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 ___S
___E
___L
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

![Diagram](image-url)
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 ___S ___E ___L
Figure 11.2 In-class management graphic tool.
instructors and school authorities to install and implement the pedagogical model and then transfers the management capabilities to the educational establishment so that it can gradually assume the running of the project without depending on external services.

To ensure the appropriation of the Eduinnova formative assessment proposal in the schools, the methodology defines a form of collaborative work that involves all of the different actors: school administrators (principals, etc.), technical support staff, teachers, and students. The administrators must provide the necessary technical and organizational framework and supervise the pedagogical quality of the planned activities; the technical support staff are responsible for maintaining the functionality of the mobile devices and associated software; the teachers are in charge of planning the activities, integrating them into the learning process, and guiding their execution in the classroom as mediators; and the students take on the role of activity protagonists, carrying out the actual collaborative work in groups of three.

The application of Eduinnova begins with the planning of a class, including a learning activity. The teacher prepares the activity with a specific objective in mind and then selects the desired content from a Web system accessed through the Internet. Since ICTs do not necessarily improve the quality of classroom instruction unless they are well integrated into the teaching curriculum (Keengwe, Onchwari, & Wachira, 2008), the methodology is implemented in conjunction with a 13,000-item database that covers mathematics and language subject matter from 3rd to 12th grade, science from 5th to 8th grade, and biology, chemistry, and physics from 9th to 12th grade.

Eduinnova’s Web-based content management system allows the instructor to do the following:

- Review, edit, and modify the different questions organized by learning (i.e., subject) areas.
- Create questions and store them in the learning area they were defined for.
- Select the desired questions to create activities that can be stored for later use.

Once an activity is created, it is downloaded from the Web site to the teacher’s machine.

To carry out an activity in a class, the teacher starts by handing out a mobile device—either a Pocket PC or an XP machine such as the Classmate ___S ___E ___L.
PC—to each student. To boot them up, each students must enter his or her identification number. A wireless network randomly distributes the class into groups of three (Nussbaum et al., 2009) and the students then physically separate into the groups so defined. At this point the teacher sends the activity to the students via the wireless network, and the actual collaborative work begins.

When the activity session ends, the monitoring information used by the teacher to mediate the activity groups (Figure 11.2) is stored by the teacher on his or her machine. It is automatically sent on to the Web site so that the teacher, the school principal, and other actors in the educational process can make use of it in decision making related to the progress of the course.

ANALYSIS OF THE EDUINNOVA PROJECT

Design of the Analysis

A study was carried out to ascertain the effects of the Eduinnova formative assessment methodology at the schools where the project was implemented. The first part of the study incorporated a mixed qualitative and quantitative design that aimed to capture the perceptions of the various actors involved in the project as they related to the implantation of the project and its ultimate impact on themselves, the students, and the school. The second part was intended to determine the final outcomes in terms of student learning. In addition to the actors’ perceptions of the outcomes, this evaluation involved an analysis of students’ scores on a standardized performance test known as SIMCE (Education Quality Measurement System), which is applied annually by the Chilean Ministry of Education to all children in the fourth grade.

The data for the qualitative aspects of the actors’ perceptions were collected through interviews and focus groups and analyzed using the techniques of content analysis. In this method the importance of an idea in a text is indicated by the frequency of its appearance (Morse, 1995).

The content analysis consisted of the following steps:

1. The qualitative data were examined to find patterns in the actors’ observations (open coding)

2. The patterns were grouped into general categories, thus yielding a hierarchical content scheme.
3. The significant categories were identified quantitatively by determining the themes that appeared most frequently.

4. Finally, the content of these categories was examined to identify perceptions and meanings.

The four categories defined by this analysis are context and general considerations, the teacher during the collaborative activity, the students during the collaborative activity, and classroom interactions. Further, on the Eduinnova project results and their analysis, these categories are each exemplified with quotations from the actor interviews and focus groups.

The quantitative data on the actors’ perceptions were gathered via a structured survey and analyzed on the basis of responses to questions relating to four social variables: mutual support, listening to one other, giving others explanations, and resolving problems.

As for the evaluation of student learning outcomes, this consists of two analyses of students’ scores on the above-mentioned national SIMCE test for each of three broad learning (subject) areas: language, mathematics, and natural and social sciences. The first analysis relates to the differences in scores between students at the schools participating in the project and students at other schools; the second one identifies differences where the participating students used Eduinnova in some but not all of the subject areas. The statistical technique used for these analyses was the $t$ test for differences between means.

**Definition and Selection of Sample**

The study covered 23 municipal (state-subsidized) schools in the Chilean cities of Santiago and Antofagasta where the Eduinnova project was implemented. The number of actors involved in the project at these educational institutions are indicated by category in Table 11.1.

**RESULTS OF THE ANALYSIS**

**Context and General Considerations**

A range of different views were expressed by the teachers in the focus groups and interviews on what they understood by collaborative, cooperative, and group work. There was a consensus, however, on the ___S ___E ___L.
complexities they faced in generating collaborative learning experiences in the classroom. They perceived that group and cooperative work were easier to achieve because in these modes the students work on their own before getting together to come up with a final product. This could be even done with homework assignments. Collaborative work, on the other hand, is understood, defined, and differentiated on the basis of interaction among group members, who need each other in order to attain a common objective. It is this positive interdependence and the generation of consensus and communication among students that is felt to be very difficult to achieve and generally does not occur. For example, one teacher from Providencia in Santiago reported that “I have always found it extremely difficult to do collaborative work with my students. I could say that collaborative work is sitting in groups, but that in itself is not in fact collaborative work.”
When the students were asked about their preferences as between traditional classes and those using the collaborative dynamic, 80% said they preferred classes with portable technology and Eduinnova methodology.

The Teacher During the Collaborative Activity

The perception of the various actors was that with the Eduinnova methodology, a change occurs in the teacher’s classroom role. Most of the teachers stated that whereas in their usual activities the frontal, expository style of instruction is predominant, with the implementation of the Eduinnova project they began adopting different styles and dynamics, combining the frontal or expository modes with others.

<table>
<thead>
<tr>
<th>ACTORS IN PROJECT</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students</td>
<td>2,731</td>
</tr>
<tr>
<td>Teachers</td>
<td>272</td>
</tr>
<tr>
<td>Pedagogical coordinators</td>
<td>9</td>
</tr>
<tr>
<td>School principals</td>
<td>9</td>
</tr>
<tr>
<td>Technical support staff</td>
<td>9</td>
</tr>
</tbody>
</table>

Table 11.1

ACTORS PARTICIPATING IN EDUINNOVA PROJECT

306 Part IV Refining Mind
that emphasized a more participatory approach and generated a more symmetrical relationship with their pupils. The educator thus assumes the role of facilitator in which, instead of merely delivering knowledge, he or she facilitates the construction of knowledge among and from the students.

I tend to give very frontal classes. . . . I explain, ask questions, taking the protagonist role. However, with Eduinnova, they [the students] are the ones who do everything, so in addition to monitoring I join a group and offer opinions. (Teacher, Peñalolén, Santiago)

In their roles as facilitators and monitors, the teachers stated that their relationship with the students was more symmetrical, allowing them to provide greater support and be more tolerant. They also took on the role of mediator, handling disagreements and conflicts among the students. This experience also validates the importance of their participation in the activity.

All of the actors involved in the implementation of the project (teachers, school principals, pedagogical coordinators, and technical support staff) referred to the methodology and the in-class management graphic tool (Figure 11.2) as elements that facilitated and assisted in the teaching task. They felt that the tool enabled them to follow the students’ learning process during the collaborative activities and also determined the performance of the teachers, thus accounting for their positive views of the technology.

Using the tool I observe the progress of the activity. If I see that a group is stagnating while another one is advancing, apparently at random, I go to the second one, sit down beside them, and if I find they’re working well I go to the other group. If it turns out from the mistakes registering on the tool that they’re just guessing at the answers, I suggest we go over together the work they’re doing. (Teacher, Peñalolén, Santiago)

Both the school administrators and pedagogical coordinators report the project’s real potential for following the progress of teaching processes and supporting the task of teaching and creating new and better coordination machinery within the schools. (Focus Group report, Las Condes, Santiago)

As for the quantitative survey data, when the teachers were asked how they evaluated their own performance during the Eduinnova collaborative dynamic as regards the attention given to the students during ___S ___E ___L
the learning process, 96% said they devoted as much or more time to them than in traditional classes. The majority of teachers stated that they put in equal or greater effort compared to other classroom dynamics, and almost 80% commented that they played a mainly monitoring role during the activity, supervising groups and guiding them through the learning process. The majority of the students (63.3%) declared that they had received enough support from the teachers, while 36.6% indicated they would have liked to receive more.

The Students During the Collaborative Activity

All of the actors stated that with the collaborative dynamic, the students assumed an active role in the learning process given that the tool challenged them by requiring they record what they had learned, using their personal resources and skills to progress through the activities. Technical support staff in Las Condes, Santiago reported that “The students become the protagonists, they themselves feel that this is the case and are motivated and enthusiastic.”

The teachers noted the appearance of leaders among the students, who made sure their groups advanced through the activity and did not fall behind. They took it upon themselves to manage their fellow group members and to involve them in the process. Another role reported by the teachers was that of the “student monitor,” who supported not only his or her own group but the entire class as well. These students would sometimes finish before the other groups and would then go around the classroom giving assistance wherever it was needed. Other students emerged in roles taking charge of the computers, their maintenance and distribution, and so on.

The various actors also expressed the view that the methodology led to the development of various cognitive skills and clearly identified the existence of interaction among the students and its value.

In the groups the students observe how their peers’ thinking develops. If a student says that the answer is such-and-such, he or she will then have to say why. Giving arguments for one’s responses is super important for the development of the student’s thinking, and I saw this process occurring in various groups. (Pedagogical coordinator, Las Condes, Santiago)

The teachers further stated that the students were forced to interact and communicate, thus developing communication skills as they solved
the problems they were given, even if they did not otherwise have good relationships.

Some children may not get along well . . . or converse very much, but they are obliged to interact and communicate. So we don’t have a situation in which friends keep to themselves within the groups and ignore the other members. They all interact with each other and the course itself functions much better. (Teacher, Peñalolén, Santiago)

Finally, the teachers found that the methodology promoted development of socioaffective skills required for collaborative work, such as respect and tolerance of one’s classmates.

As for the quantitative analysis, Table 11.2 summarizes the teachers’ responses to the survey on perceptions of the development of the four social variables (mutual support, listening to one other, giving others explanations, and resolving problems) in their students. The figures indicate the percentage of teachers who said that the variables showed more, the same, or less development under Eduinnova compared to the traditional lessons.

The students’ responses to the same survey generally coincided with those of the teachers. They were less likely to say that the social variables showed greater development under the methodology, but the majority of them stated that all of the variables—mutual support, listening to one other, giving others explanations, and resolving problems—occurred to an equal or greater extent than with traditional methods. The students thus testified to a higher degree of interaction among themselves in a collaborative work environment mediated by portable technology.

<table>
<thead>
<tr>
<th>TEACHERS’ PERCEPTIONS OF THE DEVELOPMENT OF SOCIAL VARIABLES AMONG STUDENTS DURING COLLABORATIVE ACTIVITIES COMPARED TO A TRADITIONAL CLASS</th>
</tr>
</thead>
<tbody>
<tr>
<td>MUTUAL SUPPORT</td>
</tr>
<tr>
<td>More</td>
</tr>
<tr>
<td>Equal</td>
</tr>
<tr>
<td>Less</td>
</tr>
</tbody>
</table>

S E L
Classroom Interactions

Since the students are divided into groups randomly, the members of a given group are sometimes not accustomed to interacting with each other. As they get to know each other, they often discover new aspects of their classmates’ personalities.

When one of the children told me it was the first time he’d been together with two of the others since fifth grade, I asked him how that could be since he was now in eighth grade, and he said, “they just never talked to me before but now with the Pocket PCs we talked” and I saw that the technology isn’t so cold after all. (Teacher, Providencia, Santiago)

The project actors perceived that during the activity the students helped each other, gave explanations to others, and displayed much collaborative behavior that would normally be difficult to achieve.

One learns to spot the students who have problems working in a group due to their character or personality, or because they don’t like the other members. [With this system] they are forced to participate. There were groups where the students wouldn’t even look at each other and starting squabbling, but they soon realized they were falling behind the other groups and had no choice but to mix, work together, participate and come to agreements. (Teacher, Las Condes, Santiago)

And in the words of a Las Condes pedagogical coordinator, “It’s an extremely powerful tool for communication between them and the teacher.”

All of the participating actors agreed that the activity motivated the students to perform the tasks and learn, making them more active and concentrated on what they were doing, and that they found the methodology attractive in and of itself. Another coordinator reported that “They are motivated and [the activity] allows them to be competitive . . . Suddenly they all want to improve and their self-esteem increases.”

The teachers also reported that, with the methodology, they perceived a positive environment in the classroom. It is true that when it is first implemented there is a certain amount of disorder as the children divide up into groups, but once the groups are formed, the activity runs smoothly in a relaxed and positive atmosphere.

The class holds the children’s attention and keeps them involved. With the incorporation of the technology, discipline in the classroom has improved
because the students are anxious to do their work and carry out the tasks together with their classmates, so they simply forget about being disorderly. (Teacher, Huechuraba, Santiago)

The teachers noted that under Eduinnova they can keep the whole class under control even when they are busy mediating a specific group, which would be impossible in a conventional lesson.

It’s not like a frontal class where all the children are looking at you, and you’re always having to deal with some students who are talking, or make sure others are learning or not causing a disturbance or paying attention. Here, each child is busy, and if they have questions they raise their hands. You can deal with one group without the others taking advantage to misbehave. The activity is interesting for them so they’re all involved in it. (Teacher, Peñalolén, Santiago)

As regards the quantitative perceptions survey, the majority (75%) of the teachers observed that the students shared more knowledge under the activity dynamic than in other learning contexts, showed more interest in doing a good job with the collaborative methodology, and valued positively the fact that the groups were defined randomly.

**Student Learning Outcomes**

As noted earlier, the impact of Eduinnova on actual learning outcomes was determined in terms of both the perceptions of teachers and students gathered by a structured survey and an analysis of the results of the national SIMCE (2007) test given to fourth grade students.

**Perceptions of Teachers and Students**

The perception of all of the actors in the project was that student learning attainment occurred under the collaborative methodology. The report of a technical supporter said that

“The strengths of the [collaborative] work with PDAs in the classroom is that it improves learning. The students’ concentration and relations between them are better, time is optimized, discipline is stronger and the burden on the teachers is lighter.”

The majority of the teachers and students also expressed the view that Eduinnova showed better results than traditional classroom.
methods on five variables considered to be related to significant learning. This is illustrated in Figure 11.3, which indicates the percentages of teachers and students who reported this perception for concentration, learning, participation, interest, and use of time.

In particular, the survey results indicated that almost half of the students (45.9%) felt they learned more with the project methodology, while a similar proportion (45.9%) said they learned the same amount as in traditional classes and 8.2% reported that they learned less. The teachers’ responses, on the other hand, revealed that 62% believed the students learned more with the project methodology, 35% claimed they learned the same amount, and only 2% reported that they learned less.

Analysis of SIMCE Test Scores

Whereas the foregoing analyses of perceptions included the results for all 23 schools participating in the Eduinnova project, the evaluation of the learning test results is based on only 5 of them, all located in the Antofagasta urban area in northern Chile. The other 18 schools were excluded from this part of the study for a number of reasons. First, 12 of them had not yet joined the project when the SIMCE (2007) test was given. Second, 5 of the remaining ones constituted the entire set of municipal (state-subsidized) institutions in a single district of Santiago and were therefore not comparable to the Antofagasta schools. Finally, at the 6 Santiago establishments the number of grades in which no courses used Eduinnova was relatively low (105 students in three grades, two at the same school), making it impossible to derive estimates for comparisons between students with a
sufficient degree of validity. This problem will be eliminated in future studies, in which the participating subjects will be defined more strictly to ensure the required level of compatibility for making comparisons.

Of the total of 12 courses at the five schools, 11 took part in the project; all of the 11 courses participated in mathematics, 6 in language, and 9 in natural and social sciences. The number of students thus involved was 487. In the analyses that follow, their SIMCE scores are compared with those of the control group, which consisted of the approximately 2,670 students attending the various subsidized schools in Antofagasta where the Eduinnova project was not applied. For both groups, the scores analyzed were the averages on each of the three subject areas.

**Comparison of SIMCE Test Scores by Subject Area With and Without Eduinnova**

The first SIMCE score analysis compared the students from the participating and non-participating (control group) schools on their results in the three SIMCE subject areas. A $t$-test of the scores found statistically significant differences between the two groups in all three subjects, implying that in each case the group using Eduinnova performed better. The details are given here in Table 11.3.

**Comparison of SIMCE Test Scores With Eduinnova Used in Some Subject Areas**

The second SIMCE score analysis consisted of two sets of comparisons aimed at identifying performance differences in cases where students used Eduinnova in some but not all subject areas. It was expected that such students would have higher scores than the control group mean in subjects where the methodology was applied and similar scores where it was not.

Since the test scores for the three subject areas are not directly comparable with each other, the results discussed in what follows for each subject were centered around the mean for all Antofagasta schools and weighted by the corresponding standard deviation.

The first set of comparisons contrasted students who used the methodology in mathematics but not language classes with the control group (Table 11.4). The Eduinnova group diverged from the Antofagasta mean on the mathematics test by 0.34 standard deviations, a difference that ___S is statistically significant ($p < 0.05$; $1 - \alpha = 95\%$). They did not differ ___E ___L.
## Table 11.3

<table>
<thead>
<tr>
<th>SUBJECT AREA</th>
<th>STUDENT GROUP</th>
<th>NO. OF STUDENTS</th>
<th>MEAN</th>
<th>DIFFERENCE</th>
<th>SIGNIFICANCE</th>
<th>COHEN'S D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematics</td>
<td>Not using Eduinnova</td>
<td>2,593</td>
<td>219.86</td>
<td>17.17 (7.8%)</td>
<td>p &lt; .05</td>
<td>0.32</td>
</tr>
<tr>
<td></td>
<td>Using Eduinnova</td>
<td>433</td>
<td>237.031</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Language</td>
<td>Not using Eduinnova</td>
<td>2,756</td>
<td>231.97</td>
<td>6.72 (2.8%)</td>
<td>p &lt; .05</td>
<td>0.13</td>
</tr>
<tr>
<td></td>
<td>Using Eduinnova</td>
<td>233</td>
<td>238.69</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Natural and social</td>
<td>Not using Eduinnova</td>
<td>2,669</td>
<td>225.43</td>
<td>11.03 (4.8%)</td>
<td>p &lt; .05</td>
<td>0.23</td>
</tr>
<tr>
<td>sciences</td>
<td>Using Eduinnova</td>
<td>354</td>
<td>236.46</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note: t test with 1-α = 95%.*
from the nonparticipating Antofagasta mean on the language test (.05 standard deviations, not statistically significant: \( p > 0.05; 1 - \alpha = 95\% \)). This implies that the students performed better only in the subject area where Eduinnova was applied.

The second set of comparisons contrasted students who used the methodology in natural and social science but not language classes with the control group (Table 11.5). The group that worked under Eduinnova scored .34 standard deviations higher than the Antofagasta mean for natural and social sciences and .22 standard deviations higher than the nonparticipating Antofagasta mean in language. This demonstrates that the students who had any experience with the collaborative methodology were above the Antofagasta mean in both subject areas and clearly performed better in the subject where the methodology was applied.

As regards the language test, no comparisons were possible because each grade which used Eduinnova in language classes also used it in mathematics and in natural and social sciences.

**DISCUSSION**

The presented face-to-face technology supported small group collaborative learning strategy follows the constructivist ideas of Activity Theory (Engeström, 1987), where students are participants of their learning, identifying three pillars:

1. Collaboration: Members of a group work together on the same objective. Each group member is responsible for his/her own work, role and learning effort, and each one constructs, prior to the collaborative discussion, his/her own vision of the problem. Thus, all group members are a source of information for building the common answer as they help each other reach the common goal.

2. Reflection: The experience of each student is reflected in his or her exploration of the reasoning and viewpoints of every other one, and all of them thus become experts in their own learning. In this way a shared understanding of the task is constructed, enabling the students to exchange opinions, negotiate and construct an answer together. A space is therefore required in which they can propose and defend the solutions they arrive at and ask their peers to clarify and justify their views (Kruger, 1993). Students exchange opinions through face-to-face social interactions and...
<table>
<thead>
<tr>
<th>Mathematics Score</th>
<th>No. of Students</th>
<th>Mean</th>
<th>SD</th>
<th>Difference</th>
<th>SD Difference</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without Eduinnova</td>
<td>2,593</td>
<td>219.86</td>
<td>52.58</td>
<td>18.43</td>
<td>0.35</td>
<td>p &lt; 0.05</td>
</tr>
<tr>
<td>With Eduinnova</td>
<td>202</td>
<td>238.3</td>
<td>54.19</td>
<td>(8.3%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>in math but not language</td>
<td>202</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Language Score</th>
<th>No. of Students</th>
<th>Mean</th>
<th>SD</th>
<th>Difference</th>
<th>SD Difference</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without Eduinnova</td>
<td>2,547</td>
<td>231.75</td>
<td>49.94</td>
<td>2.99</td>
<td>0.05</td>
<td>p &gt; 0.05</td>
</tr>
<tr>
<td>With Eduinnova</td>
<td>209</td>
<td>234.74</td>
<td>51.43</td>
<td>(1.2%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>in math but not language</td>
<td>209</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: t test with 1-α = 95%.
### Table 11.5

**Comparison of Test Scores: Eduinnova Used in Natural and Social Sciences Only**

<table>
<thead>
<tr>
<th>Natural and Social Sciences Score</th>
<th>No. of Students</th>
<th>Mean</th>
<th>SD</th>
<th>Difference</th>
<th>SD Difference</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without Eduinnova</td>
<td>2,669</td>
<td>225.43</td>
<td>45.6</td>
<td>15.94</td>
<td>0.34</td>
<td>p &lt; 0.05</td>
</tr>
<tr>
<td>With Eduinnova in natural and</td>
<td>121</td>
<td>241.37</td>
<td>48.58</td>
<td>(7.07%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>social sciences but not language</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Language Score</th>
<th>No. of Students</th>
<th>Mean</th>
<th>SD</th>
<th>Difference</th>
<th>SD Difference</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without Eduinnova</td>
<td>2,631</td>
<td>231.45</td>
<td>49.95</td>
<td>11.48</td>
<td>0.22</td>
<td>p &lt; 0.05</td>
</tr>
<tr>
<td>With Eduinnova in natural and</td>
<td>125</td>
<td>242.94</td>
<td>51.17</td>
<td>(4.9%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>social sciences but not language</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note: t test with 1-α = 95%.*
make compromises in order to build a consensus answer (Zurita & Nussbaum, 2007). Small groups whose members are in close physical proximity facilitate the social interactions and consensus-building required to construct an answer together (Adams & Hamm, 1996; Johnson & Johnson, 1999).

3. Significance: Learning has to be with a meaning. The tasks chosen for peer collaboration must be structured so that the students are obliged to work together cooperatively toward a common goal. Through joint actions and verbal explanations, the denotation of the task is discovered.

The perceptions of the actors in the Eduinnova project as presented and analyzed previously allow us to make a number of important observations in terms of the four categories defined by the content analysis as set out below.

**Context and General Considerations**

The actors distinguished between collaborative learning and group work, noting that the first of these is more difficult to achieve in the classroom and demands interaction between students to attain a common objective. They found that the Eduinnova project facilitated the achievement of collaborative learning. They also felt proud and privileged to be at the schools that participated in the project and valued both the project experience and the support provided by the implementation team.

**The Teachers’ Experience in the Collaborative Process**

The teachers perceived that with the application of the Eduinnova methodology, their role in the classroom changed from being expositors of learning to being facilitators of it. They also played the parts of mediator between the students and monitor of the teaching–learning process, supervising the student groups and accompanying them as they learned.

All of the actors perceived that teaching performance was facilitated by the methodology, which provided the tools for supporting and assisting in the pedagogical task. A characteristic that was particularly stressed was the ability to follow the students’ learning process and receive immediate delivery of activity results. This made it possible to intervene where necessary and provide feedback to students, thus improving learning effectiveness.
The Students’ Experience in the Collaborative Process

The actors perceived that the students also experienced a change of roles during the collaborative activities, becoming active agents in their own learning processes. Leaders and monitors emerged spontaneously. The actors also reported that the students developed both cognitive and socioaffective skills.

Classroom Interactions

All of the actors mentioned that collaborative learning took place during the dynamic supported by the Eduinnova methodology. They perceived it as a tool that facilitates this collaborative dynamic and promotes tolerant and committed interaction between group members. Teachers and school principals valued positively the fact that the groups were formed in random fashion, as this promoted both integration between students who were previously not acquainted and learning between peers. This in turn encouraged interaction among them.

In addition, the actors all spoke of the motivation that was generated among the students by Eduinnova, thanks to its novelty, as well as the impacts it had on them, especially those related to interaction with their classmates.

Finally, the actors also declared that there was a genuine change in the classroom learning dynamics, creating a different climate and a new type of discipline that required conversation, discussion, and the student to act as a protagonist. All of the foregoing resulted in a better integration of the students, which the groups then carried with them to their other courses.

The results and analyses presented above also suggest how the Eduinnova methodology may comply with the principles for effective teaching and learning defined by the Teaching and Learning Research Program of the UK-based Economic and Social Research Council in a report entitled *Improving Teaching and Learning in Schools* (ESRC and TLRP, 2006). Five of the ten principles outlined there are listed below, with a brief statement on how they are supported by face-to-face technology-supported small-group collaborative learning:

- Equip learners for life. Social abilities facilitated by small-group work empower students as members of a working team and society. Face-to-face small-group collaborative learning inculcates ___S___E___L.
scaffolding, teachers need tools to diagnose learning difficulties, a task that can be performed by the in-class management tool presented here (Figure 11.2). Also, activities should provide intellectual, social, and emotional support to help learners move forward in their learning so that once these supports are removed, the learning is secure. Small-group formative assessment promotes intellectual abilities while simultaneously developing social and communicative abilities facilitated by the face-to-face small-group interaction and technology support.

Assessment must be congruent with learning. The use of assessment to adapt teaching to meet learning needs is defined as formative assessment. Assessment should be designed and implemented with the goal of achieving maximum validity both in terms of learning outcomes and learning processes. It should help to advance learning as well as determine whether learning has occurred (TLRP & ESRC, 2006). The in-class management tool provides this.

Promote the active engagement of learners. The promotion of learners’ independence and autonomy through the acquisition of a set of learning strategies and practices that enables them to be agents in their own learning is an objective that was achieved in this project. Each student must take responsibility for his or her work through self-assessment when answering a question and then through peer assessment as the group searches for agreement on a single answer.

Foster individual and social processes and outcomes. As we have seen, the strategy presented in this study encourages the building of relationships and communication with others through the learning objectives, which assist in the mutual construction of knowledge in order to enhance the achievement of the group and its peer members.

**CONCLUSION**

Formative assessment plays a role in knowledge practice and reinforcement through the evaluative practice of posing questions. Students should develop the capacity to monitor the quality of their own work,
understand what high quality work is and where their own work stands in relation to it, and develop criteria for modifying their own work (Sadler, 1989). With the technology-supported face-to-face small-group formative assessment strategy described in this paper, the students’ work is monitored through peer evaluation and then by the in-class management graphic tool’s group evaluation. The teacher’s role, supported by the graphic tool, is to mediate when and where such action is required. Finally, it was demonstrated by actual classroom application that implementation of the Eduinnova strategy leads students to modify their group work habits, thus bringing about an improvement in their social abilities and in learning.

ACKNOWLEDGMENT

This chapter was partially funded by the project Centro de Estudios de Políticas y Prácticas en Educación, CIE01—CONICYT.

NOTE

1. The present research used the sources of databases from SIMCE of the Chilean Ministry of Education. The corresponding authors appreciate the access to the information given by the Ministry of Education. All results presented in this study are the responsibility of the authors and in no way to be ascribed to this institution.

REFERENCES


Morse, J. (2003). *Critical issues in qualitative research methods*. Universidad de Antioquia, Medellín, Colombia.


Author Query

1 Correct that here you refer to Figure 11.2?