A Mobile Scaffolding-Aid-Based Bird-Watching Learning System*

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Abstract

In this paper, we develop a mobile scaffolding-aid-based bird-watching learning system, which aims to construct an outdoor mobility-learning activity under the up-to-date wireless technology. The proposed Bird-Watching Learning (BWL) system is designed on the wireless mobile ad-hoc network. In the BWL system, each learner's device has PDA (Personal Digital Assistances) with Wi-Fi (IEEE 802.11b) card, within a WLAN environment. Specially, the BWL system contains a mobile learn sheet sub-system, which to integrate the scaffolding-aid learn model into the BWL system. Finally, we conduct a formative evaluation to provide statistical results, which is evaluated for the following two purposes; (1) to explore the possible roles and scaffolding aids that the mobile PDA of the BWL system can play and offer in the bird-watching activities, (2) to investigate if the affective and cognitive learning could be possibly benefited from the mobility, portability, and individualization of the mobile PDA of the BWL system.

1. Introduction

Advances in wireless communication technologies [16, 17, 18, 19, 20] recently provide the traditional educators to create new educational models, which are intensively investigated. With the aid of wireless communication technology, the educational practice is embedded in the mobile life without wired-based communication. With the trend of the educational media to be more mobilized, portable, and individualized, the learning form is dramatically changed. This work aims to synthesize the cognition, sentiment, and technology domains to establish new outdoor-ecological learning model.

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Many unique characteristics of the mobile learning environment are possessed as follows. (1) *Urgency of learning need*: The wireless applications are usually be used upon an urgent matter of learning, such as the timing at the chances for problem solving or knowledge linking. Otherwise, the learner may record the questions and look for the answer later in the library, on line with computer, or form the experts. (2) *Initiative of knowledge acquisition*: Most of time, the information provided by the wireless applications is based on the learners' requests, i.e. information on demand. Therefore, the learning involved is more self-directed. Based on the learners' request, the wireless application can provide high-related information in time. (3) *Mobility of learning setting*: The wireless devices are developed to be more and more easy-carried. Therefore, the educational practice can be performed at any time and any place, such as tour bus, camping area, exhibit room, etc. All kinds of field trip situations can be facilitated. This kind of learning setting can be pre-planned or on occasion. (4) *Interactivity of learning process*: Through the interfaces of voices, pointing, mails, icons, even videos, the learner could communicate with the experts, peers, or materials fast and effectively, in the form of synchronous or asynchronous communication. Hence, the expert is more reachable and the knowledge is more available. (5) *Situating of instructional activity*: Via the wireless applications, the learning could be embedded in our daily life. The problems encountered as well as the knowledge required are all presented in the nature and authentic forms. It helps learners notice the features of problem situations that make particular actions relevant. (6) *Integration of instructional content*: The wireless learning environment integrates many infomation resources and supports learners to do un-linear, multi-dimensional, and flexible learning and thinking. It especially facilitates complex and ill-structured learning content, such as the cross-subject, theme-based learning activities.

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In the past 20 years, the constructivist paradigm has gradually come to educational research. From the constructivist perspective, the purpose of education is to cultivate independent and self-directed learners. Bruner's metaphor of scaffolding [3] provides an explicit strategy to direct our teaching toward this end. Scaffolding refers to the interactive support that instructors or more skillful peers offer learners to bridge the gap between their current skill levels and a desired skill level. In the process, the amount of support is gradually withdrawn as the learners become more proficient. Ultimately, the learners can complete tasks on their own [10]. Therefore, the method of scaffolding is consisted of two major processes: one is "support building", the other is "support fading". Cazden [4] has used a vivid and familiar picture to make clear the concept and the pervasiveness of its exemplars.

The literature review suggests that scaffolding can enhance comprehension, improve independent learning and application, and promote knowledge transfer [3, 4, 10]. Evidence of these advantages has been found in many studies in the field of language and cognitive development [2, 6, 9, 14]. At the same time, limitations of scaffolding have also been pointed out. This technique has been criticized for its lack of discussion concerning development of the expert's role in providing the novice with assistance [8]. Its implementation has also been criticized for not being able to capture the challenge of responding to the diversity of children's intentions in classroom teaching [7].

This paper intends to apply the above characteristics of the wireless application, PDA to the outdoor bird-watching situation. Based on that, we investigate the influence of this technology on the instructional process, management, and evaluation. In this work, we develop a mobile scaffolding-aid-based bird-watching learning system, which aims to construct an outdoor mobility-learning activity under the up-to-date wireless technology. The proposed Bird-Watching Learning (BWL) system is designed on the wireless mobile ad-hoc network. In the BWL system, each learner's device has PDA (Personal Digital Assistances) with Wi-Fi (IEEE 802.11b) card, within a WLAN environment. Specially, the BWL system contains a mobile learn sheet sub-system, which to integrate the scaffolding-aid learn model into the BWL system. Finally, we conduct a formative evaluation to provide statistical results, which is evaluated for the following two purposes; (1) to explore the possible roles and scaffolding aids that the mobile PDA of the BWL system can play and offer in the bird-watching activities, (2) to investigate if the affective and cognitive learning could be possibly benefited from the mobility, portability, and individualization of the mobile PDA of the BWL system.

The rest of the paper is organized as follows. Section 2 describes basic ideas of the BWL system. Section 3 presents the BWL system. Section 4 illustrates the formative evaluation and provide statistical results. And, Section 5 concludes this paper.

2. Basic Ideas and Challenge

This scaffolding technique has also drawn great attention from the media researchers for media can provide a more realistic learning environment with rich and varied support. In the area of media research, the term "scaffolding" has been used to describe various instructional techniques for use in learning activities that reflect authentic task situations. One major concept of this technique is to enable the learner to engage in out-of-reach activities; having a "knowledgeable other" or "more capable peer" to bring the learner along; having something or someone "share the cognitive load" [11].

Especially, the medium of computer has introduced unprecedented levels of autonomy into education. The processing and integrating capabilities of computers can create a realistic, interactive, support-rich, and individualized learning environment. These characteristics may overcome the limitations of scaffolding and ease the implementation of this instructional technique. Several researchers have developed scaffolded computer-based instruction, integrating more than one medium to support learners' knowledge construction in authentic learning activities [11, 15]. However, the discussion has focused mainly on the software development and the support-building models.

Lieberman and Linn [13] contended that scaffolding is one of the several ways computers can be used to encourage students to be self-directed. This can be attributed to the support-fading characteristic of scaffolding. The Cognition and Technology Group at Vanderbilt University [5] has proposed a risk of over-relying on the support of integrated media. To educate individuals to be independent and active learners, there is a need to emphasize the support-fading component of scaffolding while we try to integrate this instructional technique into media assisted instruction. However, to use this skill, the major challenge is to determine when the support should be faded and how much the support should be reduced at the time. This requires us to ascertain the learner's mastery level at any point of the scaffolded learning process.

With this notion, Day and Cordon [6] built and faded support in a sequence of authentic practice with five different support levels. The support consisted of a series of hints, ordered in terms of explicitness. Each practice was used as an assessment of learner's mastery of the learning task. Based on the learner's performance of the current practice, the instructor decided if it was the right time to reduce the current support level in the next practice. Their study provided a good scaffolding model which can be used in the scaffolded computer-based or integrated-media-based instruction. With the mass storage and dynamic ability of the computer, this model can be easily built, and quantitative evaluation data can be easily collected.

Under Day and Cordon's model, Kao and Lehman [12] proposed the basic elements of scaffolded instruction which are especially relevant to integrated-media design. They extended the example of an adult aiding a toddler [4] for illustration.

1. Hierarchical component skills. It is the instructor's responsibility to decompose the final task into hierarchical component skills based on the nature of the task and the learner's ability. In the example of an adult aiding a toddler, the child must learn how to balance on his feet before taking his first step, must learn how to balance on his first step before stretching out for the second.

2. Decreasing support levels. In the sense of support withdrawn, the instructor must recognize what kind of support is crucial in the learning and classify the support into decreasing levels. In the example of an adult aiding a toddler, the levels of support could be: helping by holding two hands, helping by holding one hand, helping by holding one finger, etc.

3. Repetitive authentic practice. The instructor has to set up a sequence of authentic practice involving the performance of the same skills. In the walking examp le, the child actually experiences the practical task, walking. The practice of walking involves the same component skills and the practice can be repeated in different realistic settings: walking on carpet, walking on solid ground, walking on sand, and so forth.

4. Ongoing assessment. The instructor must measure the learner's progress against the global picture of the task and make corrections when needed. In the walking example, the adult observes and measures the child's progress with each baby step. If holding one hand of the child doesn't keep his balance, the adult gives him the other hand right away. If the child walks well by holding one hand, the adult will consider letting him walk by holding only one finger.

Therefore, an operational definition of scaffolding could be as follows. The instructor or the more skillful peer decomposes the task into hierarchical sub-tasks, classifies the amount of support in decreasing levels, and sets up repetitive authentic practice. The practice begins with the highest level of support and the lowest level of sub-task. With the completion of each sub-task in the practice, the instructor measures the learner's performance and judges the level of support he/she should provide and lets the learner perfect the component sub-task that he/she can manage. The new technology of wireless applications even extends the abilities and territory of computers. The characteristics of interactivity, situating, and integration could facilitate the implication of the four basic elements of scaffolding. We believe the integration of scaffolding and wireless application will create an effective learning environment for our future classroom.

This work develops a mobile scaffolding-aid-based bird-watching system, and further investigate the impact of the mobility-learning activity for e-learners. The components of the scaffolding-aid learning contain the repetitive authentic practice, the hierarchical components, the decreasing support levels, and the ongoing assessment. To implement the scaffolding-aid-based system, a loop-structure is used to combine all components, as illustrated in Fig. 1. The purpose of the scaffolding-aid learning is to provide suitable scaffolding-aid, while the scaffolding aid level is determined according to the learning effect for each learner. With an ongoing assessment, each learner's learn ability can be formally evaluated. The scaffolding-aid nature is to eliminate the assistance or decrease the support-level when the leaner has better ability. During each repetitive authentic practice, the system must provide a hierarchical learning tools and skills to assist leaner to easily learn/accept the knowledge.

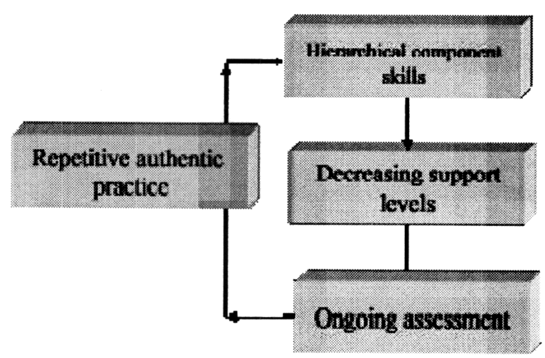

Figure 1: The structure of scaffolding-aid model.

This paper designs the mobile scaffolding-aid-based bird-watching system using the wireless communication technology. The challenge is to design a PDA-version and to implement scaffolding-aid model, as displayed in Fig. 1, on the PDA handheld devices.

3. The BWL system

3.1. The Wireless Ad-Hoc Learning Model

The bird-watching activity is designed and built on a wireless ad-hoc network [16, 17, 18, 19, 20] which is described below. The wireless mobile ad-hoc networking environment is formed by many mobile devices. Each e-learner keeps a mobile device which is a handheld device (PDAs) and a Wi-Fi (IEEE 802.11b protocol) wireless network card. Specially, one instructor has a small-sized mobile notebook with a Wi-Fi wireless network card and keeps a digital video camera. All e-learners and the instructor form a wireless ad-hoc network (MANET). The efficient wireless MANET communication protocols [16, 17, 18, 19, 20] developed supports the wireless transmission of the bird-picture and bird-information between e-learners. The scenario of a bird-watching activity based on a MANET is shown in Fig. 2.

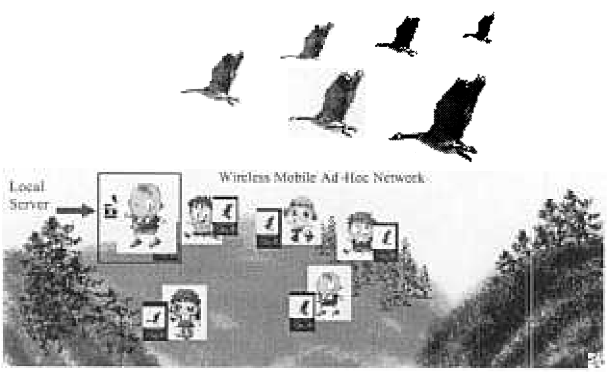

Figure 2: The scenario of a bird-watching activity.

3.2. The Implementation of Scaffolding-Aid Model

This subsection describes how to implement and operate the scaffolding-aid model in the BWL system. The major characteristic of scaffolding-aid model is to support structure-assistance during the learning process. The purpose of the BWL system is to support the structure-assistance. The less assistance provides, the more knowledge-owner will be. Observe that, the more assistance should be given for the beginner. If the beginner becomes a professional, then the less assistance is given. Our BWL system provides the different level of support for the knowledge-giving depending on the learner's capability. To reflect the learning effect, the BWL system additionally provides an on-line test mechanism.

3.2.1. Implementation of Hierarchical Component Skills. The BWL system offers a hierarchical component skills as follows. The component of the hierarchical component skills is divided into mobile bird-watching hardware and software.

First, the mobile bird-watching hardware includes a handheld device, PDAs, each having a IEEE 802.11b wireless network card. The handheld devices with a Wi-Fi wireless LAN card build a wireless ad-hoc learning environment. It is different learning environment for all leaners in the conventional classroom. The knowledge-acquiring is through the wireless handheld device, not the conventional book. E-learners naturally promote their learn willing when using the wireless handheld device.

Second, the mobile bird-watching software includes the following interfaces.

(1) *The wireless bird-watching interface:* This interface includes e-learner and e-instructor interfaces. First, the e-instructor interface supports the functions of wireless transmissions of the bird-picture and bird-video to e-learner interface.
(2) *The wireless bird-searching interface:* For hierarchically learning the bird-knowledge, the BWL system offers a data-mining bird-searching system to assist e-learner to easily search the bird-knowledge from the (3) *the wireless database interface*, as illustrated in Fig.2 and Fig. 3. The data-mining bird-searching system automatically produces bird-query conditions. Following the bird-searching system step-by-step, e-learner can acquire the bird-information and bird-knowledge smoothly and effectively. The data-mining bird-searching system additionally supports the different level of assistant functions (for **(4) implementation of decreasing support levels)** by adjusting the difficulty-level of bird-query conditions based on each e-learner's capability. Each e-leaner can be familiar with the bird-ecology and bird-knowledge step-by-step by using the wireless bird-searching interface.
(3) *The wireless bird-database interface:* A web-based bird-data is built on (http://140.115.155.87/twbd/pda/mini.html). Our BWL system builds the wireless bird-database interface on e-instructor's notebook. Each e-learner can dynamically query the bird-knowledge to/from the wireless bird-database through the wireless handheld device.
(4) *The wireless bird-searching trace file:* To more easily understand the bird-searching patterns, a trace file is created on e-instructor's notebook to record all bird-query actions for all e-learners during each bird-watching activity.

(a) (b) (c)

Figure 3: The bird-watching and searching interfaces.

3.2.2. Implementation of Repetitive Authentic Practice. The purpose of the repetitive authentic practice offers a bird-knowledge accumulation environment. To implement the repetitive authentic practice, we design three tests, including the pre-test, the middle-test, and the post-test, in a bird-watching activity, as illustrated in Fig. 4. The pre-test result can easily understand each e-learner's capability before the bird-watching activity. The post-test result can easily understand each e-learner's capability after the bird-watching activity. The middle-test is used to enhance the learn impress, since each e-learner in the middle-test can acquire the bird-knowledge by using the wireless bird-searching interface.

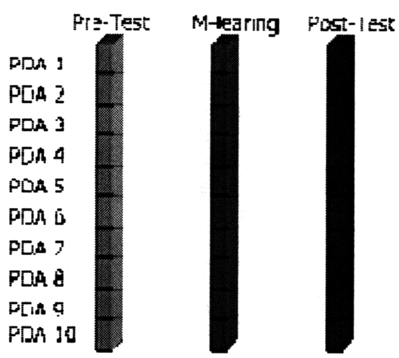

Figure 4: Three tests in a bird-watching activity.

3.2.3. Implementation of Ongoing Assessment. For each authentic practice, the teacher assists students in accordance with their learning efficiency. Therefore, an ongoing assessment system is designed, which is divided into the following interfaces.

(1) The wireless bird-question assignment interface: This interface is designed for e-instructors, Because the amount of bird-record in bird-database (http://140.115.155.87/twbd/pda/mini.html) is too huge, the wireless bird-question assignment interface provides a filter operation to filter bird-record from bird-database (about 535 Taiwan bird-records). The filter conditions contain *month* (from January to December), *altitude* (low, middle, high), and *ecological environment* (water area, forest, wide area). As illustrated in Fig. 5, 535 Taiwan bird-records may be filtered to 35 Taiwan bird-records under a giving filter condition. For instance, (*month*=January, *altitude*=low, *ecological environment*=water area). Finally, as illustrated in Fig. 5, the e-instructor selects 10 bird-questions from filtered bird-records, and to wireless transmit to (2) *wireless bird-answer interface* for all e-learners on the pre-test, the middle-test, and the post-test.

Figure 5: The Bird-question assignment interface

(2) The wireless bird-answer interface: Each e-learner do a bird-answer operation by using a pull-down window-interface as shown in Fig. 6. The pull-down window-interface offers a friendly input-interface for e-learners. All input-data under the bird-answer interface for all e-learners will be wireless transmitted to e-instructor's device to make a statistics table.

Figure 6: The wireless bird-answer interface.

(2) *The learn-statistics interface:* In a bird-watching activity, all answer-records are collected into e-instructor's device. Therefore, there are totally eighteen bird-test results for each e-learner in a season. Consequently, we design a learn-statistics interface, as displayed in Fig. 7, to understand the learn efficiency, where the *x*-axis denotes as the various tests, the *x*-axis is the score, and the *z*-axis presents all learners. Our system is implemented by two kinds of programs. The client program runs in PDA by using the RDA (remote data access), and server program runs in notebook by using the SQL 2000.

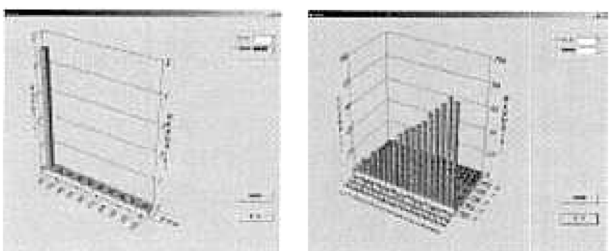

Figure 7: The learn-statistics interface.

3.2.4 Implementation of Decreasing Support Levels. To implement the decreasing support levels, we adjust the select-item number in the pull-down window based on the (3.2.3) ongoing-assessment result. Our system provides different level of assistance because each e-learner has different learning efficiency. For each e-learner, the selected-item number is three if the average score is lower than 40%. When the average score of e-learner is higher, the number of selected-item will be increased. This system attempts to use the select-item number in the pull-down window to describe the support levels. For example, as shown in Fig. 8, the selected-item number is three for e-learner, kept PDA 1, since its average score is lower than 40%. In addition, the selected-item number of our system can be four or five to decrease the support level if the learner has better average score.

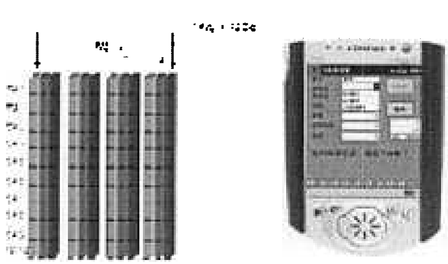

Figure 8: Example of decreasing support levels.

4. Formative Evaluation and Statistical Results

This section describes a formative evaluation to have the statistical results for the BWL system.

4.1. PDA as Tool for Individualized Learning

Ming-Tao at Taipei, Taiwan.

The PDA assisted procedure was applied for the whole bird-watching process. The PDA completely took over the role of the expert. The learners could only observe the static image of bird on PDA. They had to identify the key features of the bird on their own for searching. And the searching results are the only information they could learn about the bird. Along the process, the teacher only checked their searching results for correct or not.

The integration model was developed because the learners were divided into two experiment groups, one assisted with PDA, the other with the expert. The group with the expert completely followed the traditional bird-watching procedure. The PDA group was arranged at least four yards away from the traditional group. The integration model intent to simulate the PDA assisted bird-watching situation without the expert's attendance. It is more suitable for individualized learning.

4.4. Effects on Learning

This subsection mainly compares the learning performance of the three integration models in affective and cognitive domains.

4.4.1. Affective Domain: Feelings & Values. In evaluating the effect of affective learning, we first concern how the students' feelings and values affected by the PDA assisted bird-watching activities. The following data are collected at the third activity of each school.

The results show that most of students responses positively to the bird-watching activities, no matter which integration model was applied.

PDA as Tool for Mastery Learning- (Hsi-Men)

Questions	Highly Agree		Agree		No Opinion		Not Agree			
	f	%	f	%	f	%	f	%		
The activity is interesting	16	29	27	49	5	9	5	9	2	4

PDA as Tool for Discovery Learning- (Chang-Hsing)

Questions	Highly Agree	Agree	Not Agree	Highly Not Agree

	f	%	f	%	f	%	f	%
Birds are creatures with wisdom	13	**50**	11	**42**	2	8	0	0
Birds are creatures with motions	13	**50**	9	**35**	3	11	1	4
The Environment for birds has been destroyed	14	**54**	3	**11**	7	27	2	8

PDA as Tool for Individualized Learning- (Ming-Tao)

Response	f	%
Interesting	19	**86**
Expecting	1	5
Nice environment	1	5
No response	1	4
Total	22	100

4.4.2. Preferences. We next concern the learners' preference on PDA. The following two tables present the third time data we collected from His-Men and Chang-Hsing. For Ming-Tao, we present all the three time data to show the changes.

The data from model of mastery learning show vary possible response to PDA. On the other hand, the data from model of discovery learning show only 17% of students appreciated the assistance of PDA. The data from model of individualized learning present very interesting results. There are 38% of students felt nervous for first time using PDA. They are afraid of breaking the expensive equipment. The data of second time show competitive results on the percentage of preference to PDA and guidebook. However, the PDA was totally defeated by the guidebook in the last time. That is probably because the novel effect of PDA was gone and the students was not ready for individualized learning for lacking the bird-watching experience and modeling. The responses the students provided also indicated that the database of the bird-watching system v.1 is not sufficient enough in comparing with the guidebook.

4.4.3. Willingness. The last aspect we concern in the affective domain is to detect if the activities influence the learners' willingness to some related future actions. The following two tables report the corresponding data we collected from His-Men and Chang-Hsing.

PDA as Tool for Mastery Learning- (Hsi-Men)

Questions	Highly Agree		Agree		No Opinion		Not Agree		Highly Not Agree	
	f	%	f	%	f	%	f	%	f	%
Would like to seek for related information	11	**20**	28	**51**	9	16	7	13	0	0
Would like to buy bird-watching equipments	7	**13**	30	**55**	14	25	3	5	1	2
Would like to describe the birds you know to others	13	**24**	21	**38**	19	34	2	4	0	0
Would like to participate similar activities	26	**46**	27	**49**	3	5	0	0	0	0

PDA as Tool for Discovery Learning- (Chang-Hsing)

Questions	< 1		1-5		6-10		> 11	
	f	%	f	%	f	%	f	%
How many hours would you like to spend on bird watching	0	0	8	31	12	**46**	6	**23**
How many hours would you like to spend on bird protection	0	0	9	35	11	**42**	6	**23**

Either model of integration shows positive influence on students' willingness for actions.

4.4.4. Amount of Identification. The data from model of discovery learning seems to be normally distributed. 70% of the students reported that they could identify 6 to 15 kinds of birds. On the other hand, the data from model of individualized learning shows a right skew distribution. 45% of the students claimed they only could identify less than 5 kinds of birds. Again, it shows the students were too naive to perform individualized learning. It is important to provide enough guidance and support to scaffold students' knowledge construction.

4.4.5. Type of Measurements. The three participant school also developed their own measurements to evaluate students' learning in cognitive domain, including bird naming, counting, describing, drawing, feature marking, etc. Especially, the teachers of Hsi-Men elementary school incorporate the bird -watching activities into some course units of Nature Sciences. They designed logs and worksheets according the objectives of these course units. With their efforts, we believe the bird-watching activity could be even designed into a cross-subject theme-based instructional activity in the future.

5. Conclusion

This article designs a mobile scaffolding-aid-based bird-watching learning system, which aims to construct an outdoor mobility-learning activity under the up-to-date wireless technology. The BWL system contains a mobile learn sheet sub-system, which to integrate the scaffolding-aid learn model into the BWL system. Finally, we conduct a formative evaluation to provide statistical results.

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