Jaime Carbonell as both SCHOLAR and TEACHER

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Abstract

“It is often said of Jaime Carbonell that one meeting with him is worth ten with anyone else. Though my interactions with Jaime were few, I can honestly say they were worth the wait.”

Quote from the Acknowledgements of one of the first Language Technologies Institute dissertations (Rosé, 1997)

1 Introduction

While Jaime is best known for his tremendous contributions and impact in the areas of Natural Language Processing, Artificial Intelligence, and Machine Learning, his impact has also been keenly felt in the area of technology supported education.

As a personal note, my first introduction to this area came during a survey course on research in computer science at the University of California at Irvine, where I was an undergraduate in the late 80s. As I carefully considered my options for undergraduate research in the Computer Science honors program, I was torn between working with Alfred Bork on technology supported education and Richard Granger on computational neuroscience. Not able to choose between the first, which seemed to have greater potential for human impact, and the second, which seemed more intellectually stimulating, I chose to pursue both. Little did I know at that point that both paths would ultimately point back to Jaime’s seminal work and career debut, beginning with research Jaime did during his graduate school years in Roger Schank’s group at Yale (Carbonell, 1969; Carbonell, 1970; Collins et al., 1973; Carbonell, 1977).

While Jaime was busy sowing the seeds of impact with his own research contributions during those years, he was enjoying the company of two office mates and fellow students of Roger Schank, namely Janet Kolodner, who eventually became the Matriarch of the Learning Sciences and a close colleague of mine to this day, and Richard Granger, who I already mentioned was my second mentor at UC Irvine, and instructor of my first graduate level Machine Learning course in Spring of 1990. It has clearly been to the great advantage of many that Roger Schank invested his energy mentoring these three. In the remainder of this article, an outline will be provided of three different areas of online education where Jaime’s work has made an impact, beginning with research in Tutorial Dialogue, then Computer Supported Collaborative Learning, and most recently work in the area of Massively Open Online Courses (MOOCs). Each of these discussions highlights a connection with and benefit from Jaime and his work.

2 Tutorial Dialogue

In Alfred Bork’s work on tutorial at the University of California at Irvine in collaboration with the University of Geneva in the late 80s, the concept of tutorial dialogue was a key technology used to engage students in valuable learning experiences in a variety of educational domains. The concept was not new, however. The idea of tutorial dialogue systems was conceived over a decade earlier, by both Jaime and his father, also named Jaime Carbonell, in their work on the landmark SCHOLAR system (Carbonell, 1969; Carbonell, 1970). The seeds were sewn in this project work with Alfred Bork that eventually inspired research towards development of more robust technology for dialogic interactions between computer agents and humans in the next decade (Rosé, 1997). Bork and his contemporaries taught that the biggest road block to impact in that area was that the technology for understanding human language was too brittle. Upon further reflection and digging deeper into the theoretical underpinnings of the field of Learning Sciences, the naiveté of that belief eventually
came to light. Nevertheless, this taste of research paved the way for pursuing a Ph.D. in Computational Linguistics, to develop technology for robust language understanding. And what better place to do that than Carnegie Mellon University, where the opportunity presented itself to earn a Master’s degree in Computational Linguistics and then a Ph.D. in Language and Information Technologies. At that time, tutorial dialogue was not a major area of language technologies, so there were not opportunities to work directly in that area. In fact, it was sometimes said that one who followed that path might not find a job. However, upon completing my dissertation at the end of the 90s when the field of Language Technologies was undergoing a great paradigm shift, the field of Learning Sciences was experiencing its own paradigm shift, and a rebirth of interest in Tutorial Dialogue systems. Thus, at the perfect time, an opening to pursue this research presented itself at the Learning Research and Development Center (LRDC) at the University of Pittsburgh, where there were also opportunities to benefit from mentoring and instruction from great leaders in Education, Cognitive Science, and Educational Psychology such as Alan Lesgold, Lauren Resnick, Johanna Moore, Kurt VanLehn, and Micheline Chi.

In this context one is frequently reminded of Jaime and his earlier work on SCHOLAR. For example, the goal of the WHY2 project (VanLehn et al., 2002; Rosé & VanLehn, 2005; VanLehn et al., 2007) was to focus specifically on conceptual physics problems and support students in developing the skills to articulate multi-step conceptual physics explanations. As in all scholarly work, we acknowledge the lineage of our ideas and efforts. We often harkened back to the ways in which that work grew out of a long term and multi-faceted effort to emulate in intelligent tutoring technology the elements that were believed to make human tutoring such an effective form of instruction. Expert human tutors were known to be highly successful at educating students (Bloom, 1984; Cohen, Kulik & Kulik, 1982). Students working with an expert human tutor were thought to achieve a learning gain of up to two standard deviations above those in a regular classroom setting. Emulating this “2 sigma effect” has long been the holy grail of intelligent tutoring research. While great strides in developing instructional technology had been made by that time, especially in the area of building coached problem solving practice environments (Gertner & VanLehn, 2000; Koedinger et al., 1997), achieving the goal of the full extent of the effectiveness of expert human tutors remains elusive to this day. The search for the answer to this mystery has taken many forms, but one common thread through generations of investigation has been the belief that the answer lies in the natural language dialogue that is the dominant form of communication between students and human tutors, and especially in adopting a Socratic tutoring style where students are lead to construct knowledge for themselves through directed questioning (Carbonell, 1969; Rosé et al., 2001b). Early efforts to emulate the effectiveness of human tutorial dialogue, such as the SCHOLAR system (Carbonell, 1969; Carbonell, 1970) and the original WHY system (Stevens & Collins, 1977), were often acknowledged as the landmark systems in the history of intelligent tutoring research. Nevertheless, it was acknowledged that in that early work the conception of what Socratic tutoring is and why it should be effective was not sufficiently well worked out, and the technology to support such interactions was not yet mature.

The work at the Learning Research and Development Center at that time in some ways picked up where Jaime’s work had left off. In one thread of work, I developed tools for efficiently constructing robust tutorial dialogue agents capable of leading students through directed lines of reasoning, initially in a physics instruction context (Freedman et al., 2000; Rosé, 2000; Jordan, Rosé, & VanLehn, 2001; Rosé et al., 2002; Rosé et al., 2005a). These tools enabled a series of successful evaluations in real classrooms (Rosé et al., 2001; Rosé et al., 2005b; Kumar et al., 2006). Nevertheless, it eventually became clear that one major road block to achieving impact with the technology was that student expectations of computer agents acted as a hindrance to them interacting with the agents in instructionally beneficial ways, regardless of the technical capabilities of such agents (Rosé & Torrey, 2005). It also became clear that even human tutoring wasn’t always as effective as claimed in the earlier Cohen and Bloom studies (VanLehn et al., 2007). Thus, attention turned to the use of conversational agents as facilitators in collaborative learning interactions, where the richness of human interaction could be experienced through peer interactions, which also have some benefits from a Piagetian theoretical perspective. In this environment, correct content and guidance could be provided by carefully designed agents.
One of the first projects I worked on with Jaime when returning to the Language Technologies Institute in the early part of the century was to co-advice a student on work focusing on automated collaborative learning process analysis (Donmez et al., 2005), bringing together a common interest in technology supported education and machine learning. Indeed, there had been much work in the computer supported collaborative learning community on modeling the process of collaborative learning with coding schemes applied to corpus data by hand (de Wever et al., 2006; van der Pol et al., 2006). Some early work towards automating the application of a well-established collaborative learning process analysis coding scheme (Weinberger & Fischer, 2006) demonstrated that patterns that indicate trouble in a collaborative discourse can be detected with a high degree of reliability and, thus, that a more dynamic support approach for collaborative learning is feasible. This early work sowed the seeds for the TagHelper project (Rosé et al., 2008), which became one of the most highly cited efforts in the field of Computer Supported Collaborative Learning in the past five years, and eventually LightSIDE (Mayfield & Rosé, 2013), which has recently grown into an award winning startup company. Since the 2005 debut into automated collaborative learning process analysis, there has been a growing number of publications related to script based collaboration that mention using machine learning, and of those, more than half cite this work. TagHelper and LightSIDE each have gotten over 4,000 downloads in the past five years.

An important contributing factor to this work’s success was that automated collaborative learning process analysis had been a long desired technology in the field of Computer Supported Collaborative Learning. The goal was for the field to move past the standard of static scaffolding for collaborative processes referred to as script-based support. Previous approaches to scripting were static, one-size-fits-all approaches. In other words, the approaches were not responsive to what was happening in the collaboration. This non-adaptive approach can lead to over scripting (O’Donnell, 1999) or interference between different types of scripts (Weinberger et al., 2004). With these things in mind, and considering that ideally we would like students to internalize the principles encoded in the script based support, a more dynamic and potentially more desirable approach would be to trigger support based on observed need and to fade scaffolding over time as students acquire the skills needed to collaborate productively in a learning context.

The concept of adaptive collaborative learning support was first evaluated in a Wizard-of-Oz setup and found to be effective for supporting learning (Gweon, Rosé, Zaiss, & Carey, 2006). As a further proof of concept of the feasibility and potential impact of such an approach, one former LTI Ph.D. student, Rohit Kumar, evaluated tutorial dialogue agents as support for pairs working together in a power plant design task used in CMU’s sophomore thermodynamics course (Kumar et al., 2007). In that study, working with a partner student and the support of an agent led to a 1.24 standard deviation improvement in learning over a control condition where students worked alone. Students who worked either just with a partner or just with the computer agent learned 1 standard deviation more than the control condition students. Thus, the support offered by the partner student and the agent were synergistic rather than redundant. Context-sensitive or need-based support necessitates online monitoring of collaborative learning processes.

In contrast to prior work on scripted collaboration, new dynamic forms of collaboration support “listen in” on student conversations in search of important events that present opportunities for discouraging dysfunctional behavior or encouraging positive behavior using automated analysis of collaborative learning processes. Work from the Language Technologies Institute is widely recognized as playing a major role in enabling this paradigm shift. Its value has been recognized in awards and award nominations for my group’s work at conferences such as ACM SIGCHI, AI in Education, the International Conference of the Learning Sciences, and Computer Supported Collaborative Learning.

4 **MOOCs and Beyond**

With the recent press given to online education and increasing enrollment in massively open online courses, the need for scaling up quality computer-mediated educational experiences has never been so urgent. Current offerings provide excellent materials including video lectures, exercises, and some forms of discussion opportunities. The biggest limitations are related to the
human side of effective educational experiences, including personal contact with instructors and the cohort experience. The primary focus of the above discussed work has focused on pairs and small groups working synchronously. However, with the rise of Massively Open Online Courses (MOOCs) more research has turned to supporting collaborative interactions within thriving online learning communities in order to create a more conducive learning experience in those contexts for students (Yang et al., 2013; Rosé et al., 2014).

Within this space, again the opportunity to collaborate with Jaime and others at the Language Technologies Institute presents itself as an exciting next adventure. In this sphere, Jaime proposes the concept of TEACHER, a planning system to aid students in navigating the free and open resources for learning that can be found on the Web. Here the department vision aims to give MOOCs a needed re-education. Take the learning of computer programming as an example. The vision begins with the realization that in recent years, a plethora of question/answer sites for programming have become available that have grown into thriving Communities of Practice (Lave & Wenger, 1991) for programmers. In these online communities, programmers can get mentoring from those who are more expert than they are. StackOverflow, for example, has become a forum not only for getting specific questions answered, but for negotiating the pros and cons of alternative ways of solving technical problems. The code proposed as part of alternative solutions remains as part of the community memory, which is then accessible for those who come later with similar concerns.

Where StackOverflow falls short is in providing an appropriate environment for the active involvement of very novice programmers, which is an important ingredient from a theoretical perspective in Communities of Practice. In this theoretical framework, novices connect with communities in small ways where they can gain elementary skills while contributing meaningfully to the group. This is referred to as legitimate peripheral participation, and it serves an essential motivational and socialization function. Nevertheless, when such novices come to a forum like StackOverflow and present their naive questions, they are frequently met with sarcastic responses, if they get a response at all. MOOCs for learning programming skills fill a niche left open by such environments, in that they welcome the very novice and provide forums where naive questions are not shunned. Nevertheless, discussion forums that only include such novice programmers would be akin to the blind leading the blind were it not for the involvement of a few more expert students and the teaching staff. This does not fully solve the problem, however. Many threads are still left without a satisfactory resolution. Currently, it is challenging for the teaching staff and expert participants to know where in the massive amount of communication to look for opportunities where their support is most needed. An additional and potentially bigger problem stemming from the disconnect between these "traditional" MOOCs and communities of practice like StackOverflow is the extent to which these MOOCs fall prey to motivational problems that also plague face-to-face classrooms. Specifically, the issue is the extent to which these environments are disconnected from real practice, in contrast to environments like StackOverflow where the effort to collaboratively construct solutions has real world impact in the programming endeavors where the solutions are used.

The vision of Jaime and others is to build a middle ground, specifically a community of practice where novice programmers have the opportunity to engage in the kind of legitimate peripheral participation that enables them to learn appropriately while participating in the community in small ways that do not disturb its general functioning. Within such a vision, Jaime's TEACHER planner can serve as a guide to novice students, pointing them to resources they can use to gain competence and move towards more meaningful engagement with the community. In collaboration with Jaime, others will contribute work on social recommendation in that context to strategically connect students to slightly more expert users who are new enough to be willing to offer the occasional helping hand (Yang et al., under review).

5 Final Remarks

One hundred and fifty peer reviewed publications past my dissertation research, I can confidently say that in many ways, Jaime’s work has influenced my career thus far both directly and indirectly. As discussed in this article, his shaping influence on my career began long before I even arrived in Pittsburgh over two decades and millions of dollars in research grants ago. Though Jaime’s research stands on its own in terms of its tremendous impact, I believe his im-
pact on me and my career has been greatest in his role as department head. The Language Technologies Institute, which in many ways has been Jaime’s baby, was a home for me as a Ph.D. student. It was a home-away-from-home for me during my six years at the Learning Research and Development Center at the University of Pittsburgh, when I continued to collaborate with faculty here. And it has been my home department since returning as a faculty member to the School of Computer Science, where I plan to enjoy my tenure for the years ahead. Thus, perhaps beyond just acknowledging Jaime as SCHOLAR and TEACHER, it would be more appropriate to bestow upon him the name PATRIARCH.

References
B.S. Bloom. 1984. The 2 Sigma Problem: The search for methods of group instruction as effective as one-to-one tutoring. Educational Researcher, 13, 4-16.


