Connected Spaces: Helping Makers Know Their Neighbors

Vishesh Kumar
University of Wisconsin–Madison
Madison, WI 53706, USA
vishesh.kumar@wisc.edu

Mike Tissenbaum
Massachusetts Institute of Technology
Boston, MA 02142, USA
miketissenbaum@gmail.com

Lauren Weilgus
Matthew Berland
University of Wisconsin–Madison
Madison, WI 53706, USA
lauren.weilgus@gmail.com
mberland@wisc.edu

IDC '17, June 27-30, 2017, Stanford, CA, USA

ACM ISBN 978-1-4503-4921-5/17/06.
http://dx.doi.org/10.1145/3078072.3084335

Abstract
This paper presents Connected Spaces (C-S) – a tool designed to promote collaboration in makerspaces. It also describes a pilot study designed to test C-S's effectiveness in enabling people to seek help from peers. In our pilot, some (but not all) students were able to leverage C-S's affordances. We explore both supporting and mitigating factors, and highlight design features for environments as well as tools to support divergent, open-ended exploration and learning.

Author Keywords
Makerspaces; help; scaffolding; collaboration; help-seeking; constructionism; expertise; communication

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous;

Introduction
Help-seeking by novices plays a valuable role in learning and achievement [8]. Yet, novices lack the competencies and support to effectively seek help from experts [11]. The ability to seek help from experts or peers is especially important in open-ended, exploratory, and inquiry environments, where learners have many different pathways to develop domain knowledge [2]. The openness of such spaces

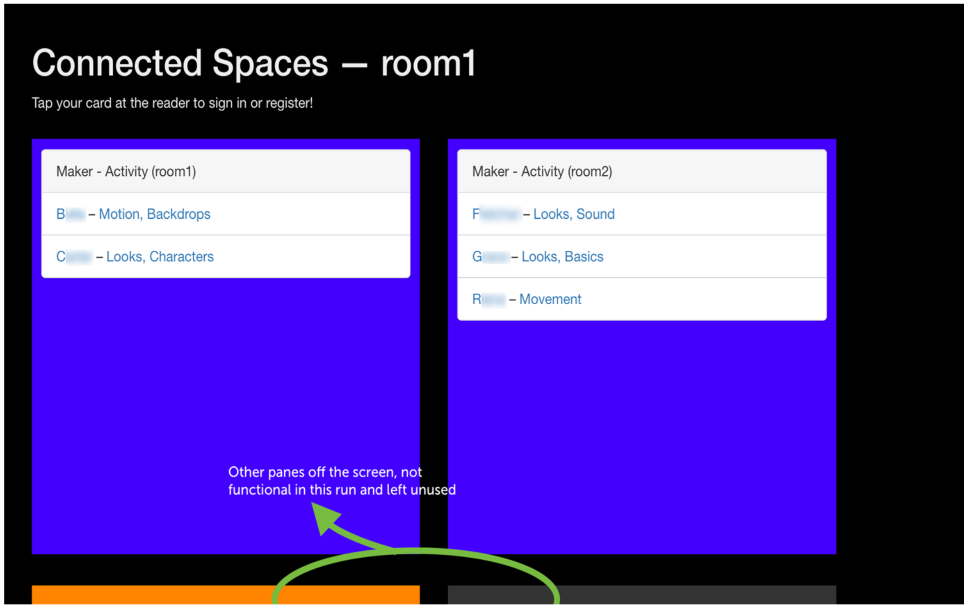

Figure 1: Screenshot of the Connected Spaces skill list tablet, as visible in this study's run. The contents of the two spaces are explained later in Table 1.

compounds the challenges for effective help-seeking as learners are often unaware of the activities and abilities of their peers, a critical feature in building a community of like-minded learners [4,5,6]. To overcome these barriers, there is a need to develop learning spaces and the supportive technologies within these spaces which can reduce the barriers to effective help seeking and mentorship.

Makerspaces are an excellent example of open-ended, exploratory learning environments in which participants can design and construct solutions to problems themselves [15]. However, because of this open-ended nature of makerspaces, making connections between one's work and that of one's peers is more difficult than in more structured traditional pedagogical settings. This can create a critical gap in the awareness of what others are doing and how it relates to one's own work (termed "knowledge awareness" by Ogata and Yano [10]), both within and across makerspaces. This lack of awareness reduces the opportunities for effective collaboration and cooperation between participants [14]. As a result, makerspaces frequently have learners in need of assistance; however, they lack awareness of who has the relevant expertise [3,16].

With the aim of making this expertise visible and to facilitate assistance for to newcomers to makerspaces, this paper examines the design of Connected Spaces (C-S) – a technology framework that uses ambient displays to track and connect learners across makerspaces – and its success in helping learners find help and collaborate in real-time. This paper describes C-S, a pilot study designed to see how makers use Connected Spaces to find and obtain help (if at all), and a design debrief and feedback session with participants to solicit ideas on how C-S could be improved.

Connected Spaces: An Ambient Awareness Tool for Connecting Distributed Makerspaces in Real-Time

Novices often fail to leverage the experts in the same space due to their inability to recognize these experts and/or their expertise [1]. This failure presents a need to make visible the interests and activities of the wide range of makers in makerspaces. In response, we have developed a technology platform named Connected Spaces (C-S), which displays the names of everyone present in a network of connected makerspaces, along with their self-identified interests (affinities) and the activity they are engaged in (Figure 1). To further support help seeking, collaboration, and mentorship, C-S provides light-weight video conferencing capabilities to connect learners across these spaces in real-time.

When a participant wants to engage with members at a partner site, they use a C-S "calling tablet" to call another space. If remote participants want to collaborate, they can accept the call and engage in conversation. Through these integrated tools, Connected Spaces provides multiple avenues for providing awareness of the broader community and developing maker and STEM+C skills, as well as ways to engage with their distributed maker community.

Methods
In the following sections, we present the design of the study and its enactment, followed by a description of the data we focused on collecting and analyzing.

Study
For this pilot study, we recruited 5 participants (8-11 years old). The study began with basic introductions intended to gather an overview of the participants' past programming experience. We then gave everybody a basic introduction to Scratch – a graphical programming language built for young programming novices [12] – to show how to make a working script where a user input triggers a perceptible program action.

To emulate a makerspace-like environment – where makers did not share the same skills, but had different specializations they might need to leverage in completing their projects – we separated the participants into two groups randomly, and taught each group separate "specialized" Scratch programming abilities – "motion", and "looks". The participants were then brought back together in the main room, given details on their final project, and a description of Connected Spaces. They were told that they would be split into two groups again, and individually work on their final project (making an interactive pet that can eat food, make sounds, and 'play').

This project was designed to be representative of a common "maker project" – it is: open to interpretation; involves design components; requires a breadth of knowledge; and produces a coherent product. The project was assigned to them for the purposes of the study, though we expect people in actual makerspaces working on their own projects, would experience the presence of C-S rather similarly.

In describing Connected Spaces, we showed two tablets to the participants – one which lists people in both the rooms, along with their self-chosen affinities; and the other which can be used to call people in the other room. Since all the students were working on the same project, we did not use the participants' "current activity" function of C-S. We then asked each participant to share what specializations they wanted to appear alongside their name, and added them to their C-S accounts.

The participants were again randomly separated into two groups, sent to separate rooms, and told to work on their projects for the next 45 minutes. The two groups during this phase had mixed specializations – both had rooms with some people being fluent with "motion", and some with "looks". This was intended to reduce a deliberate sequestering of skills across the rooms, to see if Connected Spaces worked productively in finding help within the same room itself as well, and to see if calls across spaces occur even if makers in one space have an adequate variety of skills.

At the end of their individual project work time (which lasted for 45 minutes), all participants came back to the initial room, and spent 15 minutes presenting their projects to everybody else. Following that, we debriefed with the participants about their experience with using Connected Spaces, their design suggestions to improve the system, and what they felt they needed when they were struggling with a challenge.

Data Collection and Analysis

We used field notes for our data collection and analysis. We paid close attention to times when participants approached the Connected Spaces tablets, and how it affected their help-seeking behavior. When the participants would query us, we encouraged them to figure things out on own, or seek help from their fellow participants. We would sometimes make a discretionary choice to help them ourselves.

For this work, we employed a case study approach [7]. Case studies are particularly effective for this kind of pilot study as they can provide us a detailed lens into the interactions within the learning activity and the role that Connected Spaces played in supporting these interactions. The post-activity focus group interview aimed to better understand participants' perceptions of C-S; to get direct feedback to help with future design iterations; and also to provide us with evidence about aspects of making participants focused on, especially with respect to C-S.

Findings

When the participants were introduced to Connected Spaces, they chose their own descriptions of the affinities they wanted displayed next to their names, to all participants in both rooms. The different specializations taught, the affinities claimed, and the rooms the different participants conducted their project work in, are presented in table 1. The distribution of participants for the second half made it so that there was at least one person for each of the two specializations (looks and motion) in each room. This distribution helped us see if inter-room calls ever happen if there is adequate skill distribution in the rooms.

Participant	Skill taught	Affinity	Room
B	Motion	Motion, Backdrops	1
C	Looks	Looks, Characters	1
R	Motion	Movement	2
F	Looks	Looks, Sound	2
G	Looks	Looks, Basics	2

Table 1: Participants' taught specializations, claimed affinities, and room location.

Room 1 had 2 participants, N1 as the note-taking researcher, and F1 as the facilitator. Room 2 had 3 participants, N2, and F2 as the note-taker and facilitator, respectively.

A total of 4 notable interactions with the C-S tablets took place during the 45 minutes of project work, and are presented here (sorted by room, and time).

Event 1 (Room 1 + Room 2): 25 minutes into project time, B asked F1 "how to send messages from one sprite to another". C did not know, and F1 asked B if she would want to call and ask anybody in the other room. B accepted F1's prompt, and was assisted by F1 in calling Room 1 – a call that was picked up, and responded to, by the participants in Room 1.

In Room 2, when the call came, G was closest to the tablet and grabbed it to respond. Others in the room gathered around G, expressing interest in helping B. G led most of the instruction, and answered B's query.

Event 2 (Room 2): Around 10 minutes into project time, F expressed that he was struggling with motion. Then unprompted, F got up to look at the C-S tablet, then came back to his laptop, and worked on his issue. We observed that F managed to solve his own problem.
Event 3 (Room 2): 25 minutes into project time, F again faced a challenge with motion. Then he went to the C-S tablet, looked carefully, went to R (who had motion as an affinity), and pointedly asked a query. R was able to competently solve F's problem.
Event 4 (Room 2): 35 minutes into project time, G expressed a difficulty with "broadcasting" (a specific function in Scratch). On being prompted to see C-S, G picked up the C-S tablet, looked carefully at it, then put it back, and continued to work by herself. It did not seem like her query was solved – she seemed to be trying to circumvent that specific programming challenge while trying to accomplish her goals.
Post-Activity Debrief Session: During the debrief session, the participants brought up highly specific, relevant, and valuable recommendations. They can be summarized into the following points:

1. There should be photos of people's faces beside their name, so it is easier to know and find who the name and relevant expertise belongs to.
2. Clicking on people's names in the skill display tablet should make the call, rather than needing to make a call from a separate tablet.
3. Callers should be able to attach a photo of their project and/or relevant query before making a call, so receivers can see what their query is about before picking up a call.
4. Have a facility to make general calls for help (which specify the issue being faced), if the maker looking for help does not see the topic they are looking for in other people's listed affinity.

Discussion
Here we present analyses of when participants used Connected Spaces, and inferences from when they found help, as well as when they did not.
Explicit help-seeking following C-S interactions
Events 1 and 3 – the call across spaces, and the soliciting of help after referring to the C-S tablet – are clear instances of C-S enabling seeking as well as provision of help. These interactions productively contributed to participants' project work. Both within a space (Event 3), as well as across spaces (Event 1), having facilities to see others' skills and being able to approach them, are valuable actions enabled by Connected Spaces. Our inference that these successful interactions resulted from participants using C-S for targeted help-seeking is bolstered by participants' first three design feedback suggestions. The third point (about being able to attach photos of problems to call for help) also reflected their desire to communicate the help being sought as quickly as possible, and also judge whether they can help the help-seeker, even before picking up a call.
C-S interactions lacking explicit help-seeking
Event 2 seemed to indicate some resistance to asking for help, especially from peers, and a proclivity to solve problems independently. This could be a result of patterns entrenched in traditional classroom settings which often frown upon students seeking and receiving peers' help [13]. This might also be due to participants feeling empowered to pursue their struggle themselves. Knowing someone in the room may be able provide help is likely to encourage one to seek a solution on

one's own knowing that the answer is accessible in an 'easier' way, if needed [9].

The fourth design suggestion (offered by participant G seemed to result from G's experience in Event 4. G did not talk to anyone via C-S, because no one's affinities addressed her issue. She told us that she would have made a general call for help, if C-S had had a "general call" function. This event also supports the notion that participants were not using C-S simply for social interactions, but for critical and clear needs.

Limitations

The limited sample size of the study makes it hard to make general remarks about how participants interact with C-S. Further, while this study was not situated in a makerspace in the more traditional sense, most of the problem-solving needs and planned design features for their projects appeared to arise from the participants' desires for what they wanted their virtual pets to do. This kind of pursuit made the participants' actions fairly similar to those of newcomers in a makerspace. We also acknowledge that given the well-defined task, the affinities of participants in our study are narrower than those of makers in a traditional makerspace (sewing, electronics, etc.). These broader affinities are likely to lead to more scenarios where others do not have the knowledge to successfully help the help-seeker (but also potentially new opportunities for inspiration).

Conclusions

This pilot study strongly showed the potential of C-S as tool to foster productive collaborations between makers. Feedback from the participants also acted as evidence to show us that they understood and used C-S as we had intended. Both the participants' feedback and their experiences using C-S gave us valuable information about how to improve C-S and sparked questions to investigate about the effectiveness of C-S in supporting novices in makerspaces.

We were able to see that helping overcome the lack of knowledge awareness in open-ended learning spaces is valuable in encouraging help-seeking, talk and collaboration, and building a community of practice more welcoming for newcomers. We look forward to studying how this community creation looks and is influence by Connected Spaces through more sustained runs in the future!

References

1. Jessica Brazelton and G. Anthony Gorry. 2003. Creating a knowledge-sharing community: if you build it, will they come? *Communications of the ACM* 46, 2: 23–25.
2. Douglas H. Clements. 1991. Enhancement of creativity in computer environments. *American Educational Research Journal* 28, 1: 173–187.
3. Nathaniel Hudson, Celena Alcock, and Parmit K. Chilana. 2016. Understanding newcomers to 3D printing: motivations, workflows, and barriers of casual makers. *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*, ACM, 384–396.
4. Stuart A. Karabenick and Akane Zusho. 2015. Examining approaches to research on self-regulated learning: conceptual and methodological considerations. *Metacognition and Learning* 10, 1: 151–163.
5. Jean Lave and Etienne Wenger. 1998. Communities of practice. *Retrieved June* 9: 2008.
6. Piritta Leinonen, Sanna Järvelä, and Päivi Häkkinen. 2005. Conceptualizing the awareness of collaboration: A qualitative study of a global virtual

team. *Computer Supported Cooperative Work (CSCW)* 14, 4: 301–322.
7. Matthew B. Miles and A. Michael Huberman. 1994. Qualitative data analysis: A sourcebook. *Beverly Hills: Sage Publications*.
8. Sharon Nelson-Le Gall. 1981. Help-seeking: An understudied problem-solving skill in children. *Developmental review* 1, 3: 224–246.
9. Richard S. Newman. 2008. The motivational role of adaptive help seeking in self-regulated learning. *Motivation and self-regulated learning: Theory, research, and applications*: 315–337.
10. Hiroaki Ogata and Yoneo Yano. 2000. Combining knowledge awareness and information filtering in an open-ended collaborative learning environment. *International Journal of Artificial Intelligence in Education (IJAIED)* 11: 33–46.
11. Minna Puustinen. 1998. Help-seeking behavior in a problem-solving situation: Development of self-regulation. *European Journal of Psychology of education* 13, 2: 271–282.
12. Mitchel Resnick, John Maloney, Andrés Monroy-Hernández, et al. 2009. Scratch: programming for all. *Communications of the ACM* 52, 11: 60–67.
13. Allison M. Ryan and Paul R. Pintrich. 1997. " Should I ask for help?" The role of motivation and attitudes in adolescents' help seeking in math class. *Journal of educational psychology* 89, 2: 329.
14. Kjeld Schmidt. 2002. The problem withawareness': Introductory remarks onawareness in CSCW'. *Computer Supported Cooperative Work (CSCW)* 11, 3: 285–298.
15. Kimberly Sheridan, Erica Rosenfeld Halverson, Breanne Litts, Lisa Brahms, Lynette Jacobs-Priebe, and Trevor Owens. 2014. Learning in the making: A comparative case study of three makerspaces. *Harvard Educational Review* 84, 4: 505–531.
16. Diane Slatter and Zaana Howard. 2013. A place to make, hack, and learn: makerspaces in Australian public libraries. *The Australian Library Journal* 62, 4: 272–284.