# PaWiki: A paper-based wiki system for the classroom

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## Motivation

New technologies increasingly allow the digital and physical world to connect. Rich input, such as 3D body tracking and multi-touch surfaces, enable more natural interaction (Wigdor & Wixon, 2011). Tangible objects can serve as an interface for digital interaction (Shaer & Hornecker, 2010). One compelling setting to take advantage of these new technologies is the classroom.

Already there is a substantial body of literature on using multi-touch / tangible-based interactive tabletops to support learning (Dillenbourg & Evans, 2011). From a pedagogical perspective, tabletops are particularly promising as they promote collaborative group work over instruction (Rick, Rogers, Haig, & Yuill, 2009). Yet, there are substantial barriers to adoption. Orchestrating multiple groups is challenging (Dillenbourg & Jermann, 2010; Kharrufa et al., 2013; Martinez Maldonado, Kay, Yacef, & Schwendimann, 2012). At a cost of 5000€ or more per tabletop, equipping a classroom can be prohibitively expensive, even at a ratio of four students per tabletop. Even if the hardware investment is made, suitable software is in short supply.

Unfortunately practical considerations are crucial for pervasive classroom adoption. From that perspective, two possibilities emerge. First, there are one-per-learner devices (i.e., laptops and tablets). As large-scale commercial products, these are relatively affordable / capable and have an established software foundation. While there are research and commercial efforts in this direction, there are still substantial obstacles: orchestrating learning, establishing a model of ownership, mass purchase and installation of software, maintaining a large fleet, etc. Second, there are one-per-classroom devices, such as projector-based desktop machines and electronic whiteboards. As only one is required per classroom, the unit cost can be significantly higher. Already there has been mass adoption of electronic whiteboards in the UK; however, a progress report warns that the technology tends to “reinforce a transmission style of whole class teaching in which the contents of the board multiply and go faster, whilst pupils are increasingly reduced to a largely spectator role” (Moss et al., 2007).

Can we create a practical one-per-classroom device that furthers more active learning? That goal motivates our work. As there will only be one per classroom, any learner spending a significant amount of time with the device will deprive others of that opportunity. As such, we aim for a device with lightweight interaction that functions primarily by enhancing the existing classroom ecology. We target two widely spread technologies: classroom projectors, whether attached to a desktop machine or as part of an electronic whiteboard, and paper. As it is tangible, familiar and inexpensive, paper can be a powerful interface for a digital learning system (Do-Lenh, Kaplan, & Dillenbourg, 2009; Zufferey, Jermann, Lucchi, & Dillenbourg, 2009).

We propose *PaWiki*—a simple interactive tabletop system, built with affordable hardware, that bridges the paper and digital world. Individual creation is done on paper. Browsing, augmentation, linking and orchestration is done in the digital world. PaWiki provides a transition between the worlds—scanning in paper and printing out digital artifacts. The projector computer can access the digital content through an integrated webserver.

## From Values to Approach

Research is influenced by the values of the researchers; as these help to contextualize the design and the research, it can be useful to explicitly state them (Yarosh, Radu, Hunter, & Rosenbaum, 2011). Our work is in the tradition of the *learning sciences*. Thus, we value engaging, active forms of learning over didactic instruction; we value learning skills and epistemologies over memorizing facts. We acknowledge that learning can be a long-term process of identity development (Rick et al., 2012), that learning is situated (Lave & Wenger, 1991), and that collaboration between peers can be particularly useful for driving learning.

While the learning sciences accepts that learning is complex, it still retains an empirical focus. To prove their worth, ideas must be implemented and tested in an authentic context. Creating a “toy demo” to exemplify the ideas and creating an effective tool to support learning are only milestones on the path towards the ultimate goal: a platform to simultaneously facilitate and research effective learning in context.

In this work, we are particularly inspired by *constructionism* (Papert, 1991), which holds that people learn particularly well when creating personally meaningful public artifacts, and *collabora-*

*tive scripting* (Weinberger, Ertl, Fischer, & Mandl, 2005), which presents effective, replicable patterns for orchestrating collaborative learning. PaWiki aims to provide new opportunities for the teacher to orchestrate collaborative activities and to make student creations more public. The central role of shared public artifacts led us to adopting the *wiki way* (Leuf & Cunningham, 2001) to content creation.

Though it was a simple technology, the WikiWikiWeb was a revelation: It demonstrated that an open authoring model could function quite well as social factors were sufficient for preventing inappropriate behavior. Other significant wiki insights include emphasizing contents over looks, valuing simplicity over extra features and promoting content linking (e.g., to create a new page, a link to the page must first be created on an existing page). Wiki is not a specific application but rather a medium for communication. As a medium, users can choose how to appropriate it (Bolter & Grusin, 1999). In our own studies on wikis in education, we found that both teachers and students invented new ways to appropriate the medium (Guzdial, Rick, & Kehoe, 2001). We found it useful to develop our wiki engine by situating it in an authentic context, observing what adopters did and improving the system to enhance that usage (Rick & Guzdial, 2006). We aim to use a similar process with PaWiki: Creating an initial medium, placing it in situ and iteratively improving it based on user needs.

## The PaWiki System

We are still in the early stages of design, examining the choices for available hardware / software and creating a vision of how to bring these elements together. As the main element, we envision a tabletop with cutouts / receptacles for various purposes (Figure 1). In the center of the tabletop is a receptacle for users to place their paper creations. A digital still camera, located above the tabletop, is used to capture the content in high resolution. In Europe, DIN A3 is a common paper size for classroom activities, such as art projects. For tasks where a smaller paper size is appropriate, inserts can be added to accept A4 and A5. Using a toggle wheel, users specify the heading of the paper; the paper receptacle is angled so that only two headings are intuitive: for landscape, top towards the far side and, for portrait, top towards the left side. To identify users, a fingerprint reader is provided on the right side; a toggle wheel is used to log in / log out users. To provide additional controls (e.g., for browsing existing content), a wheel and two buttons are provided at the near side. To provide interface feedback, a vertical monitor is positioned at the far side of the tabletop.

To extent the system, we envision a system of tangible widgets that can be placed on the tabletop. These would allow the system to flexibly mature and provide an intuitive, tangible way to control the system.

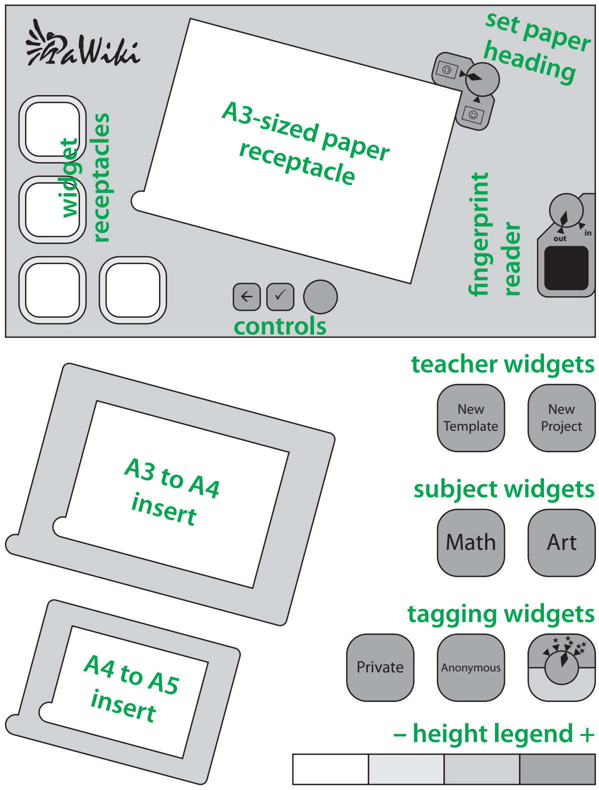


Figure 1: PaWiki tabletop components

tem. To employ a newly implemented feature, we provide a new widget; the teacher can then choose to employ it for a specific task by adding it to the tabletop. Here are examples of widgets that might prove useful: The teacher could use a "new project" widget to establish that the upcoming student work belongs to a certain project and provide a cover page for it. In the wiki, contributions would then be organized by that project. Similarly, work could be tagged with a specific subjects (e.g., math, art) to facilitate browsing. Users could also use widgets to tag work. For instance, a student could choose the "private" widget if the work is not for public consumption (e.g., a math test).

To implement the system, we will use the reacTIVision toolkit (Kaltenbrunner & Bencina, 2007). A webcam will be positioned below the table to track the id, position and heading of reacTIVision fiducials. The control and toggle wheels will be attached to such a fiducial and its heading will inform the system about turns of the wheel. The widgets will feature a specific fiducial pattern, thus allowing for a large number of widgets. The paper-size inserts will contain fiducials that inform the camera to capture an appropriately sized image. In any case, the captured image will be in the standard $\sqrt{2} : 1$ aspect ratio of the DIN format. This shared aspect ratio is particularly useful as we will also provide an A4-equipped printer to provide a path back from the digital to the paper world. The printer will feature duplex printing so that each print-out can be tagged with a unique marker that allows the system to recognize the artifact. Here is one scenario of how the system could be used:

A class is studying the water cycle. The teacher wants to make sure that students understand all the phases. For each phase, she draws an example on a blank sheet of paper. She then goes to the PaWiki, logs in and places the "new template" widget. She creates a template for each of her drawings and prints each out a couple of times. She distributes them evenly throughout the class and asks the students to complete the drawing of the water cycle. Once students are done, they go to the PaWiki, log in and scan their drawing. As the back of the page contains the marker for the template, the drawing is tagged with that template. Next, the teacher displays the creations on the whiteboard; she chooses to browse anonymously so that nobody is embarrassed by mistakes (note that students do not have to sign their creations as PaWiki will note who authored what). For each drawing, the group must determine whether it is complete or whether crucial phases are missing. As given phases were distributed throughout the classroom, the teacher can be assured that some student should notice a missing element. Later she can browse the creations to track individual progress.

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