

# Mind the Gaps: Using Patterns to Change Everyday Classroom Practice Towards Contingent CSCL Teaching

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**Abstract:** Educational research has established the benefits of adapting lesson plans and teaching to the evolution of student knowledge and emergent occurrences in the classroom. This kind of improvisatory adaptation of teaching, however, is seldom seen in everyday classroom practice of CSCL. This paper describes two independent research projects that aim to influence authentic classroom practices to promote this kind of teaching using the same collaborative learning tool, Group Scribbles. Evidence from both projects shows that merely providing technologies that support this adaptation is not enough to provoke the change and that exposing teachers to good uses of the tool (in the form of pedagogical patterns) also has limited success. Both projects highlight the difficulty for practitioners to bridge the gap between de-contextualized advice and contextualized classroom situations. We propose the use of more atomic, actionable moves to help teachers orchestrate technology to support deeper collaborative knowledge building.

## Introduction

A main concern of the CSCL community in recent years (as is evident from Dillenbourg, 2009, and from the title of this CSCL 2011 conference) is how to apply CSCL research results to everyday educational practice. For example, facilitating highly interactive discussion and adjustment of instruction based on what teachers learn from student responses have long been considered beneficial (Alexander, 2008). This is especially true for collaborative learning, where the teacher's role shifts to facilitator, working with students to help them tackle the learning challenge through the sharing and construction of questions, ideas, or data. However, the adjustment of teaching for deep and meaningful collaborative discussion is seldom seen in everyday teacher practice with information and communication technologies (ICT) (Kennewell et al., 2008).

The success of such agile instruction depends on teachers having resources that help them adjust lessons, contingent on what they find out students know and can do (Beatty et al., 2006). Yet existing research is insufficient to indicate how to best scaffold improvisational adjustments in everyday classroom practice, especially in reaction to rich, constructed student responses.

Pedagogical patterns are a common resource for scaffolding teacher enactment and enabling contingent teaching with classroom network technologies (DeBarger et al., 2010; Conole et al., in press; DiGiano et al., 2003; Prieto et al., 2010). These patterns represent best practices and prior knowledge by expert practitioners as tried-and-true solutions to recurrent problems in a field or practice (Alexander et al., 1977). Patterns can be formulated to help teachers make student thinking visible and engage students in genuine dialogue so that the students shape the flow and direction of the discussion. Such dialogic discussions improve students' learning and development of scientific explanations (Nystrand & Gamoran, 1991).

Technology is another resource for supporting instruction that can flexibly adjust in response to student thinking, making it easy for the teacher to modulate the discussion by, for example, posing a new question or activity on the fly based on student responses (Penuel et al., 2005, Roschelle et al., 2007). Only recently have the appropriate kinds of flexible technologies emerged to support such malleable, interactive instruction. In the context of collaborative learning, clickers have foreshadowed this new potential, and virtual whiteboard systems with individual and shared displays show promise in supporting the rapid exchange and submission of sketched representations (Anderson et al., 2007). Group Scribbles, a collaborative tool based on the familiar metaphors of private/public boards and adhesive stickers, is an example of a flexible, collaborative whiteboard system that supports a range of learning activities (DeBarger et al., 2010; Dimitriadis et al., 2007; Looi et al., 2010).

This paper relates findings from two independent projects—one in Spain and one in the United States—that studied Group Scribbles implementations in real classroom settings to better understand the impact of flexible network technology and pedagogical patterns on contingent, student-centered teaching. Both projects employed professional development workshops and classroom observations, but otherwise used different research approaches. Using a largely bottom-up approach, researchers in Spain introduced Group Scribbles into primary school classrooms and helped teachers transform their lesson ideas into Group Scribbles activities, documenting such practices as common design and enactment patterns and improvisational adjustments to instruction. Using a mix of researcher- and co-designed pedagogical patterns and interactive assessment

activities, researchers in the United States introduced Group Scribbles to middle school teachers, documenting implementation challenges and how teachers adjusted instruction within the provided structure.

Evidence from both projects shows that a key challenge in putting contingent teaching into practice, and especially in reusing best practices and prior knowledge from research (e.g., in the form of pedagogical patterns), is bridging the gap between de-contextualized advice and specific classroom situations and actions (Goodwin & Duranti, 1992). The multiple decisions to be made when implementing a pedagogical pattern or when reacting to rich student-generated responses present pedagogical pitfalls and risks. To circumvent this problem, researchers on both projects independently proposed using more atomic and actionable instructional moves. Initial evidence from both projects suggests that by using this approach (rather than just de-contextualized pedagogical patterns), the design and enactment of activities is greatly facilitated.

This paper first describes the research approaches of both projects and the main findings regarding the implementation of contingent teaching. Then the challenge of bridging the gap between de-contextualized advice and contextualized enactments in everyday practice is discussed. Finally, conclusions about implementing innovations for contingent teaching in CSCL are presented, as are paths of potential future work.

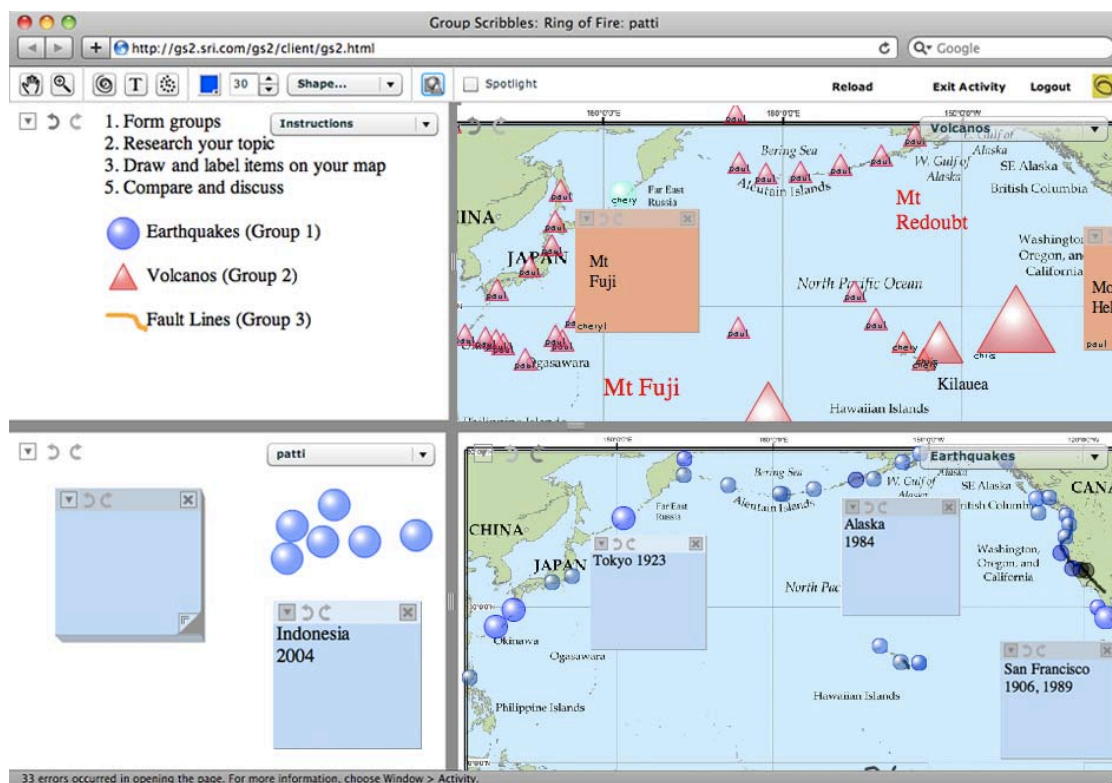


Figure 1. Screen shot of Group Scribbles boards

## A Tale of Two Projects

Group Scribbles is being used by the Grupo de Sistemas Inteligentes y Cooperativos (GSIC) research group at the University of Valladolid and in the Contingent Pedagogies project at SRI International. Since 2006, both groups have been working with Group Scribbles in several research efforts. Albeit independent, both groups were aware of each other's work as part of the tight research community around Group Scribbles. Initially, both institutions focused on the potential for Group Scribbles to support improvisation and social coordination in the classroom; subsequently, pedagogical patterns have taken on a more important role in the projects' work.

Group Scribbles is a participation-oriented network technology that supports collaborative activities using text, sketches, and images (Figure 1). The metaphor is based on common physical artifacts from the classroom: adhesive notes, whiteboards, pens and markers. Participants can scribble contributions on notes and post them anonymously in a shared public space that becomes the object of discussion. Teachers can quickly configure spaces for a short-term collaborative or group activity, and as the activity unfolds, alter the configuration on the fly and create new public boards to support multiple spaces for small groups to work.

## GSIC Experiences with Group Scribbles

The GSIC research followed a bottom-up approach driven by a case study method (Stake, 2005). The research took place in five classrooms of a primary school (with 18–25 students each, ages 6–8) in Spain with eight

teachers who had varying levels of teaching experience and ICT training. The researchers spent 2 years working closely with the teachers to help them orchestrate their activities using Group Scribbles and other ICT tools (e.g., digital whiteboards, tablet PCs) that were already in their classrooms. All the designed and enacted Group Scribbles activities were related to the teachers' usual curricula.

In the first stage of the research, Group Scribbles was introduced in a brief training session with teachers. Then, during activity design sessions, the researchers helped transform teachers' activity ideas into Group Scribbles activities. Thirty-one enactments of those activities were observed and analyzed. Additional information on the school and teacher context was gathered through three semi-structured interviews and a focus group with teachers. All sessions were audio-recorded, and observation notes were taken by at least two researchers for triangulation. See Villagr a-Sobrino & Prieto (2011) for more on the enactments analysis process.

The main result of this first stage of research was that the role of improvisation in teachers' practice was minimal, even when teachers used a tool like Group Scribbles that supports improvisation (Roschelle et al., 2007). They also acknowledged the importance of emergent occurrences in classroom enactment:

T2: Maybe during the enactment of an activity many things can happen, which I have not prepared, but I think that it is important that teachers design their activities. [Teachers' focus group, 2009/03/17, translated from Spanish]

Further, teachers tended to design high-level tasks but their enactments had more small-scale, patterned kinds of improvisation. The activity patterns extracted from actual teaching were dubbed *routines* (both design routines and enactment routines) to differentiate them from researcher-specified *patterns*. Figure 2 (A) shows an activity design from a teacher's notebook. Figure 2 (B) shows the activity enactment analysis, reflecting its phases (distinct portions of activity enactment, often traceable to a design routine) and enactment routines (recurrent teacher moves present in the enactment) observed during each phase. The activity design (in bold) was completed by phases and routines that emerged during the enactment (e.g., R4a—"Disallow tool usage").

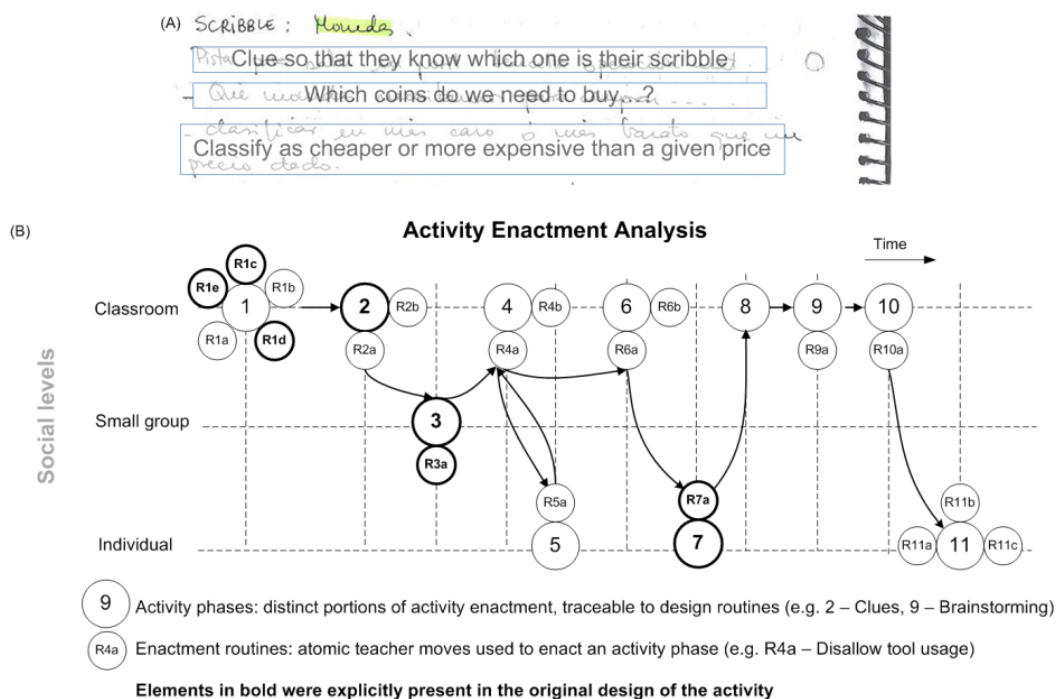


Figure 2. (A) Design, (B) Enactment analysis of one activity. Adapted from Prieto et al. (2010)

The goal of the second stage of this research was to foster collaborative learning practices among the teachers through different forms of professional development. A 2-hour training session on collaborative techniques centered on the use of collaborative learning flow patterns (CLFPs, see Hern andez et al., 2010). As illustrated in the following excerpts from the session, the macro-level CLFPs presented were considered by teachers as too separated from their classroom contexts and practice, and thus not easily re-contextualizable:

T3: It is very difficult to put into practice a role-play and a think-pair-share [names of CLFPs] with children in the first grade (6-7 years). [CLFPs training session, 2009/11/10, translated from Spanish]

T4: I would be hard-pressed to say anything I do that resembles these techniques [the CLFPs] [CLFPs training session, 2009/11/10, translated from Spanish]

The researchers speculated that routines elicited from teachers' real practice (such as the ones in Figure 2 above) might be a better entry point for teachers to design activities and to promote their reflection on the enactment (Prieto et al., 2010). A 2-hour professional development workshop was carried out with nine teachers from the same school (four teachers who were part of the previous research effort and five new to the research). After a brief presentation of the design and enactment routines from their practice, teachers were able to design and role-play an enactment of a complex Group Scribbles activity in 10 minutes. Moreover, a survey taken just after the workshop showed that the routines were familiar to them and that they appreciated their usefulness.

(To the question: Have you ever used these [design] routines? Which ones?)

T5: Yes, almost all: brainstorming, classification, ordering, where is on the image, Etc. [Survey after routines workshop, 2010/06/25, translated from Spanish]

(To the question: Did the [design] routines help you in enriching the design? Why?)

T6: Yes, because they bring new ideas about how to work the same contents in different ways. [Survey after routines workshop, 2010/06/25, translated from Spanish]

### **The Contingent Pedagogies Project**

The aim of the Contingent Pedagogies project is to improve student science learning by integrating assessment activities into a widely used Earth systems science curriculum, *Investigating Earth Systems* (IES) to create a comprehensive curricular activity system (Roschelle, Knudsen, & Hegedus, 2009). The Contingent Pedagogies project developed activities called interactive formative assessments (IFAs) for IES that use classroom network technology, clickers and Group Scribbles. The IFAs specify questions for teachers to pose; how network technology will be used to support collection, aggregation, and display of data; and how teachers can use assessment information to organize instruction. Pedagogical patterns successful in prior research for promoting individual and group learning served as templates for designing the IFAs (DeBarger et al., 2010).

In the first stage of research, five sixth-grade teachers who had experience implementing the IES curriculum were introduced to the network technology and pedagogical patterns in a professional development workshop. The teachers then worked together in small groups with an assessment researcher, curriculum developer, and subject matter expert to develop activities. After the workshop, the project team developed additional IFAs and worked with the five teachers to pilot-test the activities in their classrooms in Colorado. Each teacher taught at least three classroom sections in Earth science with 25–35 students each. The team engaged the teachers in monthly 1.5-hour teleconferences in which technology issues that teachers encountered were addressed, teachers reported on an activity that they implemented with students, and the team shared tips related to effective use of the technology. Technological support was also provided through web conferencing.

During the school year, Contingent Pedagogies researchers observed 12 classroom sections where teachers used Group Scribbles activities. Using semi-structured observation protocols, observers recorded the focal science topic and described teachers' and students' interactions. At the end of the class, observers recorded summaries of the class, including instructions teachers gave, teacher support for student engagement, variations in students' responses to the activity, questions posed and nature of the responses, breakdowns in the flow and management of activities, technology use, and communication of science content by the teacher. At the end of the year, an online survey was fielded to obtain a comprehensive view of all the activities and patterns the teachers attempted to implement and to identify activities and patterns that were more and less valuable or usable from the teacher's perspective. Detailed findings from this research appear in Penuel et al. (2010).

Both the survey and the observations indicated that the teachers could enact the Group Scribbles activities and patterns and that they did so many times during the 5 or so months when they were using the IES units. On average, each teacher used Group Scribbles activities six times in their classroom. Teachers reported that they had implemented most, but not all, of the activities developed by the team and that they had also created several of their own Group Scribbles activities based on the pedagogical patterns provided.

Results from the first stage of research suggested promising levels of adoption, but also highlighted challenges to implementation and the need for a broader set of tools to improve the quality of enactment of patterns in the classroom. The teachers felt that the patterns advanced the goals of enhancing communication, motivation, and feedback and that the IFAs helped students learn high-level skills. But they also experienced many tensions in classroom management, such as technical issues sidetracking lesson flow, figuring out the "right amount of time" to allow students to answer questions, and keeping students on task during group work.

T7: I want to have more training activities for my students to learn about it before they have to use it. I felt that was the hardest part this year; they were so enthralled to find out things that it was tough to manage. [Teacher teleconference, 2010/1/21]

T8: The only issue for me is when they're doing the wrong things—writing on each other's boards, or writing a scribble that says "hi john". I take away their computer after a warning to stop doing that. [Teacher teleconference, 2010/3/25]

Further, the quality of the student participation and the contingent teaching observed were limited. Observers noted that teachers often asked students to explain their ideas, but teachers did most of the intellectual work of building on and connecting ideas and rarely engaged students in discussion of one another's ideas. Instead, teachers addressed issues by restating correct ideas or explaining why certain answers were incorrect. For example, after trying several times to explain a scientific idea related to divergent plate boundaries, one teacher asked students to "show by giving thumbs up, to the side, or down" the level of understanding they felt they had achieved. For those who displayed a thumb down (still confused) or to the side (not completely sure), the teacher told them that they could return to the classroom during lunch for further review.

Finally, the researchers found little evidence of teachers changing the direction of lessons to address clearly problematic ideas. Project staff had planned to introduce a set of contingent activities to teachers in a field trial the next year but concluded that providing contingent activities was insufficient; the teachers needed a broader suite of tools to improve the quality of enactment of patterns in classrooms. To support a more dialogic style in such enactment (O'Connor & Michaels, 2007), the project team developed a set of classroom norms for participation, discourse moves for discussion, and decision rules for contingent teaching, all of which are being implemented and studied with 15 teachers in the current (third year) of the project. Norms set expectations about how students will participate in discussion and establish a classroom community with a shared purpose of making sense of scientific ideas and practices (e.g., everyone will reason and respond; challenge ideas, not identities). Discourse moves (e.g., inviting students to build on a classmate's idea or summarize a key idea from a discussion) can help shift responsibility for thinking to students. Decision rules provide teachers guidance on how to proceed on the basis of assessment information. For example, if the class is divided between two alternative explanations, a teacher might break the class into two groups and ask students from each to pose questions to the other group about their explanations. Preliminary indications suggest promising uptake by teachers of these dialogic supports. Weekly logs from teachers show high levels of uptake of both the norms and discourse moves, and teachers report that they helped them advance their goals for instruction in nearly all instances when they employed them in conjunction with network technologies (Penuel & DeBarger, 2011). In focus group discussions, teachers offered accounts for why:

T9: I really like the norms and I think they set a good standard in the classroom of what do to, and I see the kids using it in everything they're doing... The one I like the most is explaining, it's really making the kids support their reasoning. [Teacher teleconference, 2010/10/27]

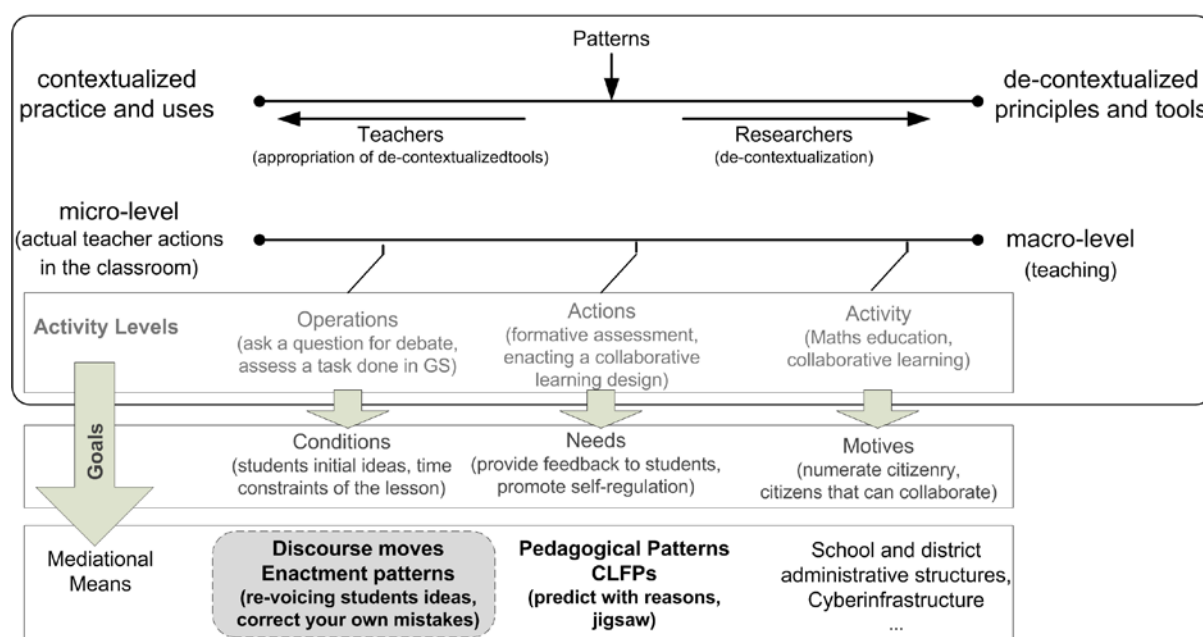
T10: I agree, it has really set a good tone for the kids... There are a lot of times when something is happening in class and I can refer back to those norms. Like the one norm about "it's okay to be wrong" based on your current understanding; that has come up on several occasions... We look at when you took that test that was what your understanding was... but now that you have this new understanding it's different. [Teacher teleconference, 2010/10/27]

### **Bridging the Gaps: A Challenge for Changing Everyday Practice**

The findings and evolution of these two projects exemplify a common problem of CSCL research that tries to influence classroom practice in authentic settings: how to make the results of past research (often in the form of de-contextualized theories and principles or reified into new technological tools) available to practitioners in a way that they can appropriate them—and, moreover, how to do it for practitioners who are not especially gifted or motivated or are not experts (Dillenbourg, 2009). Studies into the sustainability and scalability of research-based interventions (Fishman et al., 2004; Penuel et al., 2007) point to the importance of such factors as the professional development approach, its coherence with current reform ideas in the schools, and the challenges that teachers face in their daily practice. Slavin & Lake (2008) also highlight the effectiveness of programs that address changes in teacher practice (e.g. by creating architectures for collaborative learning).

The projects depicted in this paper explored pedagogical patterns as a professional development approach to help address everyday teaching challenges. The pattern approach offers several advantages: it serves as a means of communication between researchers and practitioners (and also among practitioners), it offers practitioners a number of building blocks that can be creatively combined into new solutions, and finally, it is suitable for nonexperts because of its problem orientation. However, the evidence from the two projects described above shows that its application to everyday teaching practice is not without potential limitations. The findings of both research groups highlight two important tensions or gaps that often arise when researchers try to influence everyday practice in an authentic setting. These tensions are represented graphically in Figure 3.

## The Gaps



**Figure 3.** Gaps in the contextualization and mediational support of teaching. The focus of the research presented here is highlighted with a grey background (bottom-left).

The first of these tensions appears between researchers' efforts to de-contextualize empirical data to obtain widely applicable principles and teachers' application of those principles to concrete situations, which can be seen as an act of re-contextualization (Goodwin & Duranti, 1992). Teaching practice, and especially innovative teaching practice, can be seen as the appropriation of the de-contextualized tools such as curriculum materials, classroom management techniques, as well as resources provided by researchers (e.g. theories, patterns, or even technological tools such as Group Scribbles). In this sense, pedagogical patterns provide de-contextualized advice on how to attain certain pedagogical goals. However, as noted by Winters & Mor (2009), dealing with de-contextualized tools can be difficult for teachers, even if they contain more elements of context than an abstract theory (e.g. they assume a certain kind of classroom, or they are provided along with a short narrative example of their application to other contexts). Instructional moves and design and enactment routines elicited from actual teaching practice are also examples of this de-contextualization effort, but they originate from a different source than theory. Having more elements of a familiar context present in these patterns (e.g. assuming usage of the Group Scribbles tool and a whiteboard, or assuming a specific outcome of a previous task) enhances their mirroring properties and makes them more actionable (i.e. teachers recognize them as actions that they normally take in the classroom or may take in an easily recognizable situation).

There is a second tension or gap between the macro-level designs and plans for instruction (provided by researchers, developed by teachers, or co-designed) and the emergent micro-level enactment of those plans by a specific teacher in a classroom. Such plans are incomplete by their very nature, since any representation of a practice is a simplification. Even if plans are designed by teachers thinking about their specific classroom context, plans cannot take into account all emergent occurrences or accurately predict students' notions and their evolution. If we look at this gap from the point of view of socio-cultural activity theory (Engeström, 1987), lesson plans and pedagogical patterns at the macro-level (e.g. the CLFPs mentioned above) provide mediational tools for teachers at the action level that respond to needs such as providing feedback to students or promoting self-regulation. But even with that scaffolding, teachers must still make decisions on how to enact the plans using specific instructional moves in their classroom context. These instructional moves (which correspond to operations in activity theory terminology) can be highly routinized and often vary based on teacher style. By also providing scaffolding at the operation level (e.g. Contingent Pedagogies' discourse moves, or GSIC's enactment patterns), more coherent pedagogical strategies can be enacted by teachers. Having a set of atomic, actionable patterns that are easy to call forth, tweak and recombine can empower teachers to creatively design and enact activities according to the theories and design principles of CSCL research (Hernández et al., 2010) and dialogic teaching research (Wells & Mejia-Arauz, 2006; O'Connor & Michaels, 2007).

Moreover, this combination of patterns of different granularities is supported by Alexander's concept of a pattern language (Alexander et al., 1977), that is, a set of related patterns that provide increasing detail on how to implement the higher-granularity patterns. In our case, norms, rules, moves, and routines can be seen as

tools for goal-directed action that ideally become operationalized in ways that support teachers' enactment of collaborative, dialogic activities. They also help teachers in specifying further innovations using technology in ways that can enhance their implementation (Cohen & Ball, 1999).

## Conclusions and Future Work

The pedagogical patterns approach has been motivated by the need to exchange knowledge and good practices between research literature and the real world, as a way to support practitioners and as a means of communication among various stakeholders (e.g., teachers and education or technology researchers).

However, researchers who use patterns in CSCL still encounter challenges in changing everyday classroom practice. This paper has presented two CSCL projects that tried to take contingent, adaptive teaching with flexible network technology (Group Scribbles) to the real world through the use of patterns. Despite the differences in school context or even the overall research approach, researchers on both projects independently identified and analyzed several common issues that must be addressed. One is the gap between the de-contextualized theories and tools that researchers often produce and teachers' need to provide ad-hoc practice in their classroom situations (which can be seen as an act of re-contextualization). Another is the gap between the macro-level advice (e.g. in the form of pedagogical patterns or lesson plans) that is often given to teachers and the micro-level decisions and actions that teachers must take in their particular contexts. In both cases, the use of more atomic, actionable teacher moves (coming from real practice and derived from literature) has showed promising results. The use of practice-derived enactment patterns, classroom norms, and decision rules seems to complement the advantages of macro-level pedagogical patterns and to enable a wider adoption and change of daily practice. Thus, we posit the combination of both kinds of patterns as a coherent mediational strategy for teachers to produce contextual, pedagogically-sound uses of technology, making the most of its affordances for enhancing teaching and learning.

Further research is needed to accumulate more evidence in favor of or against this proposal for an effective use of pedagogical patterns in CSCL. Our research teams in the United States and Spain intend to build on the findings of both projects and thus tackle a common problem in CSCL—the low reusability of knowledge. For example, we plan to explore the application of patterns (including routines, moves, rules, and norms) across both projects and analyze teacher practice in the U.S. context to identify additional routines that can be used in professional development workshops in conjunction with research-driven patterns. By addressing these issues in two contexts, we hope to generate insights into how to prepare teachers to become more proficient in orchestrating collaborative discussions and in enacting contingent teaching with ICT in real-world classrooms.

## References

- Alexander, R. (2008) *Towards dialogic teaching: Rethinking classroom talk*, 4th edition. York, UK: Dialogos.
- Alexander, C., Ishikawa, S., & Silverstein, M. (1977). *A pattern language: Towns, buildings, construction*. New York, NY: Oxford University Press.
- Anderson, R., Anderson, R., Davis, P., Linnell, N., Prince, P., Razmov, V., & Videon, F. (2007). Classroom Presenter: Enhancing interactive education with digital ink. *IEEE Computer*, 9, 56-61.
- Beatty, I., Gerace, W., Leonard, W., & Dufresne, R. (2006). Designing effective questions for classroom response system teaching. *American Journal of Physics*, 74(1), 31-39.
- Cohen, D. K., & Ball, D. L. (1999). *Instruction, capacity, and improvement*. Philadelphia: Consortium for Policy Research in Education.
- Conole, G., McAndrew, P., & Dimitriadis, Y. (in press). The role of CSCL pedagogical patterns as mediating artifacts for repurposing Open Educational Resources. In F. Pozzi & D. Persico (Eds.), *Techniques for fostering collaboration in online learning communities: Theoretical and practical perspectives*. Hershey, PA: IGI Global.
- DeBarger, A., Penuel, W., Harris, C., & Schank, P. (2010). Teaching routines to enhance collaboration using classroom network technology. In F. Pozzi & D. Persico (Eds.), *Techniques for fostering collaboration in online learning communities* (pp. 222-244). Hershey, PA: IGI Global.
- DiGiano, C., Yarnall, L., Patton, C., Roschelle, J., Tatar, D., & Manley, M. (2003). Collaboration design patterns: Conceptual tools for planning for the wireless classroom. *Journal of Computer-Assisted Learning*, 19(3), 284-297.
- Dillenbourg, P. (2009). Exploring neglected planes: social signals and class orchestration. *Proceedings of the 9th International Conference on Computer Supported Collaborative Learning - Volume 2* (pp. 6-7). New Brunswick, NJ: International Society of the Learning Sciences.
- Dimitriadis, Y., Asensio, J., Hernandez, D., Roschelle, J., Brecht, J., Tatar, D., Chaudhury, S., DiGiano, C., & Patton, C. (2007). From socially-mediated to technology-mediated coordination: A study of design tensions using Group Scribbles. *Proceedings of the 8th International Conference on Computer Supported Collaborative Learning* (pp. 184-186). New Brunswick, NJ: International Society of the Learning Sciences.

- Engeström, Y. (1987). *Learning by expanding: an activity-theoretical approach to developmental research*. Helsinki, Finland: Orienta-Konsultit.
- Fishman, B., Marx, R., Blumenfeld, P., Krajcik, J., & Soloway, E. (2004). Creating a framework for research on systemic technology innovations. *The Journal of the Learning Sciences*, 13(1), 43-76.
- Goodwin, C., & Duranti, A. (1992). Rethinking context: An introduction. In A. Duranti & C. Goodwin (Eds.), *Rethinking context: Language as an interactive phenomenon* (pp. 1-42). New York, NY: Cambridge University Press.
- Hernández, D., Asensio, J. I., Dimitriadis, Y., & Villasclaras, E. D. (2010). Pattern languages for generating CSCL scripts: From a conceptual model to the design of a real situation. In P. Goodyear & S. Retalis (Eds.), *E-learning, design patterns and pattern languages* (pp. 46-64). Rotterdam, The Netherlands: Sense Publishers.
- Kennewell, S., Tanner, H., Jones, S., & Beauchamp, G. (2008). Analysing the use of interactive technology to implement interactive teaching. *Journal of Computer Assisted Learning*, 24 (1), 61-73.
- Looi, C. K., Chen, W. & Ng, F. (2010). Collaborative activities enabled by Group Scribbles (GS): An exploratory study of learning effectiveness. *Computers & Education*, 54 (1), 14-26.
- Nystrand, M., & Gamoran, A. (1991). Instructional discourse, student engagement, and literature achievement. *Research in the Teaching of English*, 25(3) 261-290.
- O'Connor, C., & Michaels, S. (2007). When is dialogue “dialogic”? *Human Development*, 50, 275-285.
- Penuel, W. R., & DeBarger, A. H. (2011, April). *Supporting teacher learning to improve classroom assessment in science*. Paper presented at the Annual Meeting of the American Educational Research Association, New Orleans, LA.
- Penuel, W., Roschelle, J., & Abrahamson, A. (2005). Research on classroom networks for whole-class activities. *Proceedings of the IEEE International Workshop on Wireless and Mobile Technologies in Education* (pp. 222-229). Los Alamitos, CA: IEEE.
- Penuel, W., Fishman, B., Yamaguchi, R., & Gallagher, L. (2007). What makes professional development effective? Strategies that foster curriculum implementation. *American Educational Research Journal*, 44(4), 921-958.
- Penuel, W. R., Beatty, I. D., Remold, J., Harris, C. J., Bienkowski, M., & DeBarger, A. H. (2010). *Pedagogical patterns to support interactive formative assessment with classroom response systems*. Menlo Park, CA: SRI International.
- Prieto, L. P., Villagrà-Sobrino, S., Dimitriadis, Y., Jorrín-Abellán, I., Martínez-Monés, A., Anguita-Martínez, R. (2010). Recurrent routines in the classroom madness: pushing patterns past the design phase. *Proceedings of the 7th International Conference on Networked Learning* (pp. 499-507). Lancaster, UK: Lancaster University.
- Roschelle, J., Knudsen, J., & Hegedus, S. (2009). From new technological infrastructures to curricular activity systems: Advanced designs for teaching and learning. In Jacobson, M. J., & Reimann, P. (Eds.). *Designs for Learning Environments of the Future: International Perspectives from the Learning Sciences*. New York: Springer.
- Roschelle, J., Tatar, D., Chaudbury, S., Dimitriadis, Y., Patton, C., & DiGiano, C. (2007). Ink, improvisation, and interactive engagement: learning with tablets. *IEEE Computer*, 40(9), 42-48.
- Slavin, R.E. & Lake, C. (2008). Effective programs in elementary mathematics: A best-evidence synthesis. *Review of Educational Research*, 78 (3), 427-515.
- Stake, R. (2005). Qualitative case studies. In N. K. Denzin & Y. S. Lincoln (Eds.), *The Sage handbook of qualitative research* (pp. 443-466). Thousand Oaks, CA: Sage.
- Villagrà-Sobrino, S., & Prieto, L. P. (2011). *The making of a routine catalogue*. Valladolid, Spain: University of Valladolid. Available online at [http://www.gsic.uva.es/~lprisan/Villagra2011\\_RoutineAnalysis.pdf](http://www.gsic.uva.es/~lprisan/Villagra2011_RoutineAnalysis.pdf)
- Wells, G., & Mejia-Arauz, R. (2006). Dialogue in the classroom. *Journal of the Learning Sciences*, 15(3), 379-428.
- Winters, N., & Mor, Y. (2009). Dealing with abstraction: Case study generalisation as a method for eliciting design patterns. *Computers in Human Behavior*, 25(5), 1079-1088.

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