11 Technology-Supported Face-to-Face Small-Group Collaborative Formative Assessment and Its Integration in the Classroom

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The integration of technologies into school learning processes is motivated not only by their central role in the worlds of work and knowledge but also by their potential as mediators of social relations. They bring powerful tools to the task of converting classroom experiences into interactive and collaborative ones that deliver a range of pedagogical benefits (Wood & Malley, 1996). As Postholm (2007) has stated, the question is not whether information communication technologies (ICTs) can offer the teaching and learning activity but rather how teachers and pupils can approach and use this mediating artifact and benefit from it in their work.

Since ICT resources are found mainly in computer laboratories, activities built around these technologies imply a change in the natural context of classroom teaching and tend to focus on the purely technological aspects (Reynolds, Treharne, & Tripp, 2003). In this sense, the technologies are not truly integrated into the classroom teaching dynamic, and this may limit their impact on teaching styles traditionally used in schools (Watson, 2001).

The role of ICTs in education can be described in terms of the following categories: broadening classroom resources and reference; enhancing working processes and products; mediating subject thinking and learning; fostering more independent pupil activity; and improving pupil motivation to do lessons (Deaney, Ruthven, & Hennessy, 2006). However, the mere incorporation of technologies into the teaching environment is not enough to bring about improvements in education quality (Robertson, 2003). Critics have alleged that technological innovation has not resulted in either real curricular innovation or changes to traditional teaching systems (Soloway et al., 2001) and also maintain that the vast majority of teachers use technology to sustain existing patterns rather than innovate (Conlon & Simpson, 2003, Hayes, 2007). Postholm (2007) exemplifies this last point, noting that even among teachers who agree on the need for integrating constructivist concepts, technology is used to support lecture-based teacher-centered instruction.

It is well established that small-group collaborative activities in which group members work together toward the attainment of common goals are an effective tools for facilitating both academic and social achievement (Dillenbourg, 1999). According to Johnson and Johnson (1989), activities organized to function collaboratively lead to greater achievement and retention than do those with structures that emphasize individual action or competitive behavior.

These findings are grounded in socioconstructivist theories, which hold that learning does not take place in a vacuum but rather within a specific context and through interaction with one's peers (Vygotsky, 1979). Learning is thus understood as a process in which social interaction provides feedback, stimulation, instruction, correction, mutual scaffolding of comprehension, and socially shared construction of meaning (Salomon & Almog, 1998).

However, an effective environment for collaborative learning does not automatically materialize the moment where two or more persons begin working together; for it to emerge, certain conditions must be present that ensure learning is achieved. Adams and Hamm (1996) and Dillenbourg (1999) single out five necessary factors for generating efficient collaborative work: individual responsibility, mutual support, positive interdependence between group members, face-to-face social interaction, and work in small groups.

The role of the teacher in collaborative work is also central, whether it be in the planning of activities or their performance and supervision. The actual carrying out of an activity is the most important and arduous of these tasks (Johnson & Johnson, 1999), given that it involves a change in the conceptualization of the very role instructors adopt in the classroom to one revolving around the monitoring of student learning. This new task is thus centered on the students.

When collaborative work is supported technologically, it is known as computer-supported collaborative learning (CSCL), an approach oriented towards the development of computer programs that facilitate interaction between peers and group work. In a CSCL context the technology mediates the interaction between the participants by delivering information, regulating the tasks to be performed, administering rules and roles and mediating the acquisition of new knowledge (Kumar, 1996). The objective is for the technology to offer a medium for classroom discussions that can facilitate participation and social interaction among the students and between them and the teacher (Lipponen, Rahikainen, Lallimo, & Hakkarainen, 2003) while also increasing the effectiveness of interaction among peers (Dillenbourg, 1999).

Generally, collaborative activities suffer from certain limitations stemming from the use of desktop computers (Nussbaum et al., 2007), whose software programs are not designed for such applications and whose capacity is insufficient to support simultaneous interactions between various users (Inkpen, 1999). Furthermore, the sort of collaboration supported by most CSCL applications requires that students gather around a single computer and take turns using the mouse or keyboard (Zurita & Nussbaum, 2004a), thus sticking closely to the traditional "one computer–one person" paradigm (Inkpen, 1999). Working at a desktop machine has the added disadvantage of hindering the face-to-face work that is essential for enhancing interaction in a collaborative activity (Zurita & Nussbaum, 2007).

In the light of the above, the use of portable technologies that offer individual computer access (1:1) can be a major source of support for the development of collaborative dynamics given that such devices, if used together with appropriate pedagogical designs, facilitate communication between peers and motivate interactions (Roschelle, Rosas, & Nussbaum, 2005). The growth of these technologies has led to the emergence in the educational technology field of the concept of mobile learning. This learning model, based on mobile computers that support wireless communication, offers a number of undeniable advantages for overcoming the above-described limitations of using desktop machines. These advantages include the following:

- Lower cost. This eases the burden of providing an individual computer to each student, improving coverage by reducing the student/computer ratio (Savill-Smith & Kent, 2003).

- Portability. The mobile devices are small, light, and easy to carry; they can therefore be used anytime and anywhere, including in classrooms (Roschelle, Pea, Hoadley, Gordon, & Means, 2001).
- Face-to-face interaction between students within a single group is permitted (Cortez, Nussbaum, Rodríguez, López, & Rosas, 2005).
- Efficient organization of the learning resources used in a given activity is facilitated (Zurita & Nussbaum, 2004b).

These aspects of the mobile model lay the groundwork for a pedagogical proposition that uses technology to support teaching processes based on collaborative dynamics in which each student has access to a portable computer small enough not to impede face-to-face communication—an arrangement that also ensures the mobility necessary to allow random formation of small groups within the classroom.

In this chapter, we introduce and analyze an approach to face-to-face small-group collaborative work mediated by technology that shifts from an instructor-centered arrangement in which the teacher radiates knowledge before a passive class of students to one where the students are active and work collaboratively in small groups while the teacher acts as a mediator. This pedagogical strategy, known as the Eduinnova methodology, was developed at the Pontificia Universidad Católica de Chile over a period of 10 years. It has since been applied with upwards of 20,000 students and 700 teachers and has been successfully integrated in more than 38 schools in Chile, 1 in Argentina, 8 in Brazil, and 3 in England at various educational and socioeconomic levels. The system has also been employed by SRI International in applied research on mathematics learning at three educational institutions in the United States and by the Chilean Ministry of Education for teacher training. The heart of the present work is a study of the Eduinnova project implemented at schools in two Chilean cities, focusing on the analysis of the results obtained.

After discussing the Eduinnova methodology, we next examine the relationship between this methodology and the concept of formative assessment. Then we outline the implementation methodology of the Eduinnova project. The following section describes the study undertaken to analyze the project's results and outcomes. We next set out the results and analyses of the project and a number of aspects of the results and analyses. Finally, we offer a brief conclusion.

TECHNOLOGY-SUPPORTED FACE-TO-FACE SMALL-GROUP COLLABORATIVE LEARNING AND FORMATIVE ASSESSMENT

The Eduinnova methodology for technology-supported face-to-face small-group collaborative learning is inspired by the notion of assessment for learning, When used to adapt teaching to meet learning needs, the concept is known as formative assessment, a process that has been shown to improve students' performance (Black, 2005). It involves the development of learning assessment criteria that enable students to assess the knowledge they are acquiring in order to use it correctly in the real world (Tait, 1997). Two phases can be distinguished in formative assessment (Black & Wiliam, 1998). First, the student perceives a difference between a defined goal and his or her current understanding state; second, he or she takes action to close this knowledge gap and reach the goal.

These two phases are reflected in the functioning of Eduinnova. The formative assessment process begins when a class of students, each supplied with a mobile device, is randomly divided into groups. The teacher, equipped with a specially configured device for monitoring the progress of the entire process, then sends each student a set of multiple-choice questions (MCQs). The group members must individually respond to the questions, thus taking responsibility for doing and assessing their own work. The answers are then presented to the rest of the group, where they are subjected to a peer assessment. The group members attempt to arrive at a consensus answer through discussion, a process facilitated by face-to-face interaction and the small size of the group. All members must contribute and share ideas regardless of what they think of their correctness; the conceptual change must evolve from the learner's preexistent understanding and active involvement in the group discourse (Black, McCormick, James, & Pedder, 2006). If the members do not arrive at a consensus, the system reminds them that they must converge on a single response, in effect forcing them to do so by not permitting them to proceed to the next question. If a group chooses an incorrect response as its consensus answer, the system informs them of their error and instructs them to consider another alternative. Mutual support is the key to this process, as through the collaborative discussion the group members discover where they went wrong, clarify their ideas, and converge upon a new answer based on their individual knowledge and common experience. This loop ends when the group finally

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selects the right response alternative, at which point they proceed to the next question and repeat the procedure just described until they reach the end of the question set (Cortez et al., 2005). As can be observed in Figure 11.1, group discussion is the nucleus of this activity.

The information obtained by formative assessment is used to provide feedback for modifying the teaching work to meet learning needs (Black, Harrison, Lee, Marshall, & Wiliam, 2004). In Eduinnova this is accomplished through an online in-class management graphic tool (Figure 11.2) incorporated in the teacher's machine that supports his or her mediator role by providing information indicating what the different groups have done well, what must be improved, and how to go about it. The teacher monitors the group outcomes on the tool, to determine which group needs assistance and where they are having difficulties, and can then provide immediate reinforcement or refocus the activity content where required. The screen of the graphic tool shows the groups on the vertical axis and the various questions on the horizontal axis. Each cell formed by the intersection of a group and a question displays one of three different colors, indicating whether an MCQ task was completed correctly on the first attempt, after one mistaken response, or

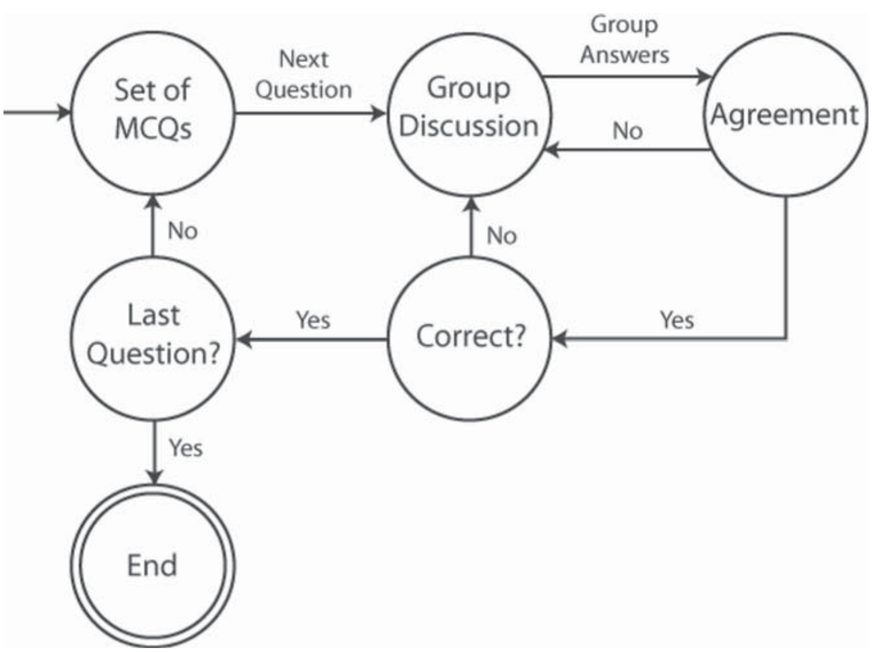

Figure 11.1 Formative assessment dynamics.

after more than one such error. The teacher can also determine whether a given group is developing positive interdependence, suggesting good group work, by observing the speed at which it progresses compared to the other groups. A very rapid advance with (almost) all questions answered correctly might mean that a particularly knowledgeable student has taken control of the group, while very slow headway may be a sign that the group members are not working well together and are therefore having trouble converging on an answer. If the three colors appear in roughly the same numbers, the group may be simply guessing. Thus, the tool allows the teacher to easily determine how well the groups are working, though corroboration by direct observation is still required.

IMPLEMENTATION OF THE EDUINNOVA PROJECT

Project Objectives

The implementation of the Eduinnova methodology in Chilean schools addressed four principal objectives:

- To promote student learning attainment in various curriculum subject areas through a collaborative work methodology mediated by mobile technology.
- To solve the computer coverage problem. Despite major efforts by Chile's Ministry of Education, the computer/student ratio remains low at 1:26 (Enlaces, 2008). The intention is to raise this figure to one notebook per student.
- To integrate the mobile technology into the classroom, the usual daily context of learning. Instead of the class having to go to the technology, the technology leaves its usual work space (labs) and goes to the class.
- To promote interaction between student and teacher through the integration of collaborative activities that deliver performance data to both actors, thus indicating where intervention is required while also strengthening feedback.

Application of the Methodology

The methodology embodies a student-centered approach in which the teacher is seen as an agent promoting the significance and effectiveness of classroom dynamics for learning achievement. Eduinnova works with

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Figure 11.2 In-class management graphic tool.