Knowledge Places: Embedding Knowledge in the Space of the Classroom

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ABSTRACT

This research investigates a novel approach to supporting classroom learning communities through the use of proxemic interaction and ambient visualizations. Specifically, community knowledge is embedded within the physical space of the classroom, with the aim of mediating opportunistic inter-group interactions, instigated through proximity and shared artifacts. This approach entails decomposing the community knowledge-base into a collection of independent thematic sub-stores, and then conceptually distributing those sub-stores to mapped, demarcated locations around the classroom, called "Knowledge Places." This necessitates physical movement among and proximity to those places in order for students to contribute to or otherwise access their peers' contributions to the emerging knowledge-base. The present research studies the materialization of Knowledge Places over the course of ten weeks within a sixth-grade life science curriculum, with topics of food webs and ecosystems.

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KEYWORDS

Ubiquitous Computing; Internet Of Things; IOT; Proxemic Interaction; Embodied Interaction; Location-Based Interaction; Ambient Visualization; Collaboration; Pedagogy; Education

Figure 1: The WallCology "Wallscope" displays presented animated views of ecosystems presumed to occupy the walls of the classroom.

INTRODUCTION

How can technology support students in building knowledge and working together as a community? One recent model that informs the design of such “learning community” curriculum [3,4], emphasizes the co-construction of knowledge with a high level of student agency and responsibility for collecting ideas, developing questions, exchanging and critiquing ideas with peers, and evaluating their own progress. Prior research on knowledge building environments has successfully advocated for a cloud-based approach to knowledge aggregation, representation and use (i.e., through a centralized web-based knowledge repository for contributing to and accessing emerging community knowledge [15]). While cloud-based designs can be successful in promoting learning [1], it can be challenging to get young learners to attend to and leverage such structured forms of the community knowledge [14]. Barriers include a lack of interest, awareness of potential value of knowledge elements, difficulty in formulating queries to access knowledge, the granularity of contributions, and the dominant role of peer discourse in daily classroom activity.

We describe a study of a knowledge-building strategy that takes advantage of in-door location technology to partition an emergent knowledge base into thematic subsets and public kiosks distributed around the classroom, to serve as dedicated interaction sites for each of those knowledge base subsets. These "Knowledge Places" display a persistent summary view of emergent knowledge around each theme, afford "walk up and use" interaction for access to individual contributions, and serve as the physical site for submitting contributions around the theme represented by the Knowledge Place. By partitioning the emergent knowledge base into smaller units, "pushing" emergent knowledge in public displays instead of "pulling" through queries, and creating interaction sites in the classroom that could serve as a "water cooler" [8] or communal artifact which could promote opportunities for thematic face-to-face discourse and the exploration of the knowledge-base. We hope the public distributed nature of Knowledge Places within the classroom will foster learner awareness through an acute or “peripheral awareness” of knowing the types of information available, where to easily find that information, and who else is interested in it also.

BACKGROUND

Over the past decade, researchers have explored the use of ambulatory, whole-room activity structures in support of community knowledge construction around shared objects of inquiry. While some of these applications require instrumentation to support continuous tracking of persons or artifacts, e.g., STEP, from Danish et al. [5], other designs such as Hunting of the Snark [13], BeeSim [12] and Hunger Games [7] require only the detection of arrivals and departures at designated "hot spots" within the room. These latter approaches suggest the potential for the use of lower-cost, "surface mount" proximity-based technologies such as Radio-Frequency Identification (RFID), inductive and capacitive Near-Field Communication (NFC), and Bluetooth Low Energy (BLE) iBeacon [9] that could be more widely adopted than technologies requiring

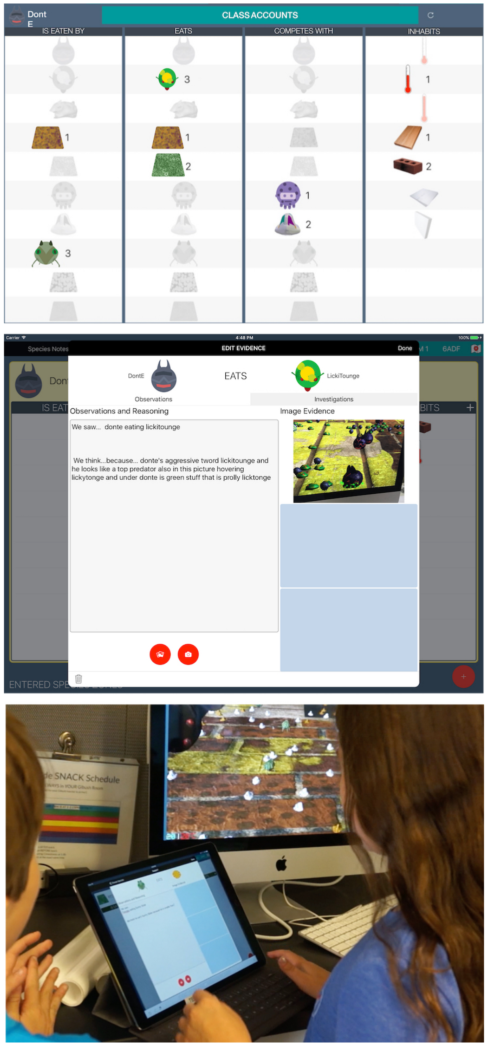

Figure 2: Top: the aggregate view of contributions displayed at a Knowledge Place. Middle: detailed contribution form used on group tablets and at Knowledge Places. Bottom: students composing contributions at ecosystems on group tablets.

extensive embedded instrumentation. These technologies are at the core of spatial computing and support the notion of embodied [6] and proxemic interaction [2] – an individual's technology-enhanced, socially mediated, micro-located actions within a physical space. Within learning environments that utilize spatial technologies, location and embodied interactions have meaning, which can become an input or information source for learning activities.

DESIGN

Learning Context

We used Knowledge Places within the context of a ten-week curriculum unit in population ecology enacted with 15-students in a sixth grade (11-12 y/o) classroom in an urban Midwestern U.S. school. The unit utilized the WallCology application [11], shown in Fig. 1, an "embedded phenomenon" [10] built around the concept that the walls of classroom contained active ecosystems that served as the objects of collective inquiry. The collective challenge for the class was to construct a "master food web" representing producer-consumer relationships among the collective community of 11 species Knowledge Place sites distributed around the perimeter of the classroom (in overlapping fashion) among the ecosystems. The instructional design for the unit required that students work in a progression of small groups, making observations and manipulations of assigned ecosystems. Their inquiry results in contributions to the community knowledge base. Periodic whole class "summits" are devoted to constructing the master food web.

Knowledge Place Partitions

We adopted a domain-centered strategy for selecting the categories that would be mapped to Knowledge Place sites. With 11 species, the full set of potential binary relationships in a complete graph of the community would require 55 Knowledge Places; limiting these to the number of direct energy relationships actually used in the simulation would reduce that number to 27, but in either case partitioning this finely would result in so many Knowledge Places that the likelihood of face-to-face intergroup interaction resulting from concurrent presence at any one site would be very low. At the other extreme, a partitioning by the three trophic levels (carnivores, herbivores, vegetation) would increase the rate of intergroup interaction, but would expose the trophic relationships that learners were intended to discover, and reduce the likelihood that concurrent visitors to a Knowledge Place would be focused on issues of common interest. As a result, we used the 11 species as the thematic foci for Knowledge Places. While this created some ambiguities (e.g., learners could contribute a food web relation at the Knowledge Place of either the producer or consumer) we felt that this partitioning would be easily understood by participants, keep the information at each site to a reasonable amount, and create sufficient opportunities for intergroup interactions.

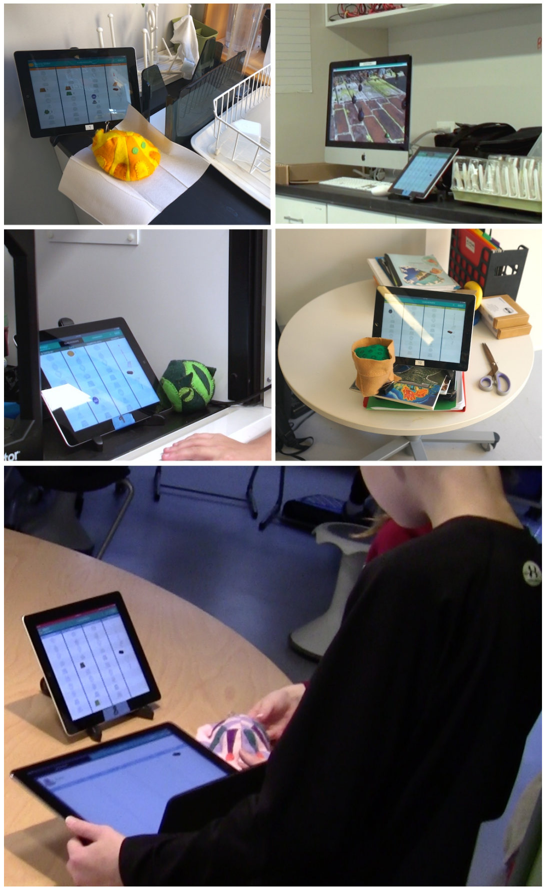

Figure 3: Several of the Knowledge Place sites used in the study. Knowledge Place sites are mapped to fixed locations in the classroom. Each site represents a collection of species-specific student contributions and is composed of a small tablet, a species plush toy with an embedded BLE iBeacon – to detect student's proximity to the site and to trigger a synchronization of their contribution. After synchronization the contribution is then reflected in the aggregate view on the sites display.

Interaction

Because student work groups collect evidence (photographs of predation and graphs of population oscillations) and formulate relationship claims at their assigned ecosystems, we provided groups with tablet computers that allowed them to inscribe their prospective contributions (see Fig. 2) at those locations, rather than using the Knowledge Places as manual data entry sites. Each contribution included the specification of the species involved in the relationship, the types of relationship (energy exchange), evidentiary supports, and the reasoning behind their claims. Contributions were synchronized to the emerging knowledge database(s) through a wireless network, using a proximity-based strategy [2] that required students to carry their group tablets to locations near one of the Knowledge Places representing a species specified in their claim. The imposition of the proximity requirement was designed to increase opportunities for interaction with groups working at other ecosystems that were also adding contributions to the Knowledge Place or consulting the Knowledge Place for contributions made by other groups. Each Knowledge Place was paired with an adjacent iBeacon tag embedded in a plush toy model of the associated species (see Fig. 3). In the initial version of the application, detection of arrival within a one-meter radius of the tag triggered an automatic retrieval of the contribution from the work group tablet and its incorporation into the local (species-specific) database represented by the Knowledge Place.

Each Knowledge Place included an associated tablet computer that was used in two ways. By default, the Knowledge Place display presented an ambient aggregated view of the contributions that had been made by multiple teams (Fig. 2, top), reflecting consensus and discrepancies among the groups. In addition, users could directly interact with the Knowledge Place tablet to view details of the individual contributions made by other teams.

PRELIMINARY RESULTS

Post-unit interviews reinforced our observation that Knowledge Places served as sites for rich disciplinary, inter-group discourse. Our measures show that inter-group interaction around Knowledge Places were at least as prominent – and on some class days greater – than those occurring at Wallscopes and other work sites in the classroom. Table 1 provides excerpted student reactions (edited for context and readability) toward using Knowledge Places during the enactment. As we hoped, some students found that Knowledge Places made the community knowledge contributions visible and easily accessible. However, opportunities for such interactions were limited by the ratio of groups to Knowledge Places and the classroom teacher's unexpected adoption of a "synchronized mass contribution" strategy, in which students synchronized their contributions at the end of the class period versus a "rolling contributions" strategy that distributed synchronization throughout the class period. We observed, for example, the role of Knowledge Places start to diminish towards the latter part of the unit as students internalized the knowledge and the activities involving the creation of master food web boiled down to a few "species controversies", e.g., "who is the apex predator?" We recognize, too, that the role of, and value of Knowledge Places, both as sites of interaction and as knowledge sources for students, may

Table 1: Post-Interview Student Comments

Id	*Comments*
S1	"...No, you needed the [Knowledge] places, because if we didn't have the places, we wouldn't have known how many people said like three people said Dante [species 1] eats Lickatung! [species 2]. That's how you started the food web! "
S2	"If you wanted to sync [synchronize] something [a contribution] you would go over to the species. I liked how they [the Knowledge Places] were [representative] of the species...I liked how they were spread out [in the classroom] ..."
S3	"And you can see one species and like how many groups agreed with the fact. Let's say I think species three eats species two, but maybe some of the people think species two eats species four. So, you can see how many people think what. And so, you have a better idea if it is true or not ..."
S4	"Like if I want to go over to Mitch [species 1] and I want to find Good Goo [species 2] and Mitch [species 1], Mitch [species 1] feeds on Good Goo [species 2] you have to travel around the room to see where it is. But I think the good part is that you walk over [to the Knowledge Place] and all the information you have [need] is there."
S5	"I think it what was cool how you could sync [synchronize your contributions] ...I thought it was very useful because then the whole community could see your ideas and what you think based on that species. I also think it was cool because we got to walk around to all the species [Knowledge Places]. Then [at the Knowledge Place] we could find out new ideas ..."

vary over the course of long instructional units. Furthermore, proximity detection needs to be made more robust in order to obviate explicit confirmation of departures from detection areas.

CONCLUSIONS

We believe that the "Knowledge Places" strategy holds promise as a means for raising awareness of emergent community knowledge and promoting disciplinary peer discourse within classroom communities engaged in collaborative investigations. While the present study cannot provide the basis for strong claims of the strategy's effectiveness relative to wholly cloud-based approaches, it does serve as a proof of concept of the viability of the strategy. More importantly, it made visible issues that could inform future designs based of Knowledge Place. Critical to the strategy is the effective partitioning of the knowledge base. This requires a careful balance among the selection of partitioning criteria (domain-based vs. alternative thematic choices), the nature of the knowledge being created, the class size, and whether the investigative work is being done by individuals or groups. We are currently analyzing our corpus of video for student's interaction patterns and will present those results in a more substantive work. The present study will be an important source of guidance in informing future designs employing the knowledge places design strategy.

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REFERENCES

[1] van Aalst, J. and Chan, C.K. 2007. Student-Directed Assessment of Knowledge Building Using Electronic Portfolios. Journal of the Learning Sciences. 16, 2 (2007), 175–220. DOI:https://doi.org/10.1080/10508400701193697 .

[2] Ballendat, T., Marquardt, N. and Greenberg, S. 2010. Proxemic interaction: designing for a proximity and orientation-aware environment. (2010), 121–130. DOI:https://doi.org/10.1145/1936652.1936676 .

[3] Bielaczyc, K. and Collins, A. 1999. Learning communities in classrooms: A reconceptualization of educational practice. 2, (1999), 269–292. DOI:https://doi.org/10.1177/019263659908360402 .

[4] Brown, A.L. and Campione, J.C. 1996. Psychological theory and the design of innovative learning environments: On procedures, principles, and systems. (1996), 289–325

[5] Danish, J.A., Enyedy, N., Saleh, A., Lee, C. and Andrade, A. 2015. Science through Technology Enhanced Play: Designing to support reflection through play and embodiment. (2015).

[6] Dourish, P. 2004. Where the action is: the foundations of embodied interaction. (2004).

[7] Gnoli, A., Perritano, A., Guerra, P., Lopez, B., Brown, J. and Moher, T. 2014. Back to the future: embodied classroom simulations of animal foraging. (2014), 275–282. DOI:https://doi.org/10.1145/2540930.2540972 .

[8] Harrison, S. and Dourish, P. 1996. Re-place-ing space: the roles of place and space in collaborative systems. (1996), 67–76. DOI:https://doi.org/10.1145/240080.240193 .

[9] Köhne, M. and Sieck, J. 2014. Location-Based Services with iBeacon Technology. 2014 2nd International Conference on Artificial Intelligence, Modelling and Simulation. (2014), 315–321. DOI:https://doi.org/10.1109/AIMS.2014.58 .

[10] Moher, T. 2006. Embedded phenomena: supporting science learning with classroom-sized distributed simulations. ACM. (2006), 691–700. DOI:https://doi.org/10.1145/1124772.1124875 .

[11] Moher, T., Uphoff, B., Bhatt, D., Silva, B. and Malcolm, P. 2008. WallCology: designing interaction affordances for learner engagement in authentic science inquiry. (2008), 163–172. DOI:https://doi.org/10.1145/1357054.1357082

[12] Peppler, K., Danish, J., Zaitlen, B., Glosson, D., Jacobs, A. and Phelps, D. 2010. BeeSim: leveraging wearable computers in participatory simulations with young children. (2010), 246–249. DOI:https://doi.org/10.1145/1810543.1810582 .

[13] Price, S. and Rogers, Y. 2004. Let's get physical: The learning benefits of interacting in digitally augmented physical spaces. (2004). DOI:https://doi.org/10.1016/j.compedu.2003.12.009 .

[14] Scardamalia, M. and Bereiter, C. 1996. Student communities for the advancement of knowledge. 39, 4 (1996), 36–37. DOI:https://doi.org/10.1145/227210.227220 .

[15] Slotta, J. 2013. Knowledge community and inquiry: New opportunities for scripting and orchestration. OISE-University of Toronto. (2013). DOI:https://doi.org/10.1145/2460296.2460352 .