# Classroom Technology Design Guidelines: A Focused Survey

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**Abstract:** Although digital technologies have been permeating our classrooms for the last three decades, educational technology designers have begun considering the specific challenges of such complex multi-user environments only recently. This contribution describes the result of a limited-scope review of works proposing technology design guidelines that address the challenges of the (physical) classroom and its orchestration by teachers. The resulting synthesis of guidelines is expected to help the workshop participants in finding ways to address the challenges of concrete classroom ecologies, while respecting the challenging restrictions of authentic settings.

**Keywords**: classroom technologies, design guidelines, survey, review, orchestration

## Introduction and motivation

The fact that a classroom is a very challenging, multi-user social environment has been known for a long time in educational research. Classrooms are inherently time-restricted, multi-activity public spaces (Doyle, 2006). With the advent of digital technologies, a new layer of complexity has been added to the challenges of managing a classroom. In educational technologies, researchers have reckoned the difficulties of managing technology-enhanced educational environments, especially in formal education, under the label of 'orchestration' (Roschelle, Dimitriadis, & Hoppe, 2013).

With this recognition, CSCL and other educational technology researchers/designers have begun studying more closely how their proposed innovations are used in the context of an authentic educational setting, trying to understand how the specific restrictions of a real classroom (in terms of time, curriculum, activity or social constraints) affect such usage. In this line of work, (Dillenbourg et al., 2011) speak of orchestration of learning as "usability at the classroom level", highlighting that educational technologies should not only be usable for individuals and enable small-group activities; they also should be manageable under the tight restrictions of learning (and managing the learning) in a classroom with a large group of students.

Educational technology design guidelines based on these ideas of "classroom usability", going beyond existing individual and small-group usability advice have started to appear, distilling the results of researchers' empirical evaluations of technology in authentic settings. However, their number is still small and there exists no single scientific forum where this emergent flavor of usability/interaction is discussed. This contribution tries to provide an initial seed for such discussions, synthesizing the works that currently offer *explicit* technology design guidelines, specific for classroom environments. Such synthesis may provide a strong base to help researchers (especially, the present workshop participants) in designing novel solutions for concrete classroom ecologies where the heterogeneous technologies are becoming an increasingly critical problem.

## Survey methodology

Our survey followed coarsely Kitchenham's classic systematic review guidelines: a focused systematic review of main technological literature databases was complemented with the author's existing expert knowledge of the field, which already included a database with several research works addressing the challenges of designing for the classroom. The systematic part of the review was performed by querying the three main literature databases specializing on technical and socio-technical literature (ScienceDirect, ACM Digital Library and IEEExplore), using the following query: *(classroom AND technology AND guidelines)*. This search string was applied only over the metadata of the entries (e.g., title, abstract and keywords). Such query returned a total of 104 results (68 for IEEExplore, 23 for ScienceDirect and 13 for ACM Digital Library). These results were then inspected and filtered according to the following criteria: they have to provide *explicit* technology design guidelines (as opposed to research or pedagogical guidelines), and do so from a technology design perspective (as opposed to a teacher or insititutional perspective). Also, the guidelines should be applicable beyond a single system or kind of learning activity, and considerable author or paper overlaps should be resolved by looking at the most complete

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source. After such filtering, only four sources were left. To these four resulting sources, the author added several previously-known works that propose design guidelines for technology design in the classroom (i.e., applying the same filtering criteria as in the systematic review selection). Table 1 presents the resulting set of 11 works to be surveyed and analyzed more deeply.

The resulting sources were carefully read, and their guidelines were clustered by similarity, as well as prioritized (so that clusters appearing in more separate sources are given more importance). The results of this analysis are presented in the next section.

Table 1: Summary of literature sources surveyed

| Review part | Reference | Journal/Conference | Specific area/subject |
|---|---|---|---|
| Systematic search | (Cramer & Hayes, 2013) | International Conference on Interaction Design and Children | Economy in primary education |
| | (Nussbaum & Infante, 2013) | International Conference on Advanced Learning Technologies | Educational technology |
| | (Stanton et al., 2001) | SIGCHI Conference on Human Factors in Computing Systems | Tangible interfaces, storytelling |
| | (Ting, 2013) | Computers & Education | Mobile learning |
| Previously-known database | (Balaam, 2013) | Computers & Education | Educational technology |
| | (Cuendet, Bonnard, Do-Lenh, & Dillenbourg, 2013) | Computers & Education | Augmented reality-based activities |
| | (Dillenbourg, 2013) | Computers & Education | Educational technology |
| | (Dillenbourg & Jermann, 2010) | New Science of Learning (book) | Educational technology |
| | (Kharrufa, Martinez-Maldonado, Kay, & Olivier, 2013) | ACM International Conference on Interactive Tabletops and Surfaces | Tabletop-based activities |
| | (Kreitmayer, Rogers, Laney, & Peake, 2013) | ACM Conference on Pervasive and Ubiquitous Computing | Collaborative learning, Tablet-based activities |
| | (Sharples, 2013) | Computers & Education | Educational technology |

## Results: The guidelines

Among the literature sources surveyed (see above), up to 58 design guidelines for classroom technologies were found. Despite this large number, many of the design guidelines were very similar to each other, or could otherwise be clustered in closely-related themes. These (overlapping) clusters define the following technology design guidelines for the classroom (in parentheses, number of guideline instances appearing in each cluster):

1. *Provide awareness and visibility mechanisms **(10)***: Probably the single most often mentioned design guideline for classroom technologies was the need to have awareness mechanisms, especially for the teacher to keep track of what is going on in the classroom, but also for mutual awareness among students in the form of public displays (Cuendet et al., 2013; Dillenbourg & Jermann, 2010; Dillenbourg, 2013; Kharrufa et al., 2013; Nussbaum & Infante, 2013). This includes making visible student states that may otherwise be invisible or hard to infer by the teacher, such as the phase/activity progress, or even student emotions (Balaam, 2013). Two other themes are closely related:
    a. *Record and show classroom history **(4)***: Since a classroom is a social space with its own history across multiple sessions and activities, it makes sense to record and eventually visualize data about process followed by students, for run-time action or post-hoc reflection (Kharrufa et al., 2013; Kreitmayer et al., 2013; Ting, 2013).
    b. *Take into account and record data for (summative) assessment **(4)***: Most of the above awareness mechanisms are intended for the general awareness of the teacher, to enable effective formative assessment during the lessons. However, mandatory summative assessments (often, individual) are still needed in most formal education. Thus, taking those assessments into account when technologies gather data, and facilitating individual accountability can greatly aid in the integration of a technology in everyday classroom practice (Cramer & Hayes, 2013; Dillenbourg & Jermann, 2010; Kharrufa et al., 2013; Nussbaum & Infante, 2013).
2. *Do not break the classroom flow **(9)***: Many authors highlight the immediacy of actions in a physical classroom, and the tight schedules teachers and students often experience. Thus, classroom technologies should allow for quick operation (e.g., no complex login/initiation mechanisms) and

changes, so as to make use of small "time pockets" and avoid unnecessary distractions (Cramer & Hayes, 2013; Nussbaum & Infante, 2013). Related to this classroom flow, many authors mention that classroom technologies should enable smooth transitions from individual to group and classroom activities, both at the level of digital and physical workflow, and managing students' attention between autonomous and group/class work (Cuendet et al., 2013; Dillenbourg & Jermann, 2010; Dillenbourg, 2013; Kharrufa et al., 2013; Kreitmayer et al., 2013). Another aspect of this integration into the classroom flow is the fact that technologies should be open and compatible with existing legacy technologies and props already in the classroom ecosystem (Stanton et al., 2001).

3. *Keep (easy) control in the hands of the teacher **(6)***: Many of the design guidelines reviewed make emphasis on the teacher-centeredness of classroom interactions, and the need to provide centralized means for the teacher to control the flow of the classroom easily (Cuendet et al., 2013; Dillenbourg & Jermann, 2010; Dillenbourg, 2013; Kharrufa et al., 2013). Other authors, like (Sharples, 2013) actually propose an opposing approach, suggesting that in some cases the teacher should share this orchestration load with students and/or the technological systems in place.
4. *Allow for flexible adaptation of the technology-enhanced activities **(4)***: Very related to the issue of teacher control of classroom flow is the fact that extraneous events (or the classroom awareness mechanisms mentioned above) may sometimes make advisable to modify flexibly the original lesson plans of the teacher, either in terms of activities, timing, etc. (Cuendet et al., 2013; Dillenbourg & Jermann, 2010; Dillenbourg, 2013).
5. *Take into account the physicality of the classroom **(6)***: Another common guideline made for classroom technologies is to consider the physical layout of the classroom and the physical properties of the classroom objects and technologies (Dillenbourg & Jermann, 2010; Dillenbourg, 2013; Kharrufa et al., 2013; Stanton et al., 2001; Ting, 2013). This can have an impact in the visibility (physical actions are more visible/glanceable) or the flow of the classroom (reifying the classroom workflow in physical actions/objects) as mentioned above, but also on finer details of the interaction, such as having devices or actions that better map to certain aspects of the subject content.
6. *Design to support (small-group) sharing and collaboration **(5)***: Especially when considering particular pedagogies such as collaborative learning, the ability to support group work is also a very important aspect, such as the creation, modification or resuming of student groupings (Cramer & Hayes, 2013; Kharrufa et al., 2013; Nussbaum & Infante, 2013). Along this dimension we can also find recommendations of how to design interfaces to encourage (equal) participation by all students and the creation of an atmosphere of productive collaboration.
7. *Provide activity structures and guidance **(6)***: Another classic educational technology advice is to provide systems that somehow provide a structure for the learning activities (Dillenbourg & Jermann, 2010; Kharrufa et al., 2013; Kreitmayer et al., 2013; Nussbaum & Infante, 2013). In particular, most authors advocate the use of simple linear sequences of activities/phases (as they are easy to understand and to explain rapidly), and to keep the individual/group activity progress as synchronized as possible (e.g., with transitions centralized/controlled by the teacher), to keep the sense of togetherness across the classroom. Aside from these classic instructional strategies, there are also recommendations more artistic in nature, for example the advice of (Dillenbourg & Jermann, 2010) about using 'drama' – occasional high-emotion states to engage students and carry them along the learning scenario.
8. *Consider the curriculum constraints and relevance **(3)***: As one of the main restrictions of any formal education setting is the adherence to a mandatory curriculum, some of the surveyed works highlight that the proposed activities and technologies should be relevant to this curriculum (either by design or through teacher customization), and that the amounts of time dedicated to the different learning objectives should be proportional to their relevance in the curriculum (Dillenbourg & Jermann, 2010; Nussbaum & Infante, 2013).
9. *Map technologies and data to the subject content **(2)***: When multi-device, multi-technology setups are considered, the gathered data (see Awareness above) and the different interaction modes they enabled should be mapped as best as possible to different aspects of the subject content (Stanton et al., 2001; Ting, 2013).
10. *Balance student needs and discipline **(1)***: The fact that new technologies enable further personalization of the learning processes for each student should be balanced against the need for the classroom to keep an order and discipline (Nussbaum & Infante, 2013).

11. *Be minimalistic!* ***(4)***: A kind of meta-principle, which runs in a way counter to all of the previous guidelines (which propose functionalities to incorporate in classroom technologies), is the fact that the classroom technology should offer only "just enough" information and functionality for the teacher or students (Cuendet et al., 2013; Dillenbourg & Jermann, 2010; Dillenbourg, 2013). The rationale in this case is that each new option or information item present in the technology adds to the cognitive load of the actors, whose cognitive resources are already stressed by the multi-task nature of the classroom.

## Conclusions and implications

As we can see, the guidelines extracted from this focused survey of the literature is not clearly separable, with overlaps and strong relationships among clusters (e.g., physicality and awareness), but also oppositions/tensions among them (activity structure vs. flexibility, no-login ease of use vs. need for individual assessment, minimalism vs. everything else). This focused review shows several methodological limitations (mainly, the restrictiveness of its search keywords, and the requirement for explicit technology guidelines). We hope this review can serve as a seed to be expanded in later, deeper reviews of this area (e.g., adding terms like "orchestration" or "lessons learned", or extracting implicit guidelines present in other classroom technology studies, or commonalities in the reification of these guidelines). We believe the critical discussion and application of these guidelines can be crucial to the development of this emergent field within learning technologies and human-computer interaction, which can eventually spawn its own research sub-community and venues for scientific discussion (of which the present workshop is an early example).

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