorizing contents, meaningful learning cultivates deep understanding and supports reasoning [21]. Knowledge and skills learned meaningfully can be applied to various problem-solving activities, facilitating critical reasoning and creative thinking to achieve goals more easily [21, 22].

B. Usability Content

Usability in an educational context means ease of use, which is an important concern for mobile learning success. Usability is able to make systems and software easier to use and adjust them more closely to learners' demands. Poor usability decreases student and user productivity and accordingly causes missing student and user [25]. Usability has profits for educational environments, including improved user satisfaction, increased productivity, decreased training costs, and higher quality of work [26]. Reducing costs has encouraged many project managers and interface designers to employ the usability theory in interface design [27].

ISO (2001) expressed that usability is "the capability of the software product to be understood, learned, used and attractive to the user, when used under specified conditions" [28]. ISO 9241-11 (1998) defined usability as "the extent to which specified users can use a product to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use" [29]. Nielsen represents that "usability is necessary for survival on the web" [30]. Usability means quality and put the users and their requests in the center. Hence, usability evaluation and its contribution or integration to the learning system is valuable [31].

C. Comparison of Usability Models

In an educational context, usability has significant implications and is used as a primary parameter to measure the usability of mobile learning technology. To assess the usability of a system, the International Organization for Standardization (ISO) determines three measurable attributes: Efficiency, Effectiveness, and Satisfaction [29]. Nielsen also recognized five usability attributes: efficiency, satisfaction, learnability, memorability, and errors [30]. A usability model named PACMAD evaluated the usability of mobile applications originated by Harrison et.al (2013) by incorporating the usability attributes developed by Nielsen (1994) and the ISO [29]. The PACMAD usability model can be used to assess the usability of mobile applications. In addition, the PACMAD model also identifies eight attributes that can be used to express metrics to guide the usability of an application. To modify the PACMAD model for a learning context, Parsazadeh et al. (2018) introduced CIMLA (Cooperative and Interactive Mobile Learning Application) by adding timeliness as another attribute of usability that should be considered in evaluating the usability of mobile learning applications. CIMLA was designed based on ISO standard, Nielsen, and PACMAD models and the adoption of the Jigsaw-based cooperative learning model (Aronson, 1978) and interaction theory (Moore, 1989). Fig 1 compares usability models, including ISO, Nielson, PAMAD, and CIMLA developed by previous studies.

III. THE PROPOSED FRAMEWORK

Research on meaningful learning and integrated course design has shown that to encourage students to acquire affective and relational skills, there needs to be success in aligning the learning goal, the assessment, and learning activities [23, 32]. To do this, a framework is proposed for developing educational mobile applications. A framework for mobile meaningful plant learning was developed. In this study, Harrison et al. (2013) adopted the usability model to develop a meaningful mobile plant learning framework.

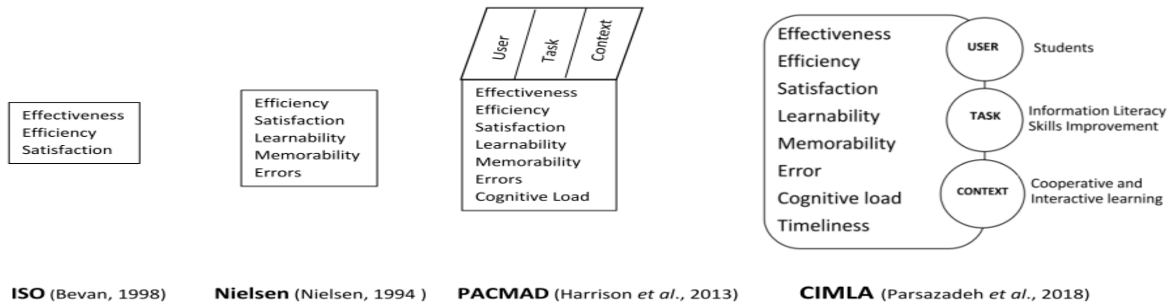

Fig 1. Comparison of Usability Models

The framework developed for this study was designed based on previous research, including the usability evaluation model adopted from [33], the cooperative and interactive mobile learning model from [34], and the meaningful learning-based model from [15].

Task, user, and context are three important factors affecting mobile learning applications' usability. In the developed framework for this study, the task was identified as the botanical learning of students that should be enhanced after students have used the mobile learning application. The task or the goal of meaningful mobile learning in this study is to guide students in learning about aquatic plant types to enhance outdoor learning activities that involve plant exploration and observation in the actual environment. The user describes the elementary school students who use the mobile application. Context describes that the development of mobile applications would be based on the meaningful learning dimensions adopted from [15].

The meaningful learning in this study included five dimensions: active, authentic, constructive, cooperative, and interactive. Huang et al. (2011) defined meaningful dimensions for mobile learning as follows: "active means that learners are dynamic, that they assume active roles in learning activities; authentic means that learners construct knowledge from situated and authentic learning activities; constructive means that learners accommodate new ideas to their prior knowledge/experiences [35]; and cooperative means that learners are encouraged to solve the problems/tasks together with their peers" [36]. Three types of interaction, including student-student interaction, student-lecturer interaction, and student-content interaction adopted from a previous study [37].

In this study, we adopted the seven usability attributes of desktop and mobile applications, including effectiveness from [29], efficiency from [30], satisfaction from [30], learnability from [30], memorability from [30], error from [30], cognitive load adopted from PACMAD model [33], and timeliness from [34].

We also identified activeness, authenticity, and constructiveness as the usability attributes necessary in evaluating the usability of meaningful mobile learning applications. The implications of usability attributes in the mobile meaningful learning context are as follows:

Effectiveness is defined as "the ability of a user to complete a task in a specific context" (Harrison et al., 2013). The Efficiency attribute is "the ability of the user to complete their tasks with speed and accuracy" [33]. The response time or timeliness means "the degree to which the user thinks a received message is time-sensitive or has immediate feedback" [38]. Satisfaction is defined as "the perceived level of comfort and pleasantness afforded to the user through the use of the software" (Harrison et al., 2013). The learnability attribute means "the ease with which a user can gain proficiency with an application" (Harrison et al., 2013). The memorability attribute is "the ability of a user to retain how to use an application effectively" (Harrison et al., 2013). Errors are "the user can complete the desired tasks without errors" (Harrison et al., 2013). The cognitive load attribute refers to the extent of cognitive processing the user requires to use the application (Harrison et al., 2013).

IV. FRAMEWORK VALIDATION

In the content validity phase, the framework of meaningful mobile learning was modified based on comments from experts. The important comments include indicating the relationship between the user, task, and context with arrows in the framework, providing references in the framework, clarifying the mobile application's role in the framework, use colored boxes in designing framework to highlight the main parts. We improved the framework based on the experts' comments.

The experts have favorably reviewed the framework and agreed that it is appropriate based on the evaluation criteria, including presentation, task support, customization, correctness, and framework suitability for developing a mobile application to help learners improve their skills.

Most of the experts strongly believe it could be used to improve elementary students' botanical learning. Table 1 shows the experts' rating on the content validity of the usability framework of meaningful mobile learning. Only criteria rated by the experts as "Agree" or "Strongly Agree" are considered in calculating the content validity index (CVI). As all five experts rated "Agree" or "Strongly Agree" on all the usability evaluation criteria in the survey, the overall content validity index is 1.00, which means that all the experts agreed with the framework's presentation, task support, and customization.

Table 1. Content validity index of usability evaluation framework

Expert **Item**	**1**	**2**	**3**	**4**	**5**	**CVI**
1. Presentation: The information provided by the framework are complete and understandable.	√	√	√	√	√	1.00
2. Task Support: The framework accurately addresses the usability evaluation of mobile meaningful learning system.	√	√	√	√	√	1.00
3. Customization: The framework can be implemented and customized to support instructional goals in future studies.	√	√	√	√	√	1.00
4. Correctness of the framework	√	√	√	√	√	1.00
5. Suitability of the framework for a study into mobile meaningful learning for natural science education.	√	√	√	√	√	1.00
6. Suitability of the framework in presenting elements of usability for usability evaluation of mobile meaningful learning.	√	√	√	√	√	1.00
7. Suitability of the framework in presenting elements of meaningful learning for mobile meaningful learning.	√	√	√	√	√	1.00
8. Suitability of the framework for the actual design of the mobile meaningful learning application.	√	√	√	√	√	1.00

9. Developing a mobile meaningful application based on the framework will help elementary students to enhance their natural scientific literacy.	√	√	√	√	√	1.00
Average CVI						1.00

Note. √ means agree or strongly agree.

V. CONCLUSIONS

Many natural science course teachers supervise outdoor cooperative learning activities in the actual environment to encourage learners to observe complex ecosystems and ecological environments in an informal learning environment. In this study, we describe developing and validating a framework for MMPLS based on the meaningful learning model and the usability evaluation framework of mobile applications. Assessment instruments enable educators to make more informed decisions regarding classroom interventions and pedagogies for effectively using technologies to foster learning.

The main goal of the proposed framework is to provide a systematic reference and guideline for professional developers to design and develop mobile applications that can motivate students. The next step in our study is to develop an actual mobile meaningful plant learning application based on the proposed framework.

The framework will be used to develop a mobile learning application to demonstrate how meaningful learning approaches help to improve students' botanical learning skills. The intended mobile meaningful plant learning application will be specifically developed to support elementary students with meaningful learning practices based on the studied course goals. This study provides a useful reference for researchers and educators working in the field of mobile meaningful learning development and evaluation.

REFERENCES

[1] Chien, Y.-C., Su, Y.-N., Wu, T.-T. and Huang, Y.-M. J. U. A. i. t. I. S. Enhancing students' botanical learning by using augmented reality (2017), 1-11.

[2] Çepni, S., Taş, E., Köse, S. J. C. and Education The effects of computer-assisted material on students' cognitive levels, misconceptions and attitudes towards science, 46, 2 (2006), 192-205.

[3] Mikkilä-Erdmann, M. J. L. and instruction Improving conceptual change concerning photosynthesis through text design, 11, 3 (2001), 241-257.

[4] Tas, E., Cepni, S. and Kaya, E. J. E. E. S. T. P. B. The effects of web-supported and classical concept maps on students' cognitive development and misconception change: a case study on photosynthesis, 4 (2012), 241-252.

[5] Huang, Y.-M., Lin, Y.-T., Cheng, S.-C. J. C. and Education Effectiveness of a mobile plant learning system in a science curriculum in Taiwanese elementary education, 54, 1 (2010), 47-58.

[6] Wang, S.-L., Chen, C.-C. and Zhang, Z. G. A context-aware knowledge map to support ubiquitous learning activities for a u-Botanical museum (2015).

[7] Sung, H.-Y., Hwang, G.-J. J. C. and Education A collaborative game-based learning approach to improving students' learning performance in science courses, 63 (2013), 43-51.

[8] Keengwe, J., Adjei-Boateng, E., Diteeyont, W. J. E. and Technologies, I. Facilitating active social presence and meaningful interactions in online learning, 18, 4 (2013), 597-607.

[9] Tsai, C.-W. J. C. and Education Do students need teacher's initiation in online collaborative learning?, 54, 4 (2010), 1137-1144.

[10] Tsai, C.-W., Shen, P.-D., Tsai, M.-C. J. B. and Technology, I. Developing an appropriate design of blended learning with web-enabled self-regulated learning to enhance students' learning and thoughts regarding online learning, 30, 2 (2011), 261-271.

[11] Tsai, C. W., Shen, P. D. and Chiang, Y. C. J. B. J. o. E. T. Research trends in meaningful learning research on e-learning and online education environments: A review of studies published in SSCI-indexed journals from 2003 to 2012, 44, 6 (2013), E179-E184.

[12] Ferguson, R. J. T. s. and creativity Meaningful learning and creativity in virtual worlds, 6, 3 (2011), 169-178.

[13] Viswanathan, V. and Goedert, K. Use of Concept Maps to Enhance Meaningful Learning (2017).

[14] Lee, C. B. J. I. L. E. Initial development of the Meaningful Learning with Technology Scale (MeLTS) for high-school students, 26, 2 (2018), 163-174.

[15] Huang, Y. M. and Chiu, P. S. J. B. J. o. E. T. The effectiveness of a meaningful learning-based evaluation model for context-aware mobile learning, 46, 2 (2015), 437-447.

[16] Jou, M., Tennyson, R. D., Wang, J., Huang, S.-Y. J. C. and Education A study on the usability of E-books and APP in engineering courses: A case study on mechanical drawing, 92 (2016), 181-193.

[17] Garcia, A. J. G. J. o. H.-S. S. R. Using the Jigsaw Method for Meaningful Learning to Enhance Learning and Rentention in an Educational Leadership Graduate School Course (2017).

[18] Ausubel, D. P. The psychology of meaningful verbal learning (1963).

[19] Anderson, L. W., Krathwohl, D. R., Airasian, P. W., Cruikshank, K. A., Mayer, R. E., Pintrich, P. R., Raths, J. and Wittrock, M. C. J. W. P., NY: Longman A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives, abridged edition (2001).

[20] Cadorin, L., Bagnasco, A., Rocco, G. and Sasso, L. J. N. o. An integrative review of the characteristics of meaningful learning in healthcare professionals to enlighten educational practices in health care, 1, 1 (2014), 3-14.

[21] Cadorin, L., Bagnasco, A., Tolotti, A., Pagnucci, N. and Sasso, L. J. J. o. a. n. Instruments for measuring meaningful learning in healthcare students: a systematic psychometric review, 72, 9 (2016), 1972-1990.

[22] Novak, J. D. L'apprendimento significativo: le mappe concettuali per creare e usare la conoscenza. Edizioni Erickson, 2001.

[23] Cadorin, L., Bagnasco, A., Tolotti, A., Pagnucci, N. and Sasso, L. J. J. o. a. n. Developing an instrument to measure emotional behaviour abilities of meaningful learning through the Delphi technique, 73, 9 (2017), 2208-2218.

[24] Jonassen, D. H. J. E. t. Supporting communities of learners with technology: A vision for integrating technology with learning in schools, 35, 4 (1995), 60-63.

[25] Shitkova, M., Holler, J., Heide, T., Clever, N. and Becker, J. Towards Usability Guidelines for Mobile Websites and Applications. City, 2015.

[26] ISO, I. 13407: Human-centred design processes for interactive systems. Geneva: ISO (1999).

[27] Karat, C.-M. Cost-benefit analysis of iterative usability testing. North-Holland Publishing Co., City, 1990.

[28] Iso, I. IEC 9126-1: Software Engineering-Product Quality-Part 1: Quality Model. Geneva, Switzerland: International Organization for Standardization (2001), 27.

[29] Bevan, N. ISO 9241: Ergonomic requirements for office work with visual display terminals (VDTs)-Part 11: Guidance on usability. TC, 159 (1998).

[30] Nielsen, J. Usability engineering. Elsevier, 1994.

[31] Anani, A. M-learning in review: Technology, standard, and evaluation. Journal of Communication and Computer, 5, 11 (2008), 1-6.

[32] Fink, L. D. J. P. R. The power of course design to increase student engagement and learning, 9, 1 (2007), 13-17.

[33] Harrison, R., Flood, D. and Duce, D. J. J. o. I. S. Usability of mobile applications: literature review and rationale for a new usability model, 1, 1 (2013), 1.

[34] Parsazadeh, N., Ali, R., Rezaei, M. J. C. and Education A framework for cooperative and interactive mobile learning to improve online information evaluation skills, 120 (2018), 75-89.

[35] Lin, Y.-C., Lin, Y.-T., Huang, Y.-M. J. C. and Education Development of a diagnostic system using a testing-based approach for strengthening student prior knowledge, 57, 2 (2011), 1557-1570.

[36] Huang, Y.-M., Chiu, P.-S., Liu, T.-C., Chen, T.-S. J. C. and Education The design and implementation of a meaningful learning-based evaluation method for ubiquitous learning, 57, 4 (2011), 2291-2302.

[37] Moore, M. G. Three types of interaction. Taylor & Francis, City, 1989.

[38] Gorla, N., Somers, T. M. and Wong, B. J. T. J. o. S. I. S. Organizational impact of system quality, information quality, and service quality, 19, 3 (2010), 207