Annotational Learning Technologies

Exploring New Solutions to Fill the Paper-Digital Gap

Silvia Gabrielli & Andy Law

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Abstract

The project starts from the observation that paper technology still represents a valuable support for current learning practices.
It provides an analysis of major trends in the evolution of these practices, by focusing on informal learning events carried out in *third places* (spaces which are neither the home nor the working place) where annotation can be a key activity sustaining learning, both in face-to-face and remote situations.
It then presents the design and evaluation of the ALT system, a prototype showing how we can bridge the gap between annotation on paper and with digital media to support peer-to-peer simultaneous and remote interaction during learning.

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1. Introduction

In recent years research on the design of new technologies has demonstrated the many benefits brought by the use of tangible interfaces and the properties of the physical world to interact in new and more intuitive ways with digital resources. This can enhance the performance of our everyday practices carried out in the home, work or outdoor environments (for an example of design and applications in this area see the Equator Research Project, UK at http://www.equator.ac.uk).

In this work we focus on the value of paper as a tangible resource that is widespread in both learning and working environments and has been supporting learners for years. More specifically, we analyse the benefits of using a pen-paper system for the common activity of annotating while reading; this system provides the right kind of affordances to make annotation easy to carry out, by allowing also many degrees of freedom in the learner's action.

However, if we analyse current educational technologies we notice that their design doesn't seem to take fully advantage of paper annotation as a support for learning practices. This might be due to the fact that paper is often seen as an old-fashioned type of technology, and that annotations taken on paper have been assigned only a private and personal value.

In this project we challenge these assumptions and envisage a new way of augmenting paper by integrating it with digital devices to support annotation during peer-to-peer interaction. We show how the paper based annotation system we designed could sustain informal learning events carried out in out-of-class and mobile situations, overcoming something which is lacking in current educational systems: the possibility of simultaneously sharing notes during remote collaboration.

In the following section we discuss the rationale and background assumptions that motivated our work, while in section 3 we describe the different studies that served to inspire the design of the ALT system, as well as its technical implementation. In section 4 we present an evaluation of the system's use within an informal learning scenario.

We conclude our discussion by relating this project to other current areas of research to which our system could offer a contribution.

2. Background

2.1 The value of paper

Paper is pervasive and plays a primary role in our learning and working environments. During the last few decades the advent of digital media led futurologists to predict the disappearance of paper from offices and educational environments and this was expected to bring ecological benefits, as well as a reduction of costs in paper consumption and storage.
In their latest book Sellen & Harper (2002) turn to analyse the historical and practical reasons why this prediction did not come true, showing how trends worldwide go in the opposite direction of an increase in paper consumption and use, especially by the growing category of knowledge workers.

The same authors pinpoint a series of attributes or affordances that paper provides and that contribute to make this technology so difficult to replace.
As an example, paper provides a high-resolution interface for reading, compared to screen resolution and its physicality enables it, when piled on a table, to show at a glance how much work or tasks a person has still to attend to. Paper is also a very cheap and light technology to carry around, which makes it ideal to support mobile conditions; it is easy to share with other people during collaborative activities, like meetings, when information represented in different formats needs to be addressed and discussed together, by laying sheets down on a table (Sellen & Harper, 97).

However, most of the attempts to get rid of paper in modern companies were motivated by managers' idea that paper was an old-fashioned kind of technology and its use a symbol of lack of innovation or inefficient working practices.
Sellen & Harper (2002) present a number of case studies showing how some companies failed in their attempt to pursue the myth of the paperless office, due to their decision to introduce complex digital procedures in support of the same working processes previously based on paper documentation. This move was often unsuccessful, since managers failed to realize the level of connection between paper and the working practices supported by it within their organizations.
Of the companies that chose to go paperless better results were achieved by those that started from the redesign of their whole working procedures and organization, taking advantage of the benefits offered by digital technology without substituting the use of paper where it was still valuable.

A good lesson to be taken from these experiences seems to be that innovation is hard to achieve by dropping new technologies into already existing working practices, but it is more likely to happen when new solutions are envisaged and introduced to provoke a gradual evolution of current practices within a human organization.

During the ALT project the role of paper, as a predominant technology supporting reading/writing practices in learning environments, was taken as a starting point.
The project's aim was to demonstrate how interaction design solutions could be applied to integrate traditional and new technologies available in learning contexts, in a way that would favour a proper evolution of the existing practices.

2.2 Towards Informal Learning

Trends in the evolution of current learning practices were also considered. They generally show an increase in learning events happening in out-of-class situations, in places that were neither the home nor the school, but "third places" (Oldenburg, 2000) where socialization and conversational processes on issues that motivate the learners' inquiries, can easily be carried out.

The idea of informal learning and *deschooling* was first introduced and encouraged by Illich (1973); it is also in line with the situated approach to learning [Lave & Wenger, 91; Clancey, 97; Wenger, 98] and ethnographic studies on the role of motivation for authentic learning experiences to happen [Eales, 94, 95; Eales et al., 02].
These studies showed, for example, that formal training played only a small part in the way employers and students of the University in Brisbane (Australia) developed their computer-related skills, while informal collaborative learning was ubiquitous and important (Eales et al., 02). It seemed that a sense of ownership of a problem (in using some piece of software, for example) represented a vital motivating force for learning, leading learners/workers to form communities of assistance based on mutual support. When the assistance role was more formalized (with a specific person in charge of it) users were encouraged to take a more passive attitude to their learning, becoming more dependent on the support person.
Ownership of the learning problem appears to be the most powerful form of intrinsic motivation to learn, while peer-to-peer informal interaction seems to be crucial in sustaining interest and the development of strong networks of practice among learners (Brown and Duguid, 2000).

Another recent example of socio-technological change that was supposed to revolutionize current learning practices was the diffusion of Internet access and its use in families (especially in the Western world), along with the concurrent explosion of offerings in distance education.

Apparently, the large and varied array of on-line courses advertised on the Web has not found an equivalent demand or interest by Internet users. One main reason for this mismatch is that the model of packaging and delivering knowledge/information to users, often on an individual basis, is not particularly successful, being very far from how everyday, authentic learning takes place.
The potential benefit of new technologies like the Web for education doesn't seem to rely on transferring huge amounts of information to passive learners/receivers, but on connecting learners on a one-to-one base so as to enable them to decide content and modality of their learning, in the way that best fits their specific and contextual needs (Thackara, 02).
New and old technologies should sustain the continuity of conversational activities among learners to be carried out across time and space (anytime, anywhere) enabling them to share, re-represent and exchange knowledge as required by their learning goals and desires.

2.3 Paper-Digital Systems

Pioneering work on the development of seamless interfaces that enable people to work collaboratively and remotely while maintaining face-to-face contact, has been done by Iroshi Ishii and his group during the last ten years, first at NTT Laboratories (Japan) and then at MIT (USA). As an example, the ClearBoard prototypes were systems designed to integrate video-conferencing technologies with more traditional editing or drawing tools (Ishii et al., 1993). Pairs of people could work together on a shared electronic workspace while seeing and talking to each other though a sort of transparent glass window. Among the main benefits of ClearBoard was the support of gaze awareness between partners during collaborative work. Unfortunately, from a practical point of view the system was implemented by using technologies that better fit indoor working environments than learning activities on the move.

That is why the ALT project, informed by all these studies and trend analyses, focused on how to promote the evolution of learning practices, based on peer-to-peer conversation, through a better use of both paper and digital technologies.

On the paper side it seemed crucial to dedicate some time to observing and understanding a typical activity learners engage in when dealing with paper documents, namely, annotation.
On the digital side it was important to understand: first, how annotation is made possible with electronic support, then how new portable devices and wireless technology would enable learners, in pairs, to carry on their annotational and conversational activities in face-to-face situations, as well as when physically apart.

Studies on the annotation process claim that the value of this activity is based essentially on turning readers into writers, provoking learners to be actively engaged with documents, so as to shift from passive reading to more active use of information (Marshall, 98).

Annotation can be seen as a customizing process carried out on documents, an activity transforming information, that may be provided in a certain format, into an external representation that makes it easier for a learner to assimilate some knowledge, according to her specific cognitive-emotional mindset.

Learners have been observed to develop through the years very sophisticated systems of annotation, to personalize the use of textbooks, notebooks and other paper artefacts. They often consist in idiosyncratic strategies that serve to highlight the different importance of paragraphs in a text, to cross reference different parts of a document and to add comments or notes that ease understanding and remembering of some of its content. Also, if annotated documents are shared/exchanged among learners the annotation process can acquire a collaborative nature, supporting face-to-face or asynchronous communication during the learning activities.

Annotation on digital documents is supported by different systems. Some examples are Acrobat, Lotus Note, ForComment which support personal annotations; CoNoter, NCSA HyperNews for public commentary (Marshall, 97).
However, digital annotation is not a widespread activity, due to learners' preference for reading long documents on paper and also for the distracting effect of editing annotations by using a typical menu interface, like the one shown below (Fig.1), while engaged in reading a text.

Fig.1: Example of menu interface for digital annotation

In recent years research and commercial solutions going in the direction of making annotation more intuitive, on digital or paper support, have been provided.

An interesting prototype is XLibris, a freeform ink annotation system developed at Xerox Palo Alto (Schilit et al., 1998), which enables the reader to use a pen-tablet display to annotate a digital page, by handling a variety of ink or highlighter pens (Fig.2-3).

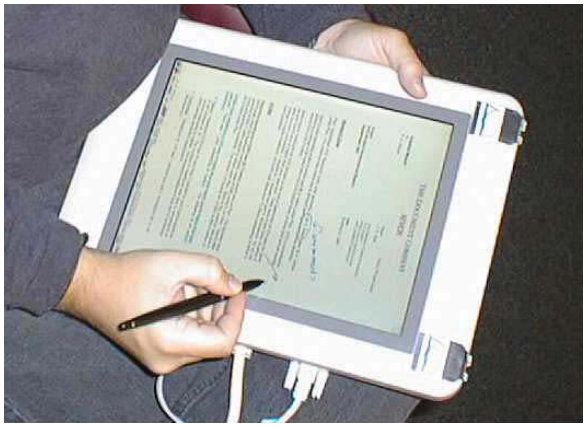

Fig.2: XLibris pen-tablet display system

House Passes Bill Boosting Benefits Under Medicare

By Joe Davidson
Staff Reporter of The Wall Street Journal

Fig.3: An annotated page

Analogue commercial products have been developed. For example, IBM produced CrossPad (Fig.4) a system enabling learners to write directly on paper

by placing it on a special tablet and using a digital pen, a small RF provided transmitter, to capture the written strokes. Notes are digitally stored and can be subsequently uploaded on a PC, by using the provided software.

Fig.4: CrossPad

Anoto has developed a digital pen that works just with paper (associated to Bluetooth technology) and enables learners to decide how to send their notes remotely (by fax or email), by making the simple gesture of ticking an apposite box printed on the paper (Fig.5).

Fig.5: The Anoto pen-paper system to support annotation

All these systems represent a significant step towards achieving a better integration between annotation on paper and on digital media.
However, these solutions do not allow the simultaneous sharing of notes among learners, during remote conversation.
This could affect the quality of collaboration experienced during a learning event, since it would make communication be based on asynchronous exchanges, instead of synchronous conversation.

The ALT system we propose tries to overcome these shortcomings by providing learners with the possibility of annotating on paper with an ink pen and to simultaneously share their notes with a remote partner by means of a chat space visualized on a display, as we describe in more detail in section 3.2 below.

A learning scenario was designed to evaluate the system, based on a collaborative treasure-hunt activity expected to nurture conversation and collaborative discovery between the learners.
The scenario was supposed to facilitate personal engagement and mutual support between participants due to the open-ended form of the play (see for other treasure hunt activities of this kind the Geocaching example at http://www.geocaching.com). Observations about the effects on the learning process, produced by the use of the ALT system within this scenario, are reported in section 4.

3. Design and Implementation of the ALT system

3.1 Inspirational and Empirical Studies

Before designing the ALT system we carried out a number of inspirational and empirical studies to understand better the relationship between paper usage and annotation practices during informal learning events.

The first three studies focused on the design of paper prototypes aimed at provoking/sustaining annotation and playful interaction of people in pairs or groups. We capitalized on the recognized value that game-like scenarios have in helping to uncover interesting aspects of interaction, useful for inspiring the design of innovative technologies (Gaver et al., 99).

We also conducted a qualitative study, based on in-depth interviews with university students, to analyze the annotational practices with paper documents that had supported their learning activity during recent years.

What follows is a brief description of these studies and of the main observations collected.

3.1.1 Narrative Game

This study started out to encourage interaction between two people by getting one of them to create a serendipitous problem from random photographs for the other to solve. We initially were more interested in the discussion generated by the two people and the way the images mediated and encouraged this.

Wanting to expand the study, we produced a book version of the images with space available for annotation. This proved to be an almost complete failure, with only one book returned. (This book was brilliantly completed, showing a highly creative interaction between the participants). We conducted phone interviews with the participants and redesigned the instructions.

Again the second version wasn't completed by anyone. We again interviewed the new participants but discovered that the fact that the book was bound was the main problem causing confusion. Because people's intuitive use of paper conflicted with the game's instructions, they were unable to complete the task. A secondary problem was that people, knowing that we were studying the connection between learning and paper, did not understand the purpose of the game and became de-motivated. This might have been avoided if part of the instructions had been a videotape of the game being used.

3.1.2 You and Your Companion (Coffee Break book)

In this study we decided to expand upon the lessons we had learnt in the Narrative Game and designed a study that again encouraged and captured the interaction between two people.

In order to speed up this process we wanted the study to be based around a short event that could be easily organized by the participants and the subject matter to be learnt to be universally interesting to all of them. The event we chose was a coffee break and the subject matter was data that was already partly shared, that is, learning more about 'each other' (their preferences, favourite objects, experiences, etc.). We decided that we would choose one participant and ask them to choose the other, a person they knew quite well.

We designed the book in the style of a magazine and carefully adapted the layout so that two people could still use it simultaneously. Not using loose sheets was a risk as it had caused such a problem before, but we were concerned about losing parts in such a mobile study.

The informal nature of the study was important as we considered this to be an important part of the learning process, increasing motivation to participate and engagement in conversation.

We were undecided about the effectiveness of observing the participants while they completed the exercise. We divided the study and observed half of the Coffee Break events and relied on our ability to interpret the participants annotations and photographic documentation for the other half.

All but one of the nine books were returned. Seven of these were extensively completed. The one book that wasn't returned was apparently partially completed, but caused such a heated interaction between the participants that it was destroyed.

The unobserved results were highly creative, very interesting and stimulating, but uninformative without follow up interviews. We concluded that capturing trace elements of a study through annotation and photography was useful but left a lot of the interaction open to interpretation.

It was very apparent in the observed studies that stimulating collaborative 'argumentation' was a highly effective method of gathering 'user data'. Provoking interaction between two familiar participants was relatively easy to start by the use of the Coffee Break book or magazine, as well as to sustain after the event by means of a digital postcards exchange (this was based on annotating some of the pictures participants had taken during the previous learning event).

The most popular exercise in the Coffee Break book was a quiz about Bill Gates (Fig. 6). This quiz allowed you to accuse your companion of being mildly autistic (not very politically correct). It seemed to be the most popular because it allowed the quickest interaction and required the least creativity. The least popular exercise was the opportunity to analyse your companion's dreams (Fig. 7). This required a good memory and a degree of openness.

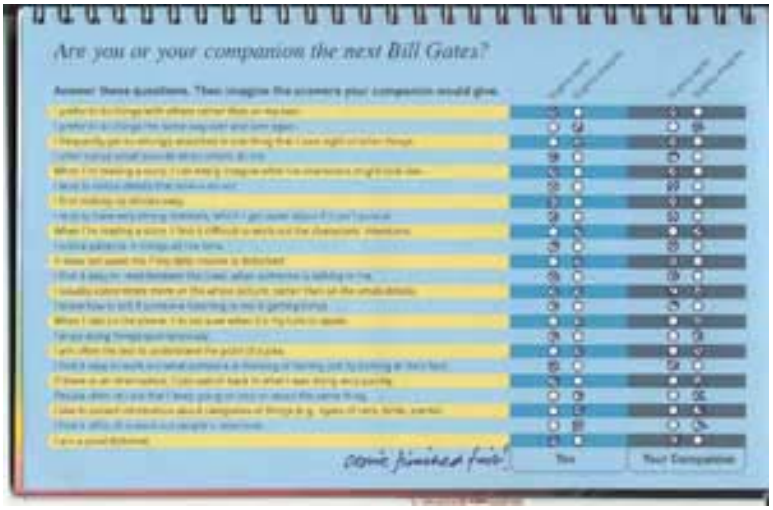

Fig. 6: A scanned page from the 'Bill Gates' exercise (coffee break book)

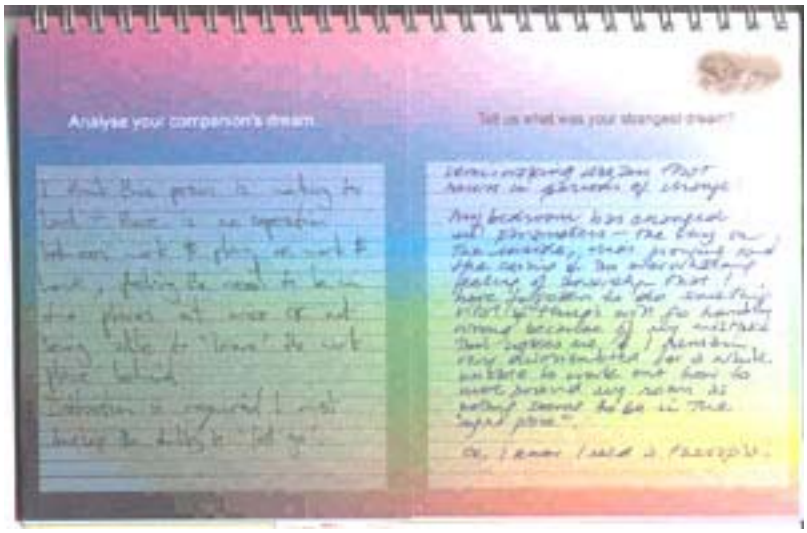

Fig. 7: A scanned page from the 'analyse your companion's dream' exercise (coffee break book)

The main conclusion we derived from this study was that even a simple paper artifact like the coffee break book could become a valuable resource for engaging participants in a more intensive and focused type of conversation. It also became a valuable medium that, by allowing partners to capture traces of their learning through mutual disclosure, could transform a usually ephemeral experience (of meeting during a coffee-break) into a more memorable kind of event.

3.1.3 Learn Sushi Event

Following the relative success of the previous study we decided to design another collaborative informal learning activity, where the subject to be learnt was more focused.

The study consisted of three stages: the first being an instructive group activity, the second a note-taking activity promoting personal reflection, and the third a learning-by-doing group activity. For these stages we invited students, researchers and staff at Interaction Design Institute Ivrea to prepare Sushi during two parties held on the 8th of March and 17th of May 2002. In between the two parties the students and part of the staff visited Japan.

For the first stage we recruited three sushi experts and asked them to prepare sushi ingredients before the event. During the events the experts would make sushi rolls and in so doing act as models to be imitated by the novice learners. As the learning was informal, novices could ask questions about specific things, such as the rice preparation or alternative roll ingredients and structure.
We documented this stage with a sequence of photographs (Fig. 8).

Fig. 8: Sequence of photographs taken during the first Sushi party

For the second part we employed the affordance of paper as a prompt to sustain learning. We produced and distributed to the learners sets of Sushi Prompt cards (Fig. 9). As these were distributed the users were told that they could make notes on these cards about Sushi during their trip (like typical ingredients, traditions related to this particular type of food or preparation).
They were also told that we didn't expect the cards to be returned to us and that they were to be kept by the users so that they could make better Sushi at the next party. This was intended to make the note-taking process personal, to promote thinking and reflection about Sushi during the trip, although by extending it into just a though process or photograph taking.

Fig. 9: Examples of Sushi Cards to be annotated in Japan

If our method of collaborative group instruction and paper prompting worked well, we would expect to see a significant improvement in the speed, quality and types of Sushi rolls produced in the following party.

For the final stage we again recruited three sushi experts and asked them to prepare sushi ingredients before the event. The difference in the event was immediately noticeable, as the learners quickly began preparing 'favourite' rolls. As hoped the speed, quality, types and creativity of Sushi rolls produced were dramatically improved. We again documented this stage with a sequence of photographs (Fig. 10).

Fig. 10: Sequence of photographs taken during the second Sushi party

We concluded that the scaffolding scenario designed to teach/learn Sushi had been effective. As expected none of the cards were returned, but interviews during the second event established that the prompt cards had sustained learning by encouraging preparation. Learners had taken sushi-related photographs and visited sushi bars in the interim.

3.1.4 Observations about Annotational Practices

To complement the inspirational phase of the project we decided to carry out some empirical investigations into the annotation practices of typical learners, like graduate and undergraduate students in a university environment. In

collaboration with the IMS [Information Management System] group at the University of Padova (I) we carried out 10 in-depth interviews with master students of Engineering and Statistics. We asked students to bring to the interview some annotated materials, like textbooks, notebooks, papers, etc. that they considered representative of their way of annotating (during a course or the preparation of an examination) and asked them to explain how their typical annotation practices or strategies helped them to better study the subject to be learnt.
The type of questions we wanted to answer were:

1) What can we learn from students' own descriptions of their annotative practices in context (that is, in front of the annotated material)?
2) Can we get a better sense of why annotation functions should be supported also in the digital world?

The interview was individual, semi-structured and lasted about 1 hour.
Discussion was enlarged to consider their use of annotations on paper or digital technologies like Text Editors, Hypertextbooks or the Web, within individual or collaborative situations, while on the move, during short or longer periods of time.

A main finding was that the reading and annotative practices of the students were almost completely based on paper documents. This could be assumed to be typical of Italian Universities, where the introduction of computer resources to support teaching and learning is still a recent phenomenon, compared to other countries. However, this finding is also in line with previous research in confirming that reading and annotating processes are better afforded by the paper medium.
Experience with digital annotation systems, provided, for example, by Text Editors, was very rare and students said they found too uncomfortable to read or write long documents by facing the computer screen.
Any use of downloaded articles, digital textbooks or hypertext-books was always followed by their printing of the document (or parts of it) for a later, more focused reading.

With regard to their annotative practices on paper documents, we resume our findings by dividing them among the following main conclusions.

- Private and collaborative use of annotations are both important.

Annotations are mainly created for private use and most of our students reported they were important to facilitate their engagement with a document (helping to sustain attention, motivation to go through all the pages, assimilation

of its content), while the function of speeding up subsequent readings of the same document was considered less important. All the students interviewed said they were used to share or exchange annotations among peers. Collaboration and note-sharing was typical of face-to-face meetings with a few peers, during which they completed exercises or solved problems related to the program of the course. Remote collaboration of any kind (by email, phone) was prevented by the difficulty of sharing notes and thoughts over documents containing graphical representations like sketches, formulas or other non-Roman alphabetic symbols. This was found particularly inconvenient for students who commuted, or lived far from university facilities.

- A removable system for annotations should be supported.

Through the interviews we came to realize the temporary value learners attribute to annotations. Most of our students claimed that they preferred to keep their books as clean as possible, saying that this would benefit a future reuse of the same books, when you often need to develop an entire new set of annotations or markings. Others admitted that sometimes they did not find enough space on a book's pages to write all the annotations they needed. So, almost all of them would prefer a removable annotation system for books, something they already tried to implement by using pencil markings or developing their annotations on separate paper notebooks.
The following quotes from two students explain better these situations of use:

> *"I often learn each theorem by memorizing its proofs and doing a number of exercises on it, afterwards I write 'Done' or 'OK' next to the formula, but this note would not be helpful if I study the book next year..."*(Omar, Statistics student).

> *"…Sometimes I don't find enough room on the page to annotate my comments, this is why I use to write 'see notebook' next to the text or stick a post-it over the page"* (Rosario, Engineering student).

Notebooks with removable pages were the most used by students, due to the importance of aggregating relevant notes and information around a book page during study. In some cases students reported the need of transferring annotations from one book to another to enable a more contextual use of notes.

- Support the hypertextual function of annotations.

What became evident was also the hypertextual function of the annotations students implemented on paper. They had developed very creative and

idiosyncratic systems for inserting bookmarks and anchors to reference different portions of text within the document's pages, like arrows, brackets, lines, coloured post-its, etc. (Fig. 11).

Fig. 11: Use of coloured post-its as bookmarks to parts of the book

These kinds of marks are often associated with other symbols and codes for differently emphasizing parts of the text or graphical representations, for re-segmenting or categorizing the document content in a way that better fits the reader's needs or mental models.
As an example, the symbol drawn by a student on Fig. 12 was meant to remind him about the risk of forgetting the concept expressed by the note.

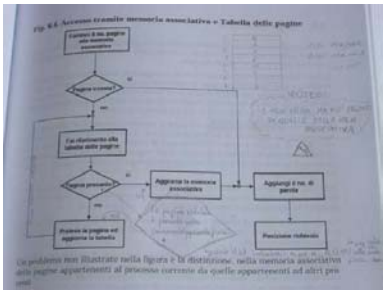

Fig. 12: The small triangle works as a warning sign for its author

Another student had developed a sophisticated colour system for both emphasizing and categorizing different properties of the text (red=new terms, green=formulas, blue=hypothesis, orange=properties), something she said enabled her to perform a subsequent browsing of the document per topic (Fig. 13).

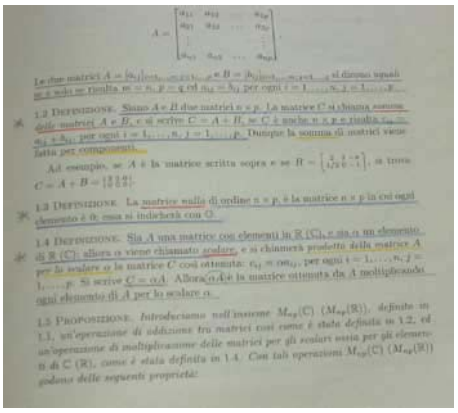

Fig. 13: Example of marks used to emphasize and differentiate parts of the text

Annotations were also inserted to establish associations or links to other parts/subparts of the same document or to a separate document (e.g., a notebook).

- The quality of annotations

Notwithstanding the variety of annotative practices we observed during the interviews, students were also aware of the potential diversity in the quality of notes. They all expressed a preference for developing their own personal annotations on the textbooks during study, a finding which shows the importance of empowering readers to transform and customize documents as they like, to better meet their specific needs. However, students claimed also that when they looked for books and annotations to borrow from their peers, they always tried to get them from 'smart' ones, people with the reputation of being very accurate in taking notes. Too much underlining or marking on books was not considered very helpful, so that they clearly distinguished between the quantity and the quality of annotations.

By the end of the interview we introduced the issue of privacy of annotations, towards which students seemed to be not very sensitive (their only concern was related to collecting back the textbooks and notes they had previously lent to their peers). We also asked about their storage system for documents and noticed that it was common among students to archive notebooks and other annotated materials separately from books. They admitted this storage method responded more to aesthetic reasons than functional ones, since retrieval of specific annotations became difficult some years after the materials had been archived. The storage and retrieval of digital documents was judged as much easier and quicker, but the amount of data in this format was less consistent compared to students' paper archives. This was due to the above mentioned difficulties in

reading and annotating with digital support during learning, but also to students' lack of confidence in keeping documents stored only in this format.

3.1.5 Main lessons learnt

As we mentioned above the aim of our inspirational studies was broader and meant to uncover interesting aspects related to learners' interaction during play, supported by annotation on paper artefacts.
We balanced these open-ended observations with more focused and traditional investigations about annotation practices within a real learning environment. From the data collected we were able to summarize the main benefits of paper vs digital interfaces in supporting annotation, that we show in Table 1 below.

Table 1
Main benefits of paper vs digital interfaces in supporting annotation

Benefits of paper as an annotation interface
High resolution for reading (both indoor/outdoor)
Portable and cheap
Affords pen input (more degrees of freedom in using hands)
Help reminding by means of its physical presence
Marking is not intrusive while reading
Supports easy marking of any kind (textual/graphic etc.)
It's easier to share in face-to-face situations
Benefits of digital interfaces for annotation
Provide no limited space for annotating
Save storage space
Save retrieval time
Make annotations easily removable
Enable remote communication and sharing of notes
Quick links to related materials
Easy transferable from one document to another

A short study helped us to observe the combined benefits of paper and digital interfaces for annotating. As we have introduced in section 3.1.2 above, this study was designed to sustain the discourse generated by the 'You and Your Companion' Coffee Break book. During the book annotation each person was asked to take photographs on behalf of their companion by using a disposable camera. The book suggested the subject matter, one being for example 'Show us their ever so typical mistake'. Obviously the companions could not see the

results during the 'Coffee Break'. We converted some of the photographs taken into digital postcards suitable for emailing and sent them to the other companion (for an example see Fig. 14). This very simple process generated a substantial digital and asynchronous conversation between the peers. In our minds this electronic postcards study highlighted the failings of paper in respect to remote conversation, whilst showing the potential benefit of its digital augmentation.

Companion A (E-mail text):

TRADUZIONE: in questa cartolina il Doc. Boldrin Tiziano ha voluto dire e neanche in maniera troppo velata che con le donne non sono sfigato ma di più (ossia termine ancora da inventare), e quindi sono con le donne che hanno circa 40 anni per gamba forse e dice forse posso combinare qualcosa.

P.S.: Tiziano questa te la faccio pagare non sò ancora come ne quando ma questa la paghi (non sono vendicatvo questo voglio ache sia ben chiaro)

Companion T (E-mail text):

Non si sa mai .....quelle due signorine (eh... Eh...) erano lì' per ammirarti.....credo che hai fatto colpo! Osserva bene, una sta pensando (...ma perchè non si fa avanti....) e la piu' bassotta ti stava mangiando con gli occhi! Ho colto l'attimo fuggente....

Ma non essere timido! Buttati!!!

Per quanto riguarda il conto....ricordati che avanzi ancora lo scherzo che hai combinato ad Andrea e a me in montagna in val Casies....ricordi nulla?

Fig. 14: Example of digital Postcard that was annotated on-line

Inspired by our previous findings we now wanted to take a main affordance from the digital territory, that is 'remote communication' and use it to augment paper based collaborative learning. We noted that this type of functionality was unsupported by most existing networked products and under explored by contemporary research. We started by developing a conceptual model for the ALT system and thought about an exemplar 'scenario of use' where it could support learning, as we describe below.

3.2 The ALT System

We developed three conceptual designs for the ALT system, the final one being implemented and tested during a user study.

The first conceptual system would implement the idea of 'connected paper'. It would be based on touch-sensitive ambient display screen technology and electronic ink, such as 'E-ink'. This would allow remote users to collaborate on a document by using a single sheet of 'connected paper'.

The initial file would be accessed from a shared network archive space, so each user would be confident of working on the same document. Each user would be aware of the page being used by the other and would be able to access it simultaneously. The annotations made on the page by each user would be shown on the other person's page. This system should be 'always on' to enable synchronous communication. The final file would be saved with the annotations.

To be successful the 'connected paper' sheet would need to be as cheap as paper, to avoid usage issues that would make it undesirable. The cheapness of paper allows it to be saved and used as a memory cue, numerous sheets can be accessed simultaneously, topical documents can be searched quickly and highlighting as well as annotation can be used.

A second model for the ALT system would implement the idea of a paper-based 'information loop'. This would be based on connected pen technology such as the 'Chat Pen' from Sony Ericsson and pocket PC displays such as the 'iPac' from Compac. It would allow remote users to collaborate on a document by using multiple sheets of 'digital paper'.

Again the initial file would be accessed and printed from a shared network archive space, so as to make each user confident of working on the same document. Each user's annotation would be tracked by the system across several sheets of paper. This means that the enlarged live annotations of your collaborator would be superimposed on the original document and their current page number would be shown on your pocket PC display. At any one moment you could see what marks you have made and what the other person is working on. There are three final documents produced, with each user saving a paper version of the work sheet and the system retaining a copy of both annotations and the original document.

This system is conceptually very intriguing as it is largely paper based and retains vital paper affordances. It also allows each user to remotely collaborate in the creation of the new document, with the 'information loop' still allowing each user to retain control of their document.

The first restriction for this system is that the Chat Pen is not capable of being 'always on' and to enable synchronous exchanges. You have to instruct the pen to send its stored annotational data. The second difficulty is relative to the data display, since the most efficient way of storing annotational data is in vector

format. Even when data are created, stored and exchanged in this way pocket PCs are not fast enough to deal with the kind of graphical processing required.

The final model we developed for the ALT system is a laptop based 'annotational chat room'. This system takes the form of a book, by using the display and processor technology from a Titanium Apple Mac laptop and pen input from a Wacom 'Intuos2' graphics tablet (Fig. 15). The specially commissioned software is written in Macromedia Director and is controlled over the 802.11b wireless network environment by a server-based application (Shockwave Multiuser Server). This system allows two users to remotely collaborate on a document in the 'annotational chat room', one sheet at a time.

Again the initial file is accessed and printed from a shared network archive space, so each user is confident of working on the same document. When the user chooses which worksheet from the document they are going to annotate, they clip that piece of paper into the 'chat room book'. On the paper is a tab system that needs to be ticked so as to inform the system and the collaborator of your current page.

The enlarged live annotations made by the collaborator are superimposed on the original document and their current page numbers are shown on the user's 'chat room book' display. The marks the user makes also appear on the display, but slightly faded. This also provides a form of system status confirmation. There are three final documents produced, as each user saves a paper version of the work sheet and the system retains a copy of both annotations and the original document.

The workflow design enables learners to 'chat' one sheet at a time, by separating instructional information onto separate sheets from the different annotational tasks. In this way it becomes possible to reference one sheet whilst annotating another on the 'chat room book'.

This system provides the advantage of being largely paper based, so as to retain vital paper affordances.

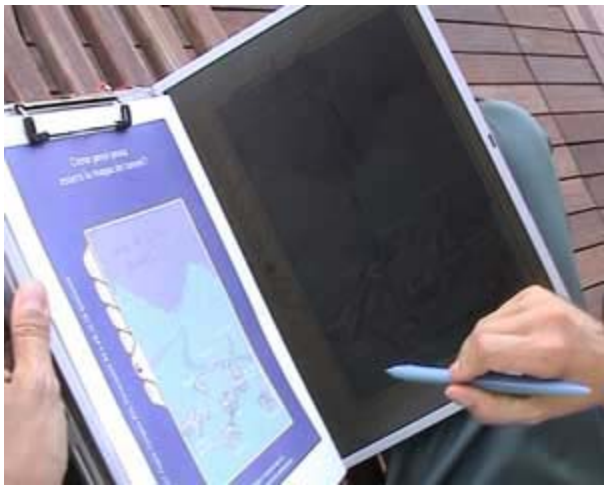

Fig. 15: The annotation system implemented

4. Evaluation

As we said before the aim of the ALT project was to facilitate an evolution of annotation practices in out-of-class learning situations, by implementing a better integration between paper and digital technologies.

To evaluate how much the system designed was able to produce this achievement we tested its use in a series of different collaborative situations.

Initially, we made the system available to pairs of interaction designers working at our Institute in Ivrea. During that time designers were involved in a phase of their research projects where they used to discuss and sketch in group concepts or scenarios to present their design ideas, so that we thought our system could have been used as a collaborative tool supporting this activity.
The nature of this testing was quite unstructured and explorative. Basically, we asked users to 'play' with the system for a while and report to us any observation or critics they might have thought that could help to improve our prototype.

The following pictures (Fig. 16-18) show how designers played with the system, the kind of sketches and annotation/communication they carried out in the collaborative space.

Their comments about the system helped us to fix some bugs and improve the interface functionalities so as to make its use more intuitive and user-friendly, reducing as much as possible the time needed for initial training or familiarization with the prototype.

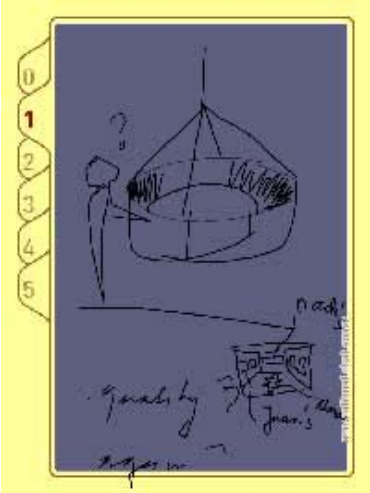

Fig. 16: Sketches to plan an exhibit


Fig. 17: Remote communication

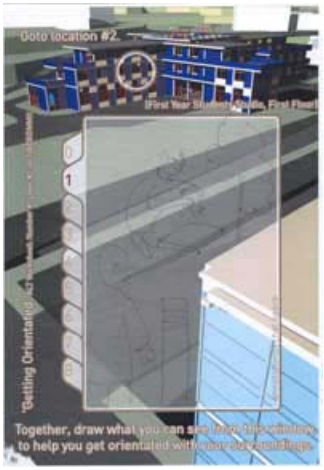

Fig. 18: Pre-testing a scenario

A more structured and focused evaluation scenario was designed after this testing. This time the aim consisted in observing the system use in a 'third place' interaction context, in which pairs of participants were involved in a learning activity designed as a form of open-ended play.

4.1 Description of the Blue House study

Five pairs of participants took part to the evaluation scenario. They were young people in the age range of 25-45, living in the neighbourhood of the Blue House, the building where Interaction Design Institute Ivrea is hosted.
Most of them knew already a few facts about the Blue House building, but still had a lot of curiosity about it and were very interested in participating to the study.

The learning activity they were asked to carry out consisted in a sort of treasure-hunt play, during which they were guided by 3 different types of information reported on paper cards found in the visited environment:

a) Cards reporting a textual and graphical indication of the location where the participant was and the one s/he was expected to visit afterwards (Fig. 19);
b) Cards reporting informative facts about the layout and historical or architectural characteristics of the building (Fig. 20) we had previously collected from documentation available at the Olivetti Archive (Ivrea). Each participant in the pair was given a slightly different type of

information (although about the same topic) so as to provoke more conversation and sharing about the facts to be learnt.

c) Cards reporting indication of 5 collaborative tasks involving annotation (Fig. 21), each one to be carried out once reached some specific location. In the first and last tasks participants were together, in the second-third tasks they were apart but could still see or hear each other, while in the fourth task they were completely remote.

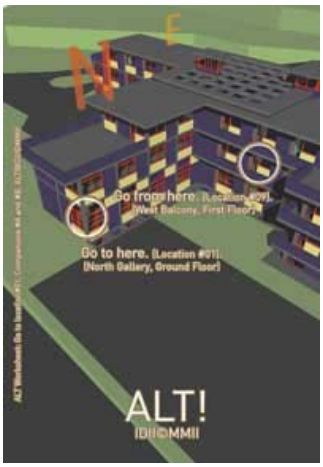

Fig. 19: Example of Location card

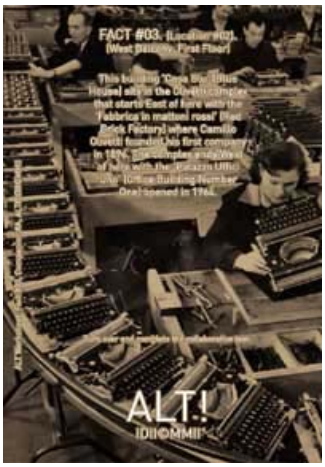

Fig. 20: Example of Fact card

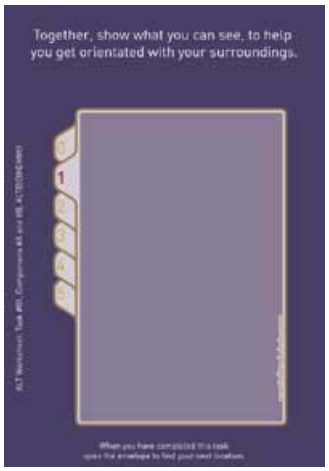

Fig. 21: Example of Task card

The procedure followed during the play consisted in:

- picking up the location card,
- reaching the indicated location
- picking up and reading the factual information provided
- reading and performing the collaborative task proposed
- picking up the following location card to start a new cycle.

Most of the locations visited were situated in the building's balconies, since this was expected to ease participants' orientation, through the use of external landmarks.

Each participant navigated the Blue House building by carrying a laptop (fitted with graphic tablet) and an ink pen. They were followed and videoed by an experimenter who interviewed them, at the end of the game, to collect their comments and evaluate the kind of learning achieved.

4.2 Main observations

The results of this qualitative study enabled us to become more aware of the design benefits and flaws involved in the use of the ALT system.

We realized, for example, that for a mobile activity like the visit of an indoor (or outdoor) place, the ALT system was quite cumbersome. The finished 'chat room book' turned out to be too heavy to carry around for a while, so that we observed our users often looking for a safe place where to put down the laptop and focus on the annotation tasks.

It was also noticed that in condition of daylight it becomes very difficult to read from an LCD screen, due to the low brightness of the display, a problem that might affect also the users of palmtops and PDAs, when these devices are used outdoor.
All these problems were overcome by our participants that tried to rely more on the information and annotations written on the paper cards, confirming the value of this technology in providing a very high resolution interface in any type of condition (i.e., indoor-outdoor, mobile-desktop).

Another drawback derived from the system's variable speed in data transmission through the server, during the working hours. Communication between the two remote laptops was sometimes slowed down by the traffic's load over the shared wireless network, and this prevented an ideal use of the chat room space during the collaborative tasks.
This issue needs to be addressed and solved in a future improvement of our system. It would be even more relevant in case the remote annotation sharing space is further extended to support connection from more than 2 users at the same time.

However, we observed that our participants found quite intuitive to understand and use the seamless interface provided, enabling them to annotate during the tasks.
The most successful aspect of the system's use consisted in engaging users to learn about the place visited in a very natural, pleasurable and informal way (Fig. 22).

During the learning tasks interpersonal collaboration and communication was useful to elicit previous knowledge users might already had about the Blue House building and its surrounding area, as well as to provoke more reflection and attention to the contextual information they had available.

Fig. 22: Users playing with the ALT system to learn about the Blue House

If we analyse the different annotations participants made on their paper-digital space we can derive the following observations:

- Some pairs produced textual annotations throughout the tasks, although some of these tasks would have intuitively elicited the use of graphical representations (like the first one, inviting to annotate the Blue House surroundings, Fig. 23).

- Other couples made use of graphics, text or a mix of them, according to the requirements of task at hand (like Task 2, see Fig. 24). They also used to go back to their previous annotated pages to find information useful to complete the subsequent tasks.

- Most of the pairs used symbols, like question marks on a shared representation (Fig. 25), as a way of communicating with their partner (or asking clarification, help) to find an agreed solution to the learning task. This system of communication seemed to work quite well.

Fig. 23: Textual notes used throughout different tasks, including Task 1

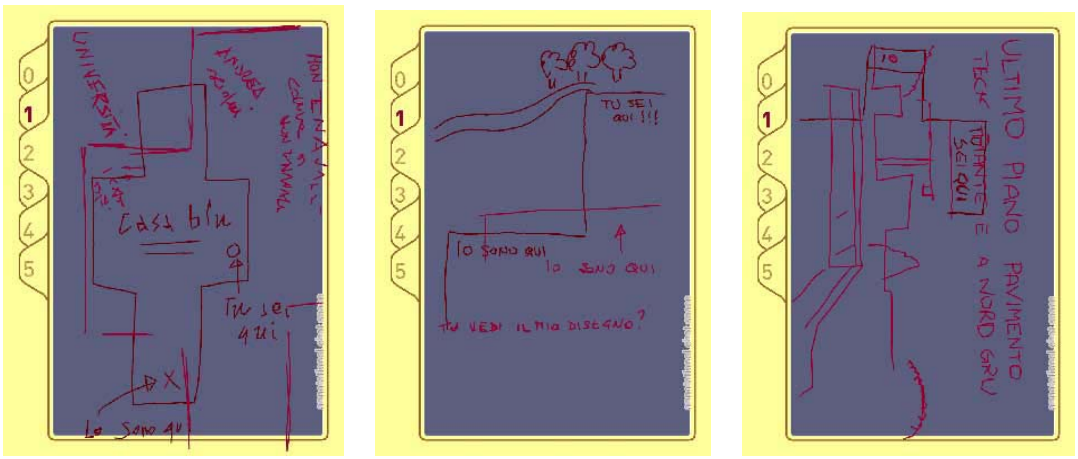

Fig. 24: Mix type of annotation used especially for completing Task 2

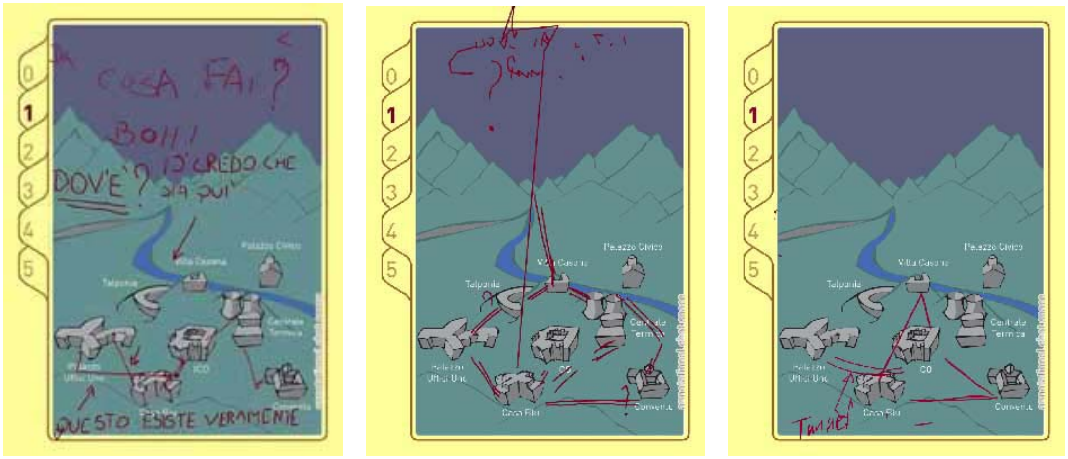

Fig. 25: Dialogue on a shared graphic

These observations led us to think about some potentialities that the ALT system might have in a learning environment:

- It extends learners' possibilities of remote discussion without being constrained to use just a textual communication modality (as it happens with SMS communication).

- It enables learners to work remotely over a shared representation (that might be graphical, textual or non Roman-alphabetic) in an intuitive, relatively cheap and simultaneous way, something we found lacking in typical learning environments (like the university where we conducted our interview study), since it is not comparable to email or phone communication.

- It makes simultaneously available both a paper and digital copy of the notes taken that can be changed or saved and stored for future reuse.

The follow-up interview with participants, at the end of the learning activity, was mostly dedicated to discuss further the facts reported on the paper cards that had particularly captured their interest.
This showed us that learners had really enjoyed the scenario and found it interesting to be involved in, although they expressed some criticism about the system's variable performance (speed), sometimes affecting the quality of their remote collaboration.

5. Conclusion

Throughout the ALT project it has been shown how annotation can be a key activity for supporting peer-to-peer learning practices.

The design and evaluation of the ALT prototype has demonstrated how the widespread use of paper, as a physical (tangible) interface for annotation, can be enhanced, by smoothing learners' transition from paper to the digital space.
This move is meant to favour a gradual evolution of current annotation practices in learning environments, to enable a better, combined use of both paper and digital resources.

As discussed in the previous section the prototype system implemented needs to be further improved to make data transmission faster and to become more portable, as it is required by learners' activity on the move.
An ideal improvement would be to get rid of the use of laptops altogether and adopt just the use of paper and digital pens, following the Anoto system's philosophy. However, the technological solutions available today are not designed to enable simultaneous communication in remote conditions, a functionality our project has demonstrated to be valuable to pursue. By means of the study presented we would like to stress also the importance of enabling learners with as many different expressive modalities as possible when working individually or collaboratively in annotating external representations.

The work here presented can offer a contribution and be related to at least two current areas of research.

The first one is CSCL [Computer Supported Collaborative Learning], where recent empirical studies have started to investigate the development and use of shared annotation systems as a way of encouraging peers/group discussion to support out-of-class learning, in university environments (Brush et al., 02).
Although we agree with the general assumptions and implications of this research, focused on designing educational technologies that take into account the value of informal learning (going beyond the class context), this approach has not yet provided a solution to the fact that learners used to print, read and annotate documents on paper over their digital versions.

The ALT project offers an alternative to the traditional comparison between annotation on paper and web-based annotation or commentary systems; the ALT prototype provides a solution oriented towards exploiting the benefit of annotating in context and on the move by taking advantage of combining both paper and digital affordances.

Another possible application of our project is related to the field of Digital Libraries (DL) development. Here it becomes important to understand what kind of use we could make of annotations (on paper or digital support) to enhance learners' access and information retrieval from large repositories of documents.
Advanced techniques could be developed to process personal annotations and make them available to other readers or learners on-line (as a form of metadata about documents or to provoke discussion). However, more empirical research on how to transform personal annotations into shared and *re-useful* ones is still needed (Marshall & Brush, 02).

In conclusion we advocate approaching the innovation of learning environments and practices by pursuing an optimal integration between old and new technologies available.
The system we have presented seems to help learners to perform their annotation activity across the physical-digital border and, at the same time, to remove part of the spatial boundaries existing in remote learning.

An interesting extension of this system would consist of developing a website enabling learners to be connected with their peers, but also with other participants to the same kind of learning event, across time.
This is an opportunity already offered, for example, by the Geocaching system, where explorers, taking part to worldwide High-Tech treasure-hunts, repeatedly upload images and annotations about their experiences of finding or hiding caches around the world.

An analogue scenario could be designed to enable the use of the ALT system to explore an outdoor environment (for example an eco-museum), where learners in pairs or small groups might associate a contextual learning about natural resources with a remote synchronous/asynchronous exchange of annotations related to their learning experience.
We believe these kinds of systems and scenarios would offer a valuable support to informal learning within third places and contribute to the emergence of new communities of interest.

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References

Brown J.S. & Duguid P. (2000). *The Social Life of Information*. Harvard Business School Press, Boston, MA.

Brush A.J.B., Bargeron D., Grudin J., Borning A. & Gupta A. (2002). Supporting Interaction Outside of Class: Anchored Discussions vs Discussion Boards. *Proc. of Computer Supported Collaborative Learning Conference, Boulder (Colorado), Jan. 7-11*.

Clancey, W. J. (1997). *Situated Cognition: On Human Knowledge and Computer Representations*. Cambridge: Cambridge University Press.

Eales R.T.J. & Welsh J. (1994). Learnability through working together. In the *Proc. of OZCHI'94*, (Melbourne, Australia, 28 Nov-2Dec. 1994), 27-32.

Eales R.T.J. & Welsh J. (1995). Design for Collaborative Learnability. In the *Proc. of CSCL '95*, (Indiana University, Bloomington, IN), 99-106.

Eales R.T.J., Hall T., Bannon L.J. (2002). The Motivation is the Message: Comparing CSCL in different settings. *Proc. of Computer Supported Collaborative Learning Conference, Boulder (Colorado), Jan. 7-11*.

Gaver B., Dunne T. & Pacenti E. (1999). Cultural Probes. *Interactions*, Jan-Feb99, 21-29.

Illich, I. (1973). *Deschooling Society.* Penguin, Harmondsworth, UK.

Ishii H., Kobayashi M. & Grudin J. (1993). Integration of Interpersonal Space and Shared Workspace: ClearBoard Design and Experiments. *ACM Transactions on Information Systems*, Vol. 11 No 4, 349-375.

Lave J. & Wenger E. (1991). *Situated Learning: Legitimate Peripheral Participation*. Cambridge, UK: Cambridge University Press.

Marshall, C.C. (1997). Annotation: from paper books to the digital library. In *Proceedings of the ACM Digital Libraries '97 Conference*, Philadelphia, PA (July 23-26, 1997).

Marshall, C.C. (1998). Toward an ecology of hypertext annotation. In *Proceedings of ACM Hypertext '98*, Pittsburgh, PA (June 20-24, 1998), 40-49.

Marshall C.C. & Brush A.J.B. (2002). From Personal to Shared Annotations. In *Proc. of CHI2002* (Minneapolis, Minnesota, USA, April 20-25), 812-813.

Oldenburg R. (2000). *Celebrating the Third Place: Inspiring stories about the 'Great Good Places' at the heart of our Communities*. Avalon Publishing Group.

Schilit B.N., Golovchinsky G. & Price M.N. (1998). Beyong Paper: Supporting Active Reading with Free-form Digital Ink Annotations. In *Proc. of CHI98* (Los Angeles, CA, April 19-26), ACM Press, 149-156.

Sellen A. & Harper R. (1997). Paper as an Analytic Resource for the Design of New Technologies. *Proc. of CHI97*, Atlanta, GA, 319-326.

Sellen A. & Harper R. (2002). *The myth of the paperless office*. The MIT Press. Cambridge, Massachusetts.

Thackara J. (2002). *Pure Play, or Pure Pain? New business concepts for interactive products and services.* Workshop held at Interaction Design Institute Ivrea (I), 16th April 2002.

Wenger, E. (1998). *Community of Practice: Learning, meaning and identity*. Cambridge University Press, Cambridge, UK.