CS in CSCL

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Key words: *CSCL, Computer science, Technology*

Abstract:

CSCL research brings together different perspectives from human sciences and computer science. This paper presents some reflections, from the standpoint of a computer scientist, on the increasingly problematic coexistence between the "CS part" ("computer support part" or "computer science part") and the "CL part" ("collaborative learning part"). Difficulties arise from both a divergent understanding of the role of technology in the discipline and from huge differences in the way research works are evaluated in the two parts. The paper provides suggestions on how to create more synergistic cooperation between CS and CL parts in CSCL.

1 Introduction

Computer-supported collaborative learning (CSCL) is a method of supporting people in learning together effectively via networked computers. CSCL research addresses the challenge of effectively enhance learning by combining computer support and collaborative learning [1]. The corresponding research agenda should include efforts for reaching a better understanding of collaborative learning with computers and for the creation of software systems that provide innovative forms of pedagogical support or scaffolding for collaborative learning. In order to meet these goals CSCL research should bring together different perspectives from a variety of disciplines of human sciences on the collaborative learning side (educational psychology, sociology, philosophy, pedagogy…) and computer science on the technological side. Therefore, it is possible to roughly distinguish between the "computer support part" ("CS part," more broadly interpreted as "computer science part") and the "collaborative learning part" ("CL part"). This paper aims at discussing the coexistence of these two parts in the CSCL research field, which is considered increasingly problematic. Several other computer scientists have recently proposed a "*computer science perspective*" on the wider Technology Enhanced Learning (TEL) research field [2] that shares several common concerns with the present work. Many symptoms of this global "coexistence problem" are reported in the recent research literature. For example, Scheuer et al. [3], in their survey of the specific research sub field of computer-supported collaborative argumentation, point out the following facts: "*Not only do, apparently, few people conduct research on educational argumentation systems from a computer science perspective, but also the existing tools are not well described from a technical viewpoint. This unfortunate situation imposes severe implications on the research community: Researchers who want to design educational argumentation systems often have to reinvent the wheel again and again, expending considerable effort in building new systems. This is because reusable system components and/or source code is generally not available, design rationales are often not well documented, and there is no technology available that offers the degrees of flexibility and* *configuration options that are required for studying most of the open research issues that we have identified. Such a flexible platform would also have great practical application in schools if teachers were able to configure their systems—guided by research results—in a manner that fits their particular needs*." These elements (few research works carried out in the CS part and few reusable and flexible designs) are not specific to computer-supported collaborative argumentation and can be observed in the whole field. Tchounikine et al. [2] also stress the fact that "*multidisciplinary work is difficult*", "*computer scientists abandon the TEL research field*" and return to "*more delimited technical domains*". Another symptom is the decreasing interest for CSCL (and TEL) research that can be observed, at least in some countries, probably because these works have yielded very few concrete results. In the French prospective study about "hot research domains" which need to be supported by public funding [4], education is not mentioned as an application domain of primary importance for CS like health, production, transport, or intelligent materials. The concept of collaboration is only marginally mentioned in specialized topics such as crisis management systems. Eight years ago, in a similar prospective study, collaborative approaches and systems were evoked in three of the four hot themes of CS research [5].

This paper presents some reflections about these questions from the standpoint of a computer scientist. It argues that this problematic coexistence is a consequence of both divergent perspectives on the role of technology and software engineering in the CSCL discipline and of huge differences in the way research works are evaluated in the CL and CS parts. The first section stresses that "CS technology" (in its broadest sense, including all its theoretical, conceptual, methodological, and practical foundations), is undoubtedly the underlying driving force of the whole TEL field and of most current evolutions in the CSCL sub field. The second section analyzes how CSCL researchers consider CS technology. The two extreme positions, "techno-neutral" which considers technology as a non-influential factor and "techno-centric" which focuses on technology alone, are first discussed and exemplified. Then, the more fruitful intermediate positions, called "techno-realist" for the CL part and "pedago-realist" for the CS part, are characterized and illustrated with several examples. The third section stresses the huge difference between the dominant ways of evaluating research works in the CL and CS parts with mainly experimental and quasi-experimental approaches on the CL empirical side, prototyping, examples of actual use, and technical comparisons on the CS design side. The conclusion provides suggestions on how to create more synergistic cooperation between CS and CL parts in CSCL.

2 The Predominant Role of Technology in TEL Evolution

The very first computer-based instructional systems in the 1960s were based on the direct application of structured algorithmic techniques. Knowledge was broken into elemental facts that were presented to students in a logical sequence. In the 1970s, intelligent tutoring systems (ITS) have included knowledge-based systems and expert systems for modeling domain-expertise and pedagogy-expertise. In the 1980s, the "Logo as Latin" movement has used interactive environments for supporting students in the construction of their own reasoning based on software programming constructs. In the mid-1990s, CSCL systems were inspired by the technological advances in computer-supported cooperative work (CSCW) and groupware, while Web-based learning (WBL) approaches were relying on Web technology. Recent developments include m-learning, based on ubiquitous computing, Grid-learning, based on Grid-technologies, and e-learning 2.0, based on Web 2.0 technologies. Some researchers try to relate TEL history to changes in educational theories: instructional systems to behaviourism, ITS to cognitivism, "Lego as Latin" to constructionism, CSCL to social constructivist and dialogical theories [1]. It is less convincing for the most recent evolutions such as WBL, m-learning, Grid-learning, and e-learning 2.0, which are undoubtedly driven by technological advances. Moreover, most current hot research topics in the CSCL field have direct counterparts in the CS research domain: learning patterns are rooted in design patterns, CSCL scripts in process models and AI scripts, simulated learning worlds rely on multi-player 3D game technology, tangible interfaces for learning and context-sensitive educational interfaces are direct applications of research results in the human-computer interaction field, to give a few examples. However, despite its predominant role in TEL evolution, technology is not considered as a key issue by all CSCL researchers as we will show in the next section.

3 Divergent Perspectives on the Role of Technology

Two extreme positions are discussed first: the "techno-neutral" position which considers technology as a non-influential factor and the "techno-centric" position which puts the focus on technology alone. The two intermediate and more fruitful positions, called "techno-realist" and "pedago-realist", are discussed in the second subsection.

3.1 The "Techno-neutral" and "Techno-centric" Extreme Positions

The "techno-neutral" position is quite frequent in the CL part, where learning processes are analyzed at a very abstract level. Laurillard's "Conversational Framework" (CF) [6] is a well-known example based on the idea that "*what it takes to learn does not change significantly, no matter how much the technologies of teaching and learning may change*". The CF aims at providing "*a technology-neutral way of stating the user requirements on any collaborative teaching method*". The approach considers the ongoing learner-teacher-peer interaction and the process of negotiation of ideas associated to practice which takes place between them. The CF integrates representations of the four main theories of learning, i.e., instructivism, constructionism, social learning, and collaborative learning (see Fig. 1). Such a very abstract and coarse-grained model is valuable for testing the value of existing digital learning technologies against the proposed model [7], but has limited value for informing the design of innovative computer-supported learning systems. Laurillard recognizes that "*the introduction*

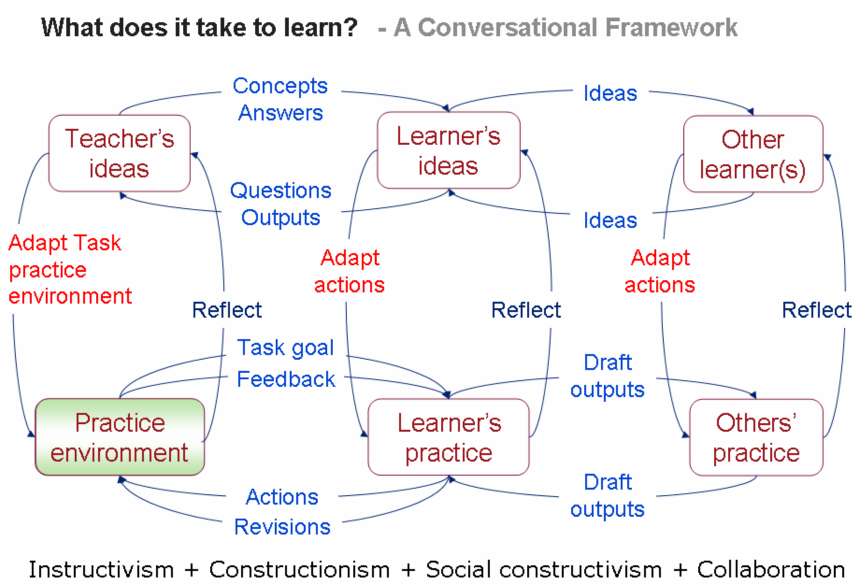

Fig. 1: The Conversational Framework.

of the digital technology enables the teacher to design at the level of much more precise learning interactions." She observes that "*the demand on teachers as learning designers must* *be simply put. They cannot be expected to undertake the levels of detailed analysis of interaction that researchers engage in*". This clearly means that CSCL systems should embed pedagogical designs and that finer-grained "techno-informed" models should be at the core of the CSCL field.

The "techno-centric" position was predominant when computer scientists were claiming that artificial intelligence could radically change learning and teaching. It is the position of the evangelists of each new technological wave who do not seriously consider the kind of educational issues their technology can contribute to (better) solve and the downside of every technology. In the e-learning 2.0 wave, for example, the general Web 2.0 principles such as "enabling and facilitating individual creativity," "harnessing the power of the crowd," "leveraging the long tail," "making functionalities available through the mix-up/mash-up culture" [8], even if very appealing, are not sufficient for characterizing educational issues that could be better solved. Added-values of existing Web 2.0 applications into teaching and learning processes are not guaranteed and some of their properties, like their openness to the external world, can create tensions and new pedagogical challenges [9].

3.2 The "Techno-realist" and "Pedago-realist" Intermediate Positions

"Techno-realist" approaches in the CL part aim at conceptualizing learning processes in realistic technological settings, thus creating a link with the CS part. For example, Cress and Kimmerle [10] have recently proposed a theory of the role of Wikis, based on a combination of Piaget's cognitive theory and Luhmann's social systems theory, to assist our understanding of how Wikis can facilitate collaborative knowledge building. Their model shows how developing a Wiki can help people enhance their individual knowledge through an iterative process at both social and individual levels. Such a detailed model can be a valuable inspiration for adapting or improving the concept of Wiki and its implementation to collaborative learning. The trialogical theoretical approach [11] is another interesting example that conceptualizes collaborative learning support around a shared space [12] (see Fig. 2): *"The trialogical approach develops models and tools for organizing learners' activities around shared objects (such as texts, models, conceptual artefacts, but also practices) that are created for some real purpose or subsequent use, which is often not the case in conventional educational practices. Individually performed activities and social interaction serve the longer-term processes of developing specific, concrete, shared objects, collaboratively."*

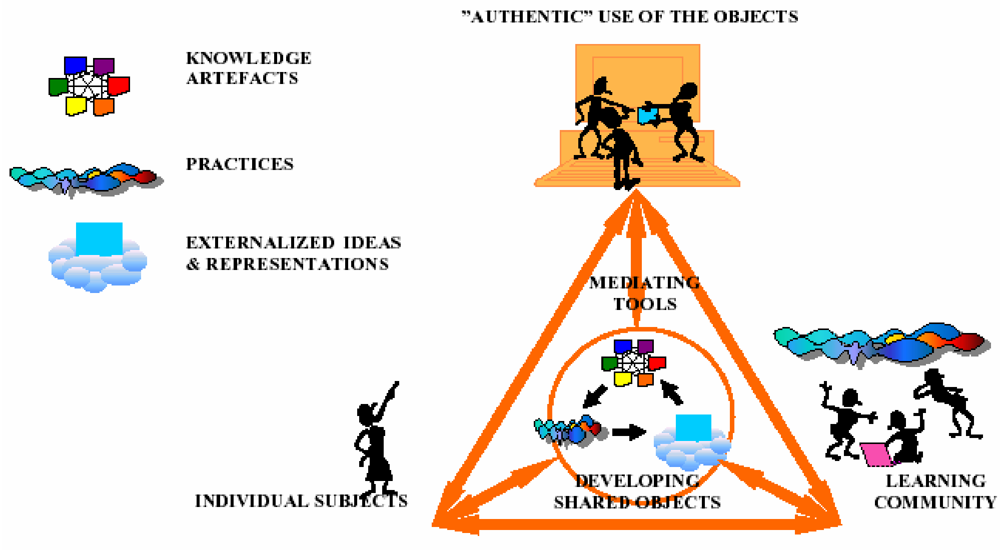

Fig. 2: The trialogical model.

The European KP-lab project has been launched for building an environment that supports forms of trialogical learning, i.e., collaborative knowledge practices around shared knowledge artefacts. The approach has been further developed into a set of design principles:

- Organizing activities around shared "objects."
- Supporting interaction between personal and social levels.
- Fostering long-term processes of knowledge advancement.
- Emphasizing development through transformation and reflection between various forms of knowledge and practices (tacit knowledge, knowledge practices, and conceptualizations).
- Cross fertilization of various knowledge practices across communities and institutions.
- Providing flexible tool mediation: "*Trialogical learning cannot easily be pursued without appropriate technologies that help the participants to create and share as well as elaborate, reflect and transform knowledge artefacts and practices. Novel collaborative technologies should provide affordances for trialogical learning processes*." [11]

The Knowledge Practices Environment (KPE) is the core tool of KP-Lab portal for collaboratively developing knowledge artefacts, planning, organizing and reflecting on related tasks and user networks [12]. This project clearly shows that the trialogical approach only constitutes a kind of conceptual foundation on top of which major design decisions remain to be made. For instance, KPE favors:

- *On the epistemic dimension,* the visual arrangement of coarse-grained content items (e.g., files, notes, web links) instead of the development, at a finer-grain level, of structured visual knowledge representations.
- *On the pragmatic dimension,* process planning through defining tasks and drafting visual process representations instead of predefined scripts (flexible) enactment.
- *On the social dimension,* asynchronous and synchronous object-bound interaction instead of separated communication tools with object referencing facilities.
- *On the reflective dimension,* data export to external off-line analytic tools instead of run time feedback for learners and tutors.

It is suggested, on the basis of these examples, that "techno-realism" requires from researchers in the CL part to go more deeply into the details of their—often very abstract—conceptualizations. Said in other terms "*computer scientists' focus is on the detailed properties of systems, which is not the case for most educationalists.*" [2]

"Pedago-realist" approaches in the CS part are motivated by pedagogical concerns and issues. They aim at adapting existing CS technologies or creating new ones for better solving these issues. For instance, at a global level there is much in common between workflow models and CSCL macro scripts. But several aspects, such as "fading" and "user rotation" [13], have no counterparts in work settings. Designing "fading" and "rotation" mechanisms are good examples of specific research issues that must be tackled in the CS part [14]. Dynamic adaptation of the process model is another example. In workflow systems the main problem is to change at the same time a large number of similar process instances that run in parallel in response to organizational changes. "Flexibility by change" [15], where the model is modified at run time and all of the currently executing instances are migrated to the new model is the privileged solution. In CSCL settings, most unforeseen events, like a student being disconnected or a deadline being postponed, only concern a single process instance. "Flexibility by deviation" [15], where some instance can deviate at run time from the execution path prescribed by the original model without altering that model seems a more natural solution. In most educational contexts, this deviation process must take into account the presence of a tutor who monitors the learning processes: designing a monitoring tool for tutors, including a dedicated support for ad hoc process deviations, constitute another example of a specific research issue for computer scientists in the CS part [16]. At a more general level, Tchounikine et al. stress the fact that "*CS and in particular software engineering has evolved towards processes and methods based on higher level abstractions such as models and components*". This trend should help researchers from both parts to focus on common abstractions similar to those underlying educational modeling languages [17]. Even, if educationalists are more interested in the descriptive side and computer scientists in the operational side (suitable for machine execution) some common conceptual framework defining at different levels of abstraction key terms and concepts for identifying and debating design issues could be agreed upon by all CSCL researchers.

4 Evaluating CSCL Research Works

Quantitative evaluations are dominant in the CL part and often take the form of controlled experiments. For example, Carr [18] compares the efficiency of using an argument diagramming system (the experimental group) as a replacement for paper and pencil assignments (the control group) to teach legal reasoning. The groups are compared in terms of the results of the practice final exam with a task similar to the ones they worked during the experiment. This kind of global approach fails to explain the reasons why the system is valuable. More focused evaluations are difficult as the number of factors that impact learning outcomes can be very high and contextual. The only possible way is to restrict the evaluation to a small number of variables (in general two) and to test all possible combinations of these variables. For example, Schwarz and Glassner [19] investigate the effects of informal ontologies and floor control in the Digalo collaborative argumentation system by counting relevant claims and arguments in the four conditions (floor control/ontology, floor control/no ontology, no floor control/ontology and no floor control/no ontology). When the number of variables is greater than two the evaluation must be performed globally and it is no more possible to characterize the effect of each individual variable on the results. For example, McAlister et al. [20] evaluate the AcademicTalk system, which aims at structuring academic argumentation with three basic mechanisms: threaded discussions used in near-synchronous fashion, sentence openers, and a model of well-formed dialogues based on dialogue game theory. The analysis is performed by comparing the computer logs of AcademicTalk on the one side and of a standard chat on the other side. It shows significantly less off-topic contributions and significantly more reasoned claims, rebuttals, and utterances of direct disagreements. But the effect of each of the three interface design mechanisms individually (and possibly of other variables) remains unknown. All other global quantitative evaluation techniques, such as satisfaction questionnaires, share the same limitations. As a result of this lack of strong evaluation processes for specific features, conflicting results are not unusual in the literature. For example, a study from Suthers [21] shows that having too many ontological elements about scientific arguments is a problem due to student's incorrect usage of the elements, whereas studies from Jeong [22] and Soller [23, 24] report on the contrary that students are able to deal with a wide variety of ontology elements.

In software engineering evaluations are quite different. Redwine and Riddle identify three phases in the research process [25]:

- Basic research: "*Investigate basic ideas and concepts, put initial structure on the problem, and frame critical research questions*."
- Concept formulation: "*Circulate ideas informally, develop a research community, converge on a compatible set of ideas, and publish solutions to specific sub problems*."
- Development and extension: "*Make preliminary use of the technology, clarify underlying ideas, and generalize the approach*."

A classical research work during the last two phases defines precise objectives in terms of functional and non-functional requirements and shows to what extent they are satisfied by a given design with a prototype implementation and representative examples (from toy examples motivated by reality to examples coming from pilot projects). The proposed design is always carefully compared with other design approaches having the same goal when they exist. There is generally no attempt to quantitatively measure the hypothesized effects on final users and field studies are very rare, with a few exceptions in the human-computer interaction field. "*If the original question was about feasibility, a working system, even without analysis, can be persuasive.*" [26] The emergence of good solutions is the result of a long-term complex process operating on a large flow of proposals sharing the same objectives from which the best ideas and implementations are progressively selected and repeatedly improved.

It would be important to acknowledge that CSCL is both an empirical science as advocated by Gerry Stahl *("Because CSCL is an empirical science, researchers must capture data that lends itself to the analysis of the various dimensions of group interaction"* [27]) and a design science as advocated by Gerhard Fischer. His approach proposes meta-design, where end-users are capable of influencing the way the design is shaped, as a methodology for CSCL [28]: "*Rather than providing access only to a small group of 'high-tech scribes,' media need to be designed to allow all participants to be and act as designers when they desire to do so*". Therefore, the CSCL research field should accept both evaluation approaches as soon as "techno-realist" and "pedago-realist" works are privileged. As advocated by Tchounikine et al. [2], when a project "*consists in developing a given computer-based system on the basis of well-defined specifications originating from the pedagogical analysis, the CS dimension can be evaluated as such. The CS work can be perfectly successful from the point of view of the CS objective addressed, independently of the fact that the underlying learning hypothesis makes sense or that the produced software has the expected impact on students. The argument here is that the success of the CS work can be disentangled from the success of the project it is part of (which of course nonetheless remains the general important objective)"*. In practice, unfortunately, unbalanced evaluation criteria such as "the CSCL field requires validation by field studies" or "the CSCL field requires cooperation with educationalists" or "this work is not accessible to most educators" are frequently used for "pedago-realist" research works. They tend to hinder technological innovation and to discourage computer scientists to contribute to the field.

Qualitative evaluations in the ethnographic tradition may create a bridge between the two parts when fine-grained analysis of how learners make use of innovative components or systems yield new conceptual and practical insights about collaborative learning with computers [29]. For example, a detailed analysis and conceptualization of the way learners use a mechanism for explicitly designating elements in graphical artefacts from chat postings is a valuable contribution for informing the design of all systems including separated task and communication spaces [30, 31].

5 Concluding Remarks

The CSCL field is an attempt to bring together researchers from the educational community and the computer science community. This multi-disciplinary field has obvious advantages over the separation between a collaborative learning sub field in the learning sciences field (which exists anyway for studying collaborative learning without computer support) and a collaborative learning system engineering sub field in different fields of computer science (human-machine interface, distributed systems, software engineering). But it is a difficult challenge for all the reasons previously discussed. Fig. 3 synthesizes most of the ideas developed in the paper and helps for presenting three key ingredients for more synergistic cooperation between CS and CL parts in CSCL.

First, CSCL research should promote 'techno-realist' conceptualizations and 'pedago-realist' designs which bring together ideas from the two parent fields. These research works must produce results that can be recognized as valuable by at least one of the parent fields as shown by the two big feedback arrows of Fig. 3. It means that CSCL should, in a large part, escape from "*established approaches and technologies*" and adopt Gerhard Fischer's formula "*thinking radically enough*" [26]. Works that are based on conventional approaches and already widely adopted technologies should not be highly valued. As exemplified in section 3.2, CSCL defines a context in which many CS issues are subject to specific constraints that can lead to valuable feedback for all other 'human-oriented' application fields of computer science. CSCL advanced approaches and technologies should, in turn, be analyzed and conceptualized by educationalists, providing new insights about collaborative learning with computers and, possibly, collaborative learning in general.

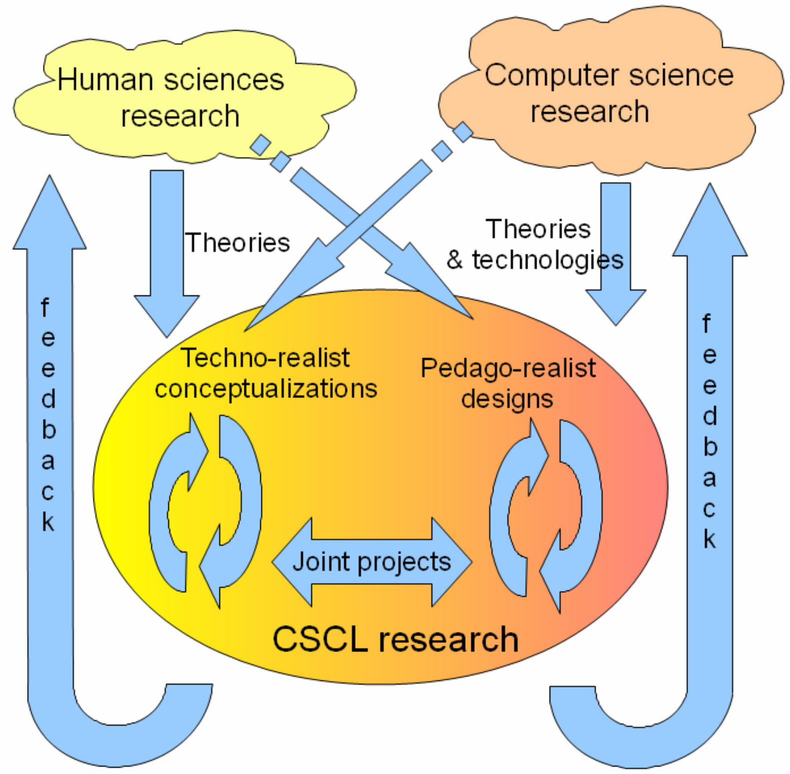

Fig. 3: A model of CSCL research

Second, it is important that standard evaluation practices from software engineering could be applied to "pedago-realist" CS works in order to have innovative solutions emerging from *a sufficient flow of proposals* (see the right internal loop in Fig. 3). A key element for CSCL success is to keep (or to develop) a research community in the CS part of a sufficient size and quality.

Third, it is impossible to launch joint projects with computer scientists and educationalists for dealing with each technological direction that must be explored. A joint project should only be initiated at the end of a "maturing phase", when both parts have progressively selected and iteratively improved the pedagogical and technical foundations for addressing some fundamental issue (see Fig. 3). The objective of these joint projects should be to develop *the powerful flexible platforms that are missing today* [3]:

- Based on the most advanced software architectures.
- With design rationales and source code available.

They would permit many researchers and teachers to:

- Customize and deploy them in a wide range of educational settings.
- Evaluate them independently of the initial project, through laboratory and field experiments.
- Generate, in turn, new conceptual and technological developments.

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