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Abstract. Field trips combine a number of favourable conditions for collaborative and situated learning. Research has shown that collaboration can be improved by the use of digital tools, such as interactive tables. However, existing tools are heavy and thus unfit for field trips. This article introduces a conceptual framework for the design of collaborative tools in a mobile context. This framework is based on three features: a shared mobile interactive display, a modular tool to support collaboration and scriptable tools to design collaborative educational scenarios. The overall objective is to provide teachers with solutions for designing field-based learning activities and to support learners' collaboration.

Keywords: computer supported collaborative learning, field trip, map, augmented reality

1 Introduction

Learning is a process that, to this day, is still not fully understood by the scientific community. Models of how learning works have changed significantly over the last 30 years [1]. Two recent theories, collaborative learning [2] and situated learning [3], are being explored in the *SituLearn* project . The aim of this project is to provide digital mobile tools to enhance field trips, such as botanical outings, visits of archaeological sites or museums and event orienteering races. These field trips are part of the school curricula, from kindergarten to college.

Research has shown how digital tools may improve collaborative learning [4]. Having access to a **shared interactive space** is a key element that facilitates collaborative learning [5]. Such shared interactive spaces are most commonly found in interactive tables: a large touch display, horizontally embedded in a table. Those devices have to be plugged into a power outlet, are heavy and cost around 3000€. They are therefore not affordable to public schools and are incompatible with field trips. The work presented in this article addresses the issue of mobility in the current collaboration tools.

Firstly, we briefly introduce the foundations and concepts of our work. Secondly, we present the state of art of current solutions. In the third section, we introduce our contribution in the form of a conceptual framework for the creation of collaborative mobile tools. Finally, the current state of work is presented.

2 Situated and Collaborative Learning

Learning may prove difficult within an education system designed to teach ever more students with fewer teachers [6]. School dropouts are still significant and current educational systems cannot suit everyone. A recent study shows that, in the European Union in 2020 alone, on average 9.9% of all 18-24 year olds do not have any qualifications above lower secondary education levels [7]. Learning means the acquisition and integration of knowledge (or knowhow) in a representation of reality that individuals build throughout a lifetime by interacting with their environment [8]. This representation is intraconnected [9].

Collaboration is therefore very suitable for learning [10], since it requires a group to build a shared representation of the scenario (or the given problem) [11]. The process of creating a shared representation can be considered *auto corrective*: the multidirectional nature of communication in groups allows each participant to get direct feedback to his/her verbal statements, and consequently to adjust his/her own mental representation. Social interactions within the group also are advantageous for the overall learning process [12].

Situated learning also has many advantages. It offers the possibility to learn within a rich and authentic context [3] that may take place outside the classroom (*e.g.* forest, castle ruins etc.). In this case, physical activities and added sensorial input also lead to better memorisation by activating different types of memory [13].

The educational advantages of collaboration and situated learning can be naturally combined in **field trips**. However, traditional tools (*e.g.* maps, scratch books) only allow for static information and limited interaction.

Yet, displaying dynamic information, such as the participants' locations, has proven valuable for enhancing collaboration [5]. A mobile tool allowing for such an interactive shared space would thus be of great benefit for situated collaborative learning in field trips.

3 State of the Art

Current solutions, such as interactive tables, have shown a variety of benefits for collaboration. However, these solutions are not suited for field trips. Thus, this chapter is a state of the art of existing work. The objective is to **exhibit the key principles** a mobile solution should implement, in order to profit from the benefits of non-mobile solutions. Those key principles, noted R1 to R8, will lead to our proposition in the following chapter.

The benefits of interactive tables compared to traditional tools have been thoroughly analyzed in the works of Mateescu *et al.* [5] taking into account 41 studies. The authors established five categories of collaborative processes: *Participation*, *Workspace Awareness, Verbal and gestural communication, Coordination flow, Artefact interac-*

tion and *Level of reasoning*. These five categories will be a guideline for the design of conceptual components of a potential tool (**R1**). The study also provides evidence for disadvantages in the use of interactive tables as collaborative tools. Indeed, large furniture (such as interactive tables) can effectively block important aspects of non-verbal communication such as gestures, hindering important interactions [14] (**R2**).
Hoppe and Ploetzner [15] found that, in groups where members had knowledge on different parts of the topic, collaboration was higher than in control groups where members had the same level of knowledge (**R3**). Members of the same group had to communicate their knowledge and learn about aspects they previously were not aware of. Dillenbourg [16] describes this as one of the ways to increase the probability for collaboration: enforce some kind of collaboration treaty (*e.g.* roles) (**R4**). He also provides three other ways to increase collaboration: an appropriate setup (*e.g.* group size), scaffold interactions (by encouraging or restraining certain types of interactions) and finally, regulating those interactions (**R5**).
Nevertheless, designing and creating collaborative tools is a complex task since it requires resources and skills in multiple disciplines **(R6):** in her thesis, Tong provides a state of the art of 30 digital tools aiming at improving collaboration [17]. Around 40% of the cited studies do not exceed the level of a pre-study. The design and creation of the tool alone seems to use up an important amount of available resources and time.
Among Tong's state of the art figures the study of Sugimoto *et al.* [18]. The authors built *Caretta*, a tool consisting of a **large shared and interactive display** (interactive table) and individual handheld displays (PDAs). This setup has two benefits. Firstly, users decide when to collaborate or to cooperate[1] (**R7**). Secondly, having individual displays allows users to take time to think and reflect, a process hard to do during collaboration, due to its synchronous nature (requiring all participants' constant attention). Sugimoto *et al.* also noticed that participants preferred cooperation with individual displays over collaboration on a shared space. Mechanisms to enforce collaboration had to be put into place (**R8**), such as a voting mechanism that had to be used, at specific times, to progress within the scenario. Another alternative is to restrict functionality on individual displays to foster collaboration on the shared display [18].

4 Conceptual Framework

To our knowledge, there is no mobile tool that covers the above key functionalities R1 to R8. We therefore propose, in the following subsections, a conceptual framework with three main principles.

[1] In this article, cooperation is considered as an activity during which each individual works on a part of the problem with few interactions with fellow team members. Collaboration, in contrast, is understood as an activity on which all team members work simultaneously following the same goal.

4.1 A Shared Mobile Interactive Display and Individual Displays

Using a shared display (interactive table) and individual displays (PDAs or smartphones) has proven to be effective (R7). However, the fact that large and bulky hardware can hinder non-verbal communication (R2) and the environment of the field trip require a light and mobile solution. To obtain the benefits of a shared display in a mobile context, the « ***dynamic peephole*** » interaction seems promising: a device is moved on a static surface with respect to an external frame of reference. The device displays an additional layer of information on top of the surface [19]. This allows to augment any surface (*e.g.* a map) with functionalities and information. The displayed information can be static (*e.g.* additional pedagogical information about the environment) or dynamic (*e.g.* data collected by participants, participant's position). Having developed a first prototype, we can demonstrate the feasibility of this approach[2]. This shared space can also be combined with individual devices (students' smartphones, see fig. 1). Collaboration tools can therefore be distributed on shared and individual displays.

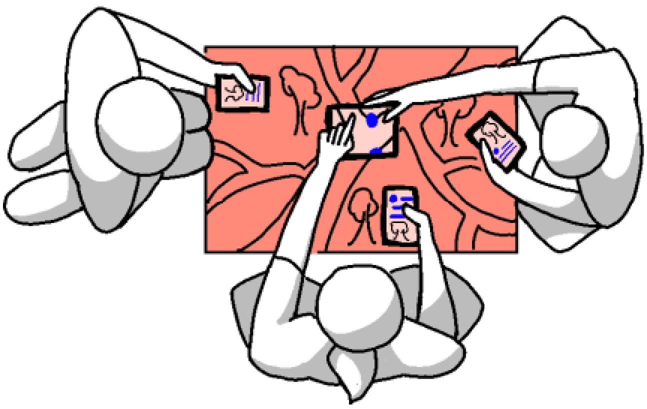

Fig. 1. Use of multiple individual displays and a central shared display using a peephole interaction

4.2 A Modular Tool to Support Collaboration

As presented in the state of the art, Mateescu *et al.* have identified five categories of collaborative processes and provided a set of mechanics that can be used to support them (R1). However, we cannot foresee how these different mechanisms (and their technical implementations) impact collaboration, especially due to the complexity of their development (R6). Hence, we propose a number of **individual conceptual modules,** allowing for individual testing (and testing of module combinations). For example, the collaborative process category *Participation* can be supported by the module M1 showing the number of contributions by members to encourage autoregu-

[2] Currently, we cannot give technical details due to a patent pending.

lation. Another module M2 could provide functionality to take decisions in a group by the means of a voting mechanism, increasing performance in the collaborative process categories *Participation* and *Coordination flow*. We strive to provide modules that can be combined and configured depending on end user needs and the context of the field trip.

Those conceptual modules will be implemented through **software modules.** The notion of software modules can be compared to the modularity within software in general, making it easy for other developers to reuse some features without using the entire program. Conceptual modules, on the other hand, might be seen as entire programs (composed of software modules) inspired by the UNIX philosophy[3]. The previously mentioned combinations of conceptual modules can be compared (to some extent) to customized UNIX systems in embedded systems. The latter are systems that are highly adapted to their environment, as what is required in the context of field trips and collaborative learning with a variety of conditions and different end users.

4.3 Scriptable Tools

The importance of mechanisms that can coerce participants into collaboration has been shown in R8. It may either be enacted through the absence of functionality on individual devices or by the presence of a mechanism, like a voting mechanism, which has to be used by all participants in order to progress. Therefore, creating such situations through triggering events seems an interesting approach. Such *scripting*[4] abilities would also allow controlling the available functionality and information to each participant at any given moment (R3, R5). Implementing role-play during a scenario would also become possible (R4) [4]. Expanding on the previous example, module M1, that shows the participation of each student in a team, could appear automatically, on a group's displays, if participation appears to be unbalanced or manually, if educators feel the need for it, based on their observations (R5).

The proposed framework therefore allows for the creation of mobile, modularized and scriptable collaboration tools, addressing needs and observations (R1 to R8) identified in our state of art (Table 1).

5 Perspectives and Experiments

Validation of our framework is complex: the number of possible combinations of conceptual modules is a major challenge to the limited resources and experiments that are available to this project. Additionally, the planned configuration both on the conceptual and software level will considerably add to the difficulty of evaluation. The ability to trigger different modules dynamically has the potential to remedy part of this problem by testing multiple modules in a single experimentation. In the medium

[3] Software design for reusability and collaboration between software

[4] Specific instructions, help or functionality to “guide” participants during collaboration

term, data and results from the scientific community using this framework for further experiments will validate modules and combinations that cannot be tested during this project and provide insights to enhance the interaction model that our experimentations will yield.
Feedback will equally help address the research question related to which combination of modules and under which conditions such a combination maximizes benefits for collaborative learning during field trips.
The modular aspect of the framework is also geared to attract researchers to use it for their own tool creation and to contribute to ongoing development of modules in an attempt to share efforts for complex tool design.
To further encourage use of this framework, design will be technology agnostic and display size independent. Thus, the framework will not be limited to mobile devices. The framework should be able to function on existing interactive tables, as well as tablets or smartphones.

In order to test and validate the shared mobile display technology and the first conceptual module combinations, three experimentations are planned for 2022, in diverse contexts: a field trip in geography with master students, an orienteering race with disabled students in secondary school and a history-geography field trip with novice primary school teachers are planned. The design of learning activities will be based on the MoCoGa model developed by Marfisi-Schottman et al. [20].

Multiple prototypes are currently under development to implement the peephole interaction on an A3 sized map. Use cases are not limited to maps exclusively but will enable any surface to be augmented with information and tools depending on context (museums, meetings etc.). The planned experimentations will (or will not) validate the hypothesis that the peephole approach recreates conditions for collaboration in a mobile context and provide the benefits described in studies on interactive tables but with a low-cost and mobile technology, usable during field trips.

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References

1. Stahl, G., Koschmann, T., Suthers, D.: Computer-supported collaborative learning: An historical perspective. Cambridge handbook of the learning sciences. 20 (2006).
2. Lave, J., Wenger, E.: Situated Learning: Legitimate Peripheral Participation. Cambridge University Press (1991).
3. Herrington, J., Oliver, R.: Critical characteristics of situated learning: Implications for the instructional design of multimedia. ASCILITE 1995, pp. 253-262, Melbourne (1995).
4. Hmelo-Silver, C., Chinn, C., Chan, C., O'Donnell, A. eds: The International Handbook of Collaborative Learning. Routledge, New York (2013).
5. Mateescu, M., Pimmer, C., Zahn, C., Klinkhammer, D., Reiterer, H.: Collaboration on large interactive displays: a systematic review. Human-Computer Interaction. 36, 1–35 (2019).
6. Collins, A., Halverson, R.: Rethinking Education in the Age of Technology: The Digital Revolution and Schooling in America. Teachers College Press (2009).
7. Eurostat: Early leavers from education and training https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Early_leavers_from_education_and_training, last accessed 2021/12/19.
8. Wadsworth, B.J.: Piaget's theory of cognitive and affective development: Foundations of constructivism. Longman Publishing, White Plains, NY, England (1996).
9. Adorno, T.W., Hullot-Kentor, B., Will, F.: The Essay as Form. New German Critique. 151–171 (1984).
10. Roschelle, J., Teasley, S.: The Construction of Shared Knowledge in Collaborative Problem Solving. Computer Supported Collaborative Learning (1995).
11. Lajoie, S.P., Derry, S.J.: Computers As Cognitive Tools. Routledge (2013).
12. Lavoué, É., Ju, Q., Hallifax, S., Serna, A.: Analyzing the relationships between learners' motivation and observable engaged behaviors in a gamified learning environment. International Journal of Human-Computer Studies. 154, 102670 (2021).
13. Kennedy, M.: The Benefit of Field Trips. Honors College Theses (2014).
14. Scott, S., Grant, K., Mandryk, R.: System Guidelines for Co-located, Collaborative Work on a Tabletop Display. In: Proceedings of the Eighth European Conference on Computer Supported Cooperative Work. pp. 159–178. ACM, New York, NY, USA (2003).
15. Hoppe, H.U., Ploetzner, R.: Can Analytic Models Support Learning in Groups? In: Collaborative-learning: Cognitive and computational approaches. 103–121 (1999).
16. Dillenbourg, P.: Collaborative Learning: Cognitive and Computational Approaches. Advances in Learning and Instruction Series. Elsevier Science, Inc (1999).
17. Tong, L.: Designing and Analyzing Collaborative Activities in Multi-Surface Environments, PhD thesis INSA Lyon (2017).
18. Mandryk, R., Maranan, D.S., Inkpen, K.: False prophets: exploring hybrid board/video games. In CHI'02 extended abstracts on Human factors in computing systems. pp. 640-641 ACM, New York, NY, USA (2002)
19. Lucero, A., Keränen, J., Korhonen, H.: Collaborative use of mobile phones for brainstorming. In: Proceedings of the 12th international conference on Human computer interaction with mobile devices and services. pp. 337–340. ACM, New York, NY, USA (2010).
20. Marfisi-Schottman, I., Laine A., Laforcarde, P.: Towards an Authoring Tool to Help Teachers Create Mobile Collaborative Learning Games for Field Trips. In: Proceedings of EC-TEL 2022, In press