

## Using text mining to retrieve educational affordances from documents

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**Abstract.** This study reports how to retrieve educational affordances from text mining technique on text documents. To address this issue, we employed a learning environment and conducted a natural science learning in classrooms and at the Guandu Nature Park for eight weeks. Detailed studies of how the students use EULER and how this course affects their learning have been recorded in text documents given by students in an open-question survey, interviews, observations, and student discussions. This study retrieved thirteen educational affordances that were extracted from the text documents via text mining technique. These educational affordances have implications for current and future developments in pedagogy.

**Keywords:** educational affordances, game-based learning, natural science learning, text mining, ubiquitous computing

### 1. Introduction

Knowledge discovery is the process of finding implicit information, potential value, and useful knowledge from data [1]. The most well-known branch of Knowledge discovery is data mining. Data Mining (DM) or Knowledge Discovery in Databases (KDD) is the process of identifying novel and understandable patterns in data [2]. Data mining seeks not only information but discovers deep knowledge embedded within the data by applying computational techniques, usually in the form of a learning algorithm, to find potentially useful patterns in the data. Text mining (TM) or Knowledge Discovery in Text (KDT), the process of finding useful or interesting patterns, models, directions, trends, or rules from unstructured text, is used to describe the application of data mining techniques to automated discovery of knowledge from text [2][3][4]. Typical text mining tasks include text categorization, text clustering, concept/entity extraction, production of granular taxonomies, sentiment analysis, document summarization, and entity relation modeling. Current methods in text mining use keywords, term weighting, or association rules to represent text content. Keywords have been used to explore connectivity and consistency within a collection of documents. Ellman and Tait used keywords to explore the connectivity and consistency within texts[6].

The term “affordance” was coined by the perceptual psychologist J. J. Gibson, who developed an “ecological” alternative to cognitive approaches [6]. Gibson defined affordances as what the environment offers to humans and what it provides or furnishes, which may be for good or ill; it emphasizes possible actions that the observer perceives as feasible in the environment [6]. Norman makes clear in an endnote in *Psychology of Everyday Things* POET that he is deviating from the Gibsonian definition of affordances [9]. Norman defined that the affordance refers to the perceived and actual (or real) properties of the thing, primarily those fundamental properties that determine just how the thing could possibly be used. A chair affords (‘is for’) support and, therefore, affords sitting. A chair can also be carried [9]. According to Norman’s opinion, the affordance would only exist if there was information to specify the possibility for action and the actor had learned how to interpret the information.

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Norman indicates that an affordance refers primarily to the fundamental properties of an object. Gibson, on the other hand, does not make the distinction between the different affordances of an object. Another important difference is that for Norman there is no actor as a frame of reference. Gibson claims that the existence of affordances is independent of an actor's experience and culture. Norman, on the other hand, tightly couples affordances with past knowledge and experience. Kirschner further defined educational affordances as those characteristics of an artifact that determine if and how a particular learning behavior can possibly be enacted within a given context [8].

To describe the relationship of affordance and purpose, some samples are provided. First, the actual affordance of a chair is "Sittability," therefore, the actual purpose of a chair is "working." But, the one of perceived affordances of a chair is "Lieability," therefore the perceived purpose of a chair is "Sleeping." Second, the actual affordance of a screwdriver is "Rotatability," therefore the actual purpose of a screwdriver is "Rotating screw." But, the one of perceived affordances of a screwdriver is "Supportability," therefore the perceived purpose of a screwdriver is "Opening the biscuit barrel." Similarly, the actual affordance of browser is "Knowledge Accession," therefore, the actual purpose of browser is "Constructing knowledge." Moreover, the one of perceived affordances of browser is "Ubiquitous Revision," therefore the perceived purpose of browser is "improving performance." Table 1 represents the relationship of education affordances and goal. This study reports how to retrieve educational affordances from text mining technique on text documents.

Table 1. Relationship of education affordance and goal

Type	Actual Affordance	Goal	Perceived Affordance	Goal
Chair	Sittability	Working	Lieability	Sleeping
Screwdriver	Rotatability	Rotating screw	Supportability	Opening the biscuit barrel
m-Browser	Knowledge Accession	Constructing knowledge	Ubiquitous Revision	Improving performance

## 2. Methodology

A case study through a series of experiments was conducted using the EULER in a classroom and at a wetland for an eight-week course. Participants included four teachers and 36 fifth-grade students.

### 2.1. System functionalities

This study employed the ubiquitous learning environment—EULER—to help natural science learning. EULER consists of two subsystems, Mobile Interactive Learning Environment (MOBILE) server, which is a learning management system and m-Tools which has fourteen functions, such as m-Messenger (receiving teacher guidance), m-RFID (processing RFID internal code), m-Loader (accessing course materials), m-Browser (browsing the contents), m-Player (playing multimedia files), m-AR (displaying virtual objects), m-Capture (recording videos and static photos), m-Notes (compiling information into articles), m-Sharer (sending data to peers), m-Test (taking tests), m-Calendar (organizing personal schedules), m-Voting (presenting personal idea), and m-Portfolio (recording personal learning records). The personal learning portfolio was saved in the m-DB. Fig. 1 illustrates the functionalities of EULER.

### 2.2. Course

The course was entitled "How can the gradually disappearing wetland ecosystems in Taiwan be protected and restored?" The course includes the following five activities. Activity 1, the "Understanding the ecology of wetlands," was undertaken in the classroom. By using their PDAs, the students perused course materials and browsed media resources from EULER, collected information from the Internet, and shared knowledge with their classmates in order to understand the creatures and environment of the wetlands.

In activity 2, "Treasure hunt game" activity, the teachers established the relationship between learning materials and the identification codes of RFID tags and then placed the information boards near the corresponding wetland creatures. Each student carried a mobile device equipped with a video camera and an RFID reader when visiting scenic areas using the treasure map. Each student approaching a scenic area could use the learning device to identify the RFID tag. The detected identification code of the RFID tag was then transmitted via WLAN to the MOBILE server. The MOBILE server recognized the location of the student and then transmitted the context-aware content to the learning device. After completing a learning unit at one

scenic area, he/she then continued to the next scenic area until all five areas had been visited. Fig. 2 illustrates the scenario of treasure hunt game [9].

In activity 3, “Wetland rescue” activity, the students selected a team project from among the themes. In case the students were unable to propose any feasible method even after group discussions, they used the messenger tool (m-Messenger) to request the teacher’s assistance. Under the guidance of the teacher, team members applied m-Capture to capture images or videos as evidential materials. Each team member organized and collected evidential materials and retrieved relevant information from the MOBILE server and then compiled these materials into an article. The members engaged themselves in a group discussion on the basis of the articles and drew an inference for a selected problem. All articles were then sent to team leaders to edit a rich team report that was submitted to teachers by using sharing tool (m-Sharer).

In activity 4, “Unexpected encounter” activity, each student utilized the AR tool (m-AR) to watch virtual wildlife that would rarely appear in the wetland area during the season. When students approaching a scenic area, the MOBILE server recognized the location of the student and season and then transmitted a virtual animation of wildlife to the students’ learning device. Therefore, the students could understand wildlife that usually appeared in this area. In activity 5, on completion of the course, teachers and researchers conducted an open-question survey, a yes/no- question survey, and in-depth interviews.

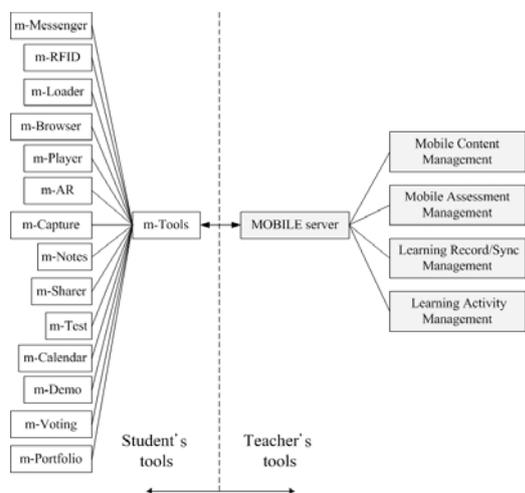


Fig. 1: Functionalities of EULER

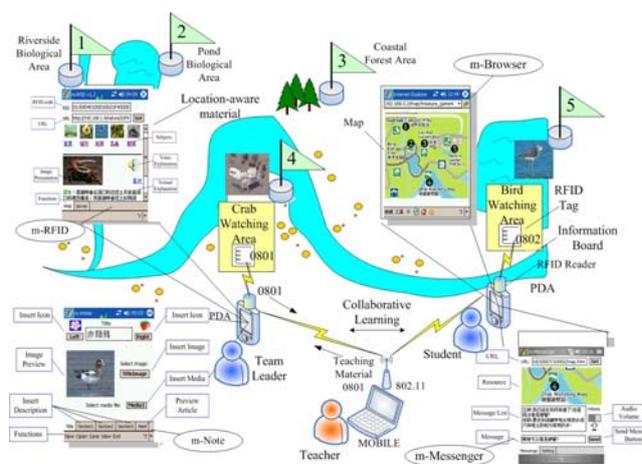


Fig. 2: The scenario of treasure hunt game

### 2.3. Data sources

Data sources for this case included the students’ written responses to the survey questions, transcripts of in-depth interviews, on-line student discussions, and the researchers’ written observation notes. The survey included the following open-ended questions. (Q1) How did you utilize m-Tools to assist you in the “Understanding the ecology of wetlands” activity? (Q2) How did you utilize m-Tools to assist you in the “Treasure hunt game”? (Q3) How did you utilize m-Tools to complete the “Wetland rescue” activity? (Q4) How did you utilize m-Tools to complete the “Unexpected encounter” activity? In-depth interviews were conducted to explore the students’ points of view, feelings, and perspectives after they completed all the learning activities. The interviews comprised the following questions: (I1) Which activity do you think is the most interesting? Why? (I2) Which tool do you think is the most useful for aiding in learning? Why? (I3) From which activity do you think you gained the most? Why? (I4) What is your biggest gain from this course? Why? (I5) What new uses for m-Tools in the learning activities did you discover?

Finally, we obtained 36 open-ended questionnaires (response rate is 100%), 28 interview records, records on 36 topics of discussion, 15 observation records, 6 team reports. Teachers and tutors helped students to understand the meaning of each question. The 36 response questionnaires comprised 218 responses and were collected from the students.

### 2.4. Data analyses

The data were collected, organized, and reviewed by researchers who manually use the text mining technique on features extraction and based on the following steps to obtain the educational affordances:

Step 1. Each student's response was assigned a number, for example, r-q3-s7 indicates the response to question#3 by student number 7.

Step 2. Extract keywords about educational affordances manually from each student's responses, such as the keyword "data collection."

Step 3. Arrange the distinct keywords that were regarded as educational affordances, from all extracted keywords.

For example, student 6 stated "I wanted to know whether all crabs move sideways. I employed the browsing tool (m-Browser) to find the answer from MOBILE server, and I found that the soldier crab (*Mictyris brevidactylus*), is an exception. Using these ubiquitous learning tools, I could easily acquire new knowledge." We got the keywords 'browsing', 'find the answer', and 'knowledge' from the statement.

### 3. Results

Table 2. Summary of educational affordances of a ubiquitous learning environment in a natural science course

Text statement	Keywords	Educational Affordances
<b>1. Actual affordances</b>		
Student#13(r-q2-s13): I used browsing tools (m-Browser) to look up the name and detailed information about the crab I saw on the seaside. The detailed information included what the crab eats, its physical shape, how to distinguish its gender, etc.. With the tool, I could easily observe animals and look up related information outdoors.	Access materials, read lectures, and play medias	Unconstrained Knowledge Accession
Student#32(r-q3-s32): The test results of our team were unsatisfactory. However, we were good at using the image capturing (m-Capture), audio recording, and editing tools (m-Notes) provided by the system, so our report was highly rated.	Evaluate outcome, examine reports, present intend, and evaluate portfolio	Real-time Evaluation
Student#24(r-q1-s24): I would input test schedules into m-Calendar in advance. One week before every test, the m-Calendar would automatically alert me of the coming test, which gave me sufficient preparation time.	Organize personal schedule	Individuality
Teacher#1(r-i4-t1): After students finishing their report and submitting it to teacher via wireless networks, teacher could immediately grad their report and presented it to other classmates with the aid of demonstration tool (m-Demo). I also could point out the strengths and weaknesses of students' reports. Therefore, I think this convenient tool can help students present and share their works (m-Share).	Share information, present ideas, and present intent, and interact with teachers and classmate	Diverse Interaction
In the discussion forum, a student said, 'In the "Wetland rescue" activity, I easily used m-Capture to take snapshots of the special things I observed, such as a crab digging up its cave, a crab swallowing sand, and a dragonfly perching on a leaf. (d-s15)	Collect videos, audios, images, articles and data	Arbitrary Data collection
Student#15(r-q2-s15): In the outdoor learning activity, when we arrived at the crab watching area, the PDA automatically provided us with learning materials.	Retrieve context-aware materials, and play ubiquitous game	Ubiquitous Game play
Teacher#1(r-i1-t1): When students walked into a learning area for an outdoor learning activity, the context-aware tool (m-RFID) on their PDA could detect their location and tell the PDA to download relevant materials for them. For instance, when a student approached the pond, the PDA immediately displayed materials related to insects in the pond.	Retrieve context-aware data, play media, combine courses with real world, and observe wildlife behavior	Authentic Context-awareness
In the interview, a student said, "With the augmented reality tool (m-AR), I could see a virtual dragonfly perching on a stone(r-i2-s18)."	Combine virtual and real world objects as well as provide contextual conceptualization	Vivid Immersion
<b>2. Perceived affordances</b>		
Student#28(r-q3-s28): When I watched birds, I heard the graceful sounds of birds. I then used the audio-recording tool to record the sounds and save them in the PDA. These tools helped me a lot when collecting animal sounds and when preparing my homework.	Access materials, collect data, play media, calculation, and compile reports	Skillful Application
According to the observations, students could learn how to analyze a problem and then form a conclusion. Therefore, the analytical process emphasizes the students' abilities to differentiate, organize, and attribute abilities (o-s1, 4, 11, 16, 22, 26, & 30)	Collect data, observe wildlife, analyze data, and make a conclusion	Methodical Analysis
Student#21(r-i5-s21): I used multimedia tools to collect many graphic and video files during outdoor learning and utilized the editing tool to integrate these files into a vivid multimedia-based webpage comprised of text, sounds, graphics, and video.	Integrate learning objects into productions	Creative Synthesis
Student#29(r-i5-s29): The PDA has an audio player function. I would store the mp3 files of the lessons in the PDA and listen to them while taking the mass transit system.	Browse learning materials, and review learning materials at any time and place	Ubiquitous Revision
Student#25(r-q3-s25): Our group used sharing tool (m-Share) to transfer the animal data that we gathered to the leader. The leader prepared a report and shared it with all the group members.	Share information, share experience, complete a common task, and produce team reports	Seamless Collaboration

Analysis of all data sources revealed eight actual educational affordances and five perceived educational affordances. The organization of the aforementioned results and discussion and the relation between the identified educational affordances, learners' actions, and educational goals are summarized in Table 2. Through the ubiquitous learning environment and natural science course offering the educational affordances, the learners' actions enabled their learning to achieve the educational goals they pursued.

#### 4. Conclusions

This study uses text mining technique to retrieve thirteen educational affordances divided into two categories. The ubiquitous learning environment and course provided eight actual educational affordances, which included unconstrained knowledge accession, real-time evaluation, individuality, diverse interaction, arbitrary data collection, ubiquitous game play, authentic context-awareness, and vivid immersion.

The educational affordances explicated in this study should be useful to teachers when they employ ubiquitous computing technology, rich educational resources, and diverse pedagogical tactics to improve the student learning effect and help students achieve their learning goals. Moreover, the educational affordances of ubiquitous learning environment employed in the natural science course have implications for current and future developments in pedagogy. Our future research will be dedicated to investigating the differences in educational affordances between different instructional environments and open courses using different learning tools, learning contexts, learning affections, theme-based activities, and instructional strategies.

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