Building a Mobile Collaborative Learning Environment for the Identification and Classification of Real World Objects

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Abstract. This paper describes the theoretical framework and in-progress implementation of the Collaborative Identification, Retrieval, and Classification Learning Environment (CIRCLE). CIRCLE uses recent research findings in collaboration, constructivism, mobile development, and retrieval learning to develop a multi-user tool for the identification and classification of real world objects. CIRCLE supports group efforts at taxonomy building by providing a framework for data gathering in the field and scientific hypothesizing and debate in a virtual laboratory. Future plans include a pilot usability study and classroom experiments to determine the effectiveness of the approach towards learning the identification of rocks and minerals (in a geology lab), weeds (in a weed identification course), and animals (in an ecology class).

Keywords: Collaborative learning · Constructivism · Mobile application · Identification and classification games

1 Introduction

Identification and classification games are not new. Classification games abound on the Internet and in mobile app stores [3–7]. Rather than socially-mediated, actively constructing knowledge, as in Vygotsky's social constructivism [8], these identification games provide a method for retrieval learning. This theory suggests that the act of retrieving knowledge in multiple different ways results in better learning outcomes [9].

Pervasive and location-based mobile gaming serves to harness the locative functionalities of mobile devices to supplement the real world with virtual information. Pervasive games "pervade" the user's life, in contrast to games that occur at one particular time and place. Montola defines a game as an activity that involves a certain set of individuals that occurs at a particular place and at a particular time [10]. He further states that a pervasive game expands on this definition along social, spatial, or temporal dimensions. Social expansion means that people not playing the game can still participate within the game structure. Spatial expansion means that a pervasive game can be played anywhere, while temporal expansion means that a pervasive game can be playing at any time.

Even before computers, students were memorizing "things" using flashcards. A number of studies have been performed to determine effective ways to improve

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learning while using flashcards [1, 2]. In addition to physical artifacts for learning identification tasks, students handle actual physical specimens in a lab or real world setting. This project seeks to enhance even these highly effective methods of learning by putting the gathering and organization of content in users' hands.

Location-based games are a subset of pervasive games, where a fixed location is used within the mechanics of the game itself. Location-based games use the environment to augment the players' experience. For example, MicroBlog [11] asks players to take pictures of their environment to share them with other users, using the environment as part of the game. In these games, a parallel world is created in virtual space. Individuals interact with this virtual world by going to real world locations. Other location based games that use user-generated content include Gopher [12] and Indigator [13].

Within this discipline, distinctions are made between designed activity and user-generated activity in mobile settings [14]. Designed activities are developed by programmers, designers, and experts with a specific pedagogical plan in place. User-generated activity is content and structure spontaneously created by users to meet their own learning needs.

A number of designed activities have been created for a variety of different subjects and situations including games for geometry learning in an outdoor setting [15], as museum guides [16], in college orientation sessions [17], in biology topics including genetics, protein synthesis, evolution, and food webs [18], and in weather forecasting [19]. While designed activities are important to provide guided opportunities for learning, the Internet allows individuals to guide and create their own learning affordances. This self-directed learning is intrinsic to this research project.

The combination of social constructivist principles that guide collaborative, user generated, multiplayer mobile games and retrieval learning that inform identification games provides an opportunity to create a new application for concept learning. We call this application CIRCLE, the Collaborative Identification, Retrieval, and Classification Learning Environment.

2 Implementation

CIRCLE is composed of five different activities: content acquisition, trait elaboration, hypothesis formation, tree construction, and game play. Students will be tracked to observe their use of the system and identify the amount of time they spend during each activity. Within the application, students can take on various collaborative roles, each correlated to one of the five activities.

2.1 Content Acquisition

First, students go out into the field using a mobile device to collect identifiable objects from the real world. The student will collect photographs, video, and audio where appropriate for the object under study. These multimedia artifacts are uploaded to a central server, where other users will be able to interact with them in real-time.

Students performing this role will be identified as gatherers. An example task for a gatherer would be to take a photograph of the interesting trees or rocks in their neighborhood.

2.2 Trait Elaboration

Second, students look at acquired content from their group and offer suggestions on traits to observe or experiments to conduct to further refine a potential identification. The originating student then performs the requested experiments and observations to elaborate on the content either by performing them immediately, if feedback is prompt, or return to the object under study. As experiments provide attributes for features (traits) these will be stored for use by future students. For example, the first person to suggest a 'hardness' experiment using a 'glass plate' to classify a mineral will have those items stored in the system. Or a player might just observe from the photographic evidence the tree is covered with sharp needles, not leaves, and store that information in the system. Later players will be able to choose these observational or experimental results from the inventory. Students in this stage will be identified as elaborators. Continuing the rock example, an elaborator would suggest an acid test be performed on the neighborhood rock specimen.

2.3 Hypothesis Formation

Third, students offer hypotheses about the general classification or precise identity of the unidentified object. Eventually, an expert (typically the teacher) will verify the hypothesis. In absence of an expert, hypotheses could be voted upon, where more votes could be measured as a confidence in an identification. Students in this role would be called identifiers, and would offer the category "Conifer" in the tree example, or suggest "Limestone" in the rock example.

2.4 Taxonomy Construction

Fourth, students build versions of identification trees together. Traits and experiments will be shown graphically as potential branches, while the content collected by students will be the leaves. Students will move the nodes and leaves around in real time, seeing how other students are arranging the tree and offering suggestions for node placement. Players in this role will be called constructors. After enough identifications have been made in the hypothesis formation stage, constructors can build dichotomous keys of the trees or rocks.

2.5 Game Play

Finally, games are automatically created by the system based on gathered content. Students are given multimedia, traits, observations, and experiments and are asked to identify the object in game form. Students in this role will be called players. These students will play identification games similar to flashcards to help them retrieve knowledge they have gained from working in the other four stages.

Observing students in each of these stages may result in the identification of roles that are motivating or act to increase student learning. Ideally, students of all roles will:

(a) Learn how to identify objects in the real world within their discipline of interest
(b) Determine the observations and experiments necessary to accurately identify these objects
(c) Classify these objects for faster identifications
(d) Use retrieval learning to strengthen their knowledge
(e) Gain collaboration skills

Ultimately, CIRCLE is an innovative approach to identification and classification that combines successful attributes of other environments into one. CIRCLE will utilize effective learning science principles, harness the advantages and inherent motivation of user generated content, including images, videos, sound, and text, allow for synchronous and asynchronous collaborative interactions, create a system of juried peer review of results and hypotheses, and finally create computationally generated “flashcard” games to strengthen student learning.

3 Rationale for Implementation

According to constructivist theorists, students combine their prior understanding and new information to actively construct new knowledge [20]. This learning is created within a social context. A person’s culture, environment, and social context combine to affect the construction of knowledge. This idea lies at the heart of social constructivism [21]. Individuals create new knowledge mediated by interactions with other human beings and with the environment. These interactions can be structured so that learning is indifferent, compromised, or supported by the efforts of other individuals. Social interdependence theory describes these interactions as being individualistic, competitive, and cooperative, respectively [22–25].

Individualistic behavior is characterized by people working towards their own personal goals. The success or failures of others do not matter to the successful completion of their goals. While this approach towards learning can be effective, it has a number of negative side effects. People working individualistically tend to have lower psychological health, including lower self-esteem and higher anxiety [26]. They also do not gain the benefits of cooperative learning listed below.

Competition is characterized by the requirement that other people must fail in order for one to achieve personal goals. Competition increases self-acceptance based on meeting external standards and expectations [27], reduces effort in lower achieving students (to reduce negative self-worth), decreases effort in high achieving students when they realize they’ll always “win” [28], marginalizes weaker, lower achieving members, and moves student focus from the process of the task to the end result [29]. Because of these drawbacks, CIRCLE focuses on cooperative learning.

Cooperative learning provides many benefits to students including: an increase in academic skills [30–33], misconception identification and repair [34–36], collaborative work skills [34], the insight that the sum of individual knowledge is greater than the parts [37], the development of social skills [38], and the strengthening of inter-group relations [33].

These many benefits do not come simply by placing individuals into a group and giving them a task. Certain conditions must be met to create the most effective group dynamic. The ideal cooperative group fosters 5 primary conditions: positive interdependence, individual accountability, promotive interaction, social skills, and group processing [25, 39].

Positive interdependence is achieved when group members depend on each other for skills, talents, and knowledge to advance shared group goals. All group members believe that all other members are needed to succeed in the task at hand. Positive interdependence in CIRCLE will be enforced using game rules. For example, a certain number of people in the group will need to offer evidence on the identity of an object.

Individual accountability means that all members of a group must participate in the shared tasks and all actions should be visible to the group. No one should do all the work, nor should anyone do no work at all. This will be enforced in CIRCLE by means of a group status window, where the number of interactions each user has completed and when they completed it can be viewed by all members of the group.

Promotive interaction means that students actively communicate with one another in the group to achieve group goals. CIRCLE will include communication mediums so that students can discuss hypotheses, potential observations, and dichotomous key construction both synchronously and asynchronously.

Social skills are also required for positive group interactions. While not envisioned for the first iteration of CIRCLE, social skills could be prompted from students. For example, a student that is not participating could be encouraged to voice their opinion. Students could also be given a lesson on appropriate social skills or proper etiquette when discussing topics in an online setting. Soller [40] instructs users to use sentence "openers" rather than allowing students to type in a free form text box. Her system uses these sentence openers to guide users to more effective conversation skills.

Finally, group processing occurs when groups reflect on their progress towards group goals. Message boards with appropriate prompts provide an opportunity for students to state how they feel the group is progressing towards the creation of their classification structures, or make suggestions on how to improve the group process.

Once students have successfully co-created knowledge in their cooperative groups, they need a way to reinforce this understanding. This reinforcement occurs when a student's knowledge is assessed. This assessment can come at the end of a lesson in the form of summative assessments, or during the lesson in the form of formative assessments. Ongoing, formative assessment is the key to higher learning gains [41]. Studies in retrieval learning have shown that students learn best when they actively attempt to "retrieve" the knowledge from memory during self-assessment, as opposed to re-reading study materials [9].

Flashcards can be used effectively to retrieve knowledge from memory [1, 2]. Ideally, we hope to show that CIRCLE will provide a more interesting and potentially motivating method in the form of identification games. The final "game play" portion of the activity can be varied substantially. Students could be given an image or other multimedia content, a list of characteristics, or an example of where the object could be found. The number of images, and thus, the number of different available contexts, would only be limited by the number of images taken by the users. This combination of well-motivated learners, cooperative and collaborative co-construction of knowledge, and focused retrieval should provide an opportunity to help students learn identification and classification tasks in a more entertaining and effective way.

4 Discussion/Future Work

Implementation of CIRCLE is ongoing as a part of the primary author's Ph.D. dissertation. Upon completion of the described implementation, a series of experiments are planned to determine the usability and educational effectiveness of the proposed work.

A pilot study is planned to be held during May 2014. Approximately 20 STEM Education faculty and graduate students from North Dakota State University (NDSU) will be involved. Subjects will be divided into two groups: a software group and a manual group. Both groups will be given a bag of candy to identify and classify into a dichotomous key. The software group will use CIRCLE as described, making note of any difficulties they encounter. The manual group will use paper and pencil to perform the same task. The groups will be video recorded to determine similarities and differences in the identification and classification of objects in both a virtual and non-virtual setting. A secondary objective of the research is to determine any software errors and usability issues that exist in the initial prototype of CIRCLE. The Software Usability Scale [42] will be administered to the software group upon completion of their tasks. This will be a useful first step, as these users come from fields as diverse as biology, chemistry, and mathematics, and will provide excellent feedback.

After the completion of the pilot study, further experiments are planned for actual classroom implementation. Three separate courses at NDSU have been identified for the use of CIRCLE. These courses include introductory geology lab, weed identification, and ecology. In these classrooms, subjects in different course sections will either use the original method of teaching identification or CIRCLE. This will provide feedback on whether the software is educationally effective or not. Since CIRCLE is an online tool, data will also be collected on what particular tasks students do, when they do them, how long it takes them, and how they interact with other students. This collection of data can also be analyzed to characterize patterns of student use and how it compares to expert use of the system.

CIRCLE is available online at circle.cs.ndsu.nodak.edu.

References

1. Nist, L., Joseph, L.M.: Effectiveness and efficiency of flashcard drill instructional methods on Urban first-graders' word recognition, acquisition, maintenance, and generalization. Sch. Psychol. Rev. **37**(3), 294–308 (2008)

2. Kornell, N.: Optimising learning using flashcards: spacing is more effective than cramming. Appl. Cogn. Psychol. **23**(9), 1297–1317 (2009)
3. Game Fish Identification. http://appshopper.com/games/game-fish-identification
4. Engine Identification Game. http://www.americantorque.com/game/engine-id/
5. Geobirds. http://geobirds.com/play
6. Identify Rock Types Game. http://www.kidsgeo.com/geology-games/rocks-game.php
7. Letter Learning Game. http://kinderwebgames.com/a.html
8. Vygotsky, L.S.: Mind in Society: The Development of Higher Psychological Processes. (M. Cole, Trans.). Harvard University Press, Cambridge (1978)
9. Karpicke, J.D.: Retrieval-based learning: active retrieval promotes meaningful learning. Curr. Dir. Psychol. Sci. **21**(3), 157–163 (2012)
10. Montola, M.: Exploring the edge of the magic circle: defining pervasive games. In: Proceedings of DAC (2005)
11. Gaonkar, S., Li, J., Choudhury, R.R., Cox, L., Schmidt, A.: Micro-blog: sharing and querying content through mobile phones and social participation. In: Proceedings of the 6th International Conference on Mobile Systems, Applications, and Services. Breckenridge, CO, USA (2008)
12. Casey, S., Kirman, B., Rowland, D.: The gopher game: a social, mobile, locative game with user generated content and peer review. In: Proceedings of the International Conference on Advances in Computer Entertainment Technology. Salzburg, Austria (2007)
13. Lee, C.S., Goh, D. H.-L., Chua, A.Y.K., Ang, R.P.: Indagator: investigating perceived gratifications of an application that blends mobile content sharing with gameplay. J. Amer. Soc. Inf. Sci. Technol. **61**(6), 1244–1257 (2010)
14. Kukulska-Hulme, A., Traxler, J., Pettit, J.: Designed and user-generated activity in the mobile age. J. Learn. Des. **2**(1), 52–65 (2007)
15. Wijers, M., Jonker, V., Drijvers, P.: MobileMath: exploring mathematics outside the classroom. ZDM **42**(7), 789–799 (2010)
16. Grinter, R.E., Aoki, P.M., Szymanski, M.H., Thornton, J.D., Woodruff, A., Hurst, A.: Revisiting the visit: understanding how technology can shape the museum visit. In: Proceedings of the 2002 ACM Conference on CSCW. New Orleans, LA, USA (2002)
17. Schwabe, G., Göth, C.: Mobile learning with a mobile game: design and motivational effects. J. Comput. Assist. Learn. **21**(3), 204–216 (2005)
18. Perry, J., Rosenheck, L.: UbiqBio: a playful approach to learning biology with mobile games. In: 2012 Conference for the ISTE. San Diego, CA (2012)
19. Klopfer, E., Sheldon, J., Perry, J., Chen, V.H.H.: Ubiquitous games for learning (UbiqGames): Weatherlings, a worked example. J. Comput. Assist. Learn. **28**(5), 465–476 (2012)
20. Richardson, V.: Constructivist pedagogy. Teachers Coll. Rec. **105**(9), 1623–1640 (2003)
21. Palincsar, A.S.: Social constructivist perspectives on teaching and learning. Ann. Rev. Psychol. **49**(1), 345–375 (1998)
22. Deutsch, M.: A theory of co-operation and competition. Hum. Relat. **2**(2), 129–152 (1949)
23. Deutsch, M.: Cooperation and trust: some theoretical notes. In: Nebraska Symposium on Motivation, pp. 275–320. University of Nebraska Press, Oxford, England (1962)
24. Johnson, D.W.: Social psychology of education. Holt, Rinehart and Winston, New York (1970)
25. Johnson, D.W., Johnson, R.: Cooperation and Competition: Theory and Research. Interaction Book Company, Edina (1989)
26. Johnson, D.W., Johnson, R.T., Smith, K.: The state of cooperative learning in postsecondary and professional settings. Educ. Psychol. Rev. **19**(1), 15–29 (2007)

27. Norem-Hebeisen, A.A., Johnson, D.W.: The relationship between cooperative, competitive, and individualistic attitudes and differentiated aspects of self-esteem. J. Pers. **49**(4), 415–426 (1981)
28. Wang, X.H., Yang, B.: Why competition may discourage students from learning? Behav. Econ. Anal. Educ. Econ. **11**(2), 117–128 (2003)
29. Shindler, J.: Transformative classroom management: positive strategies to engage all students and promote a psychology of success. Jossey-Bass, San Francisco (2010)
30. Sharan, S., Sharan, Y.: Small-Group Teaching. Educational Technology Publications, Englewood Cliffs (1978)
31. Johnson, D.W., Johnson, R.T.: Living Together and Alone: Cooperative, Competitive, and Individualistic Learning. Prentice Hall, Englewood Cliffs (1991)
32. Kagan, S.: Cooperative Learning. Kagan Cooperative Learning, San Juan Capistrano (1994)
33. Slavin, R.E.: Cooperative Learning, 2nd edn. Allyn and Bacon, Boston (1995)
34. Brown, J.S., Collins, A., Duguid, P.: Situated cognition and the culture of learning. Educ. Res. **18**(1), 32–42 (1989)
35. Janis, I.L.: Victims of Groupthink. Houghton Mifflin Company, Boston (1972)
36. Koschmann, T., Kelson, A.C., Feltovich, P.J., Barrows, H.S.: Computer-supported problem based learning: a principled approach to the use of computers in collaborative learning. In: Koschmann, T. (ed.) CSCL: Theory and Practice of an Emerging Paradigm, p. 100. Lawrence Erlbaum Associates, Mahwah (1996)
37. Feltovich, P.J., Spiro, R.J., Coulson, R.L., Feltovich, J.: Collaboration within and among minds: mastering complexity, individually and in groups. In: Koschmann, T. (ed.) CSCL: Theory and Practice of an Emerging Paradigm, pp. 25–44. Lawrence Erlbaum Associates, Mahwah (1996)
38. Goldman, S.V.: Mediating microworlds: collaboration on high school science activities. In: Koschmann, T. (ed.) CSCL: Theory and Practice of an Emerging Paradigm, pp. 45–81. Lawrence Erlbaum Associates, Mahwah (1996)
39. Johnson, D.W., Johnson, R., Holubec, E.: Cooperation in the Classroom, 7th edn. Interaction Book Company, Edina (1998)
40. Soller, A.: Supporting social interaction in an intelligent collaborative learning system. IJAIED **12**, 40–62 (2001)
41. Wiliam, D.: What does Research say the Benefits of Formative Assessment are? Research Brief. National Council of Teachers of Mathematics, Reston (2007)
42. Brooke, J.: SUS: A Quick and Dirty Usability Scale. Usability Evaluation in Industry, pp. 189–194. Taylor & Francis, London (1996)