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Contribution to a theory of CSCL scripts: taking into account the appropriation of scripts by learners

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Abstract This paper presents a contribution to the development of a theory of CSCL scripts, i.e., an understanding of what happens when learners engage in such scripts. It builds on the Script Theory of Guidance (SToG) recently proposed by (Fischer et al. in *Educational Psychologist, 48*(1), 56–66, 2013). We argue that, when engaged in a collaborative situation structured by a CSCL script, what learners consider is not "the script", but their appropriation of the script. Appropriation is a complex cognitive process which plays a role in both the recognition/conceptualization of the task to be achieved and its enactment, and is not dependent on the script only: it may be influenced by different external aspects. Therefore SToG and, actually, any theoretical framework attempting to provide an explanation of what happens when learners engage in CSCL scripts, should take into account appropriation issues. We develop our argumentation by focusing on technology-related aspects of appropriation and the role of institutional, domain and motivational aspects.

Keywords CSCL scripts · Appropriation · Script Theory of Guidance (SToG)

Introduction

A Computer Supported Collaborative Learning script ("CSCL script" or "script" for short) is a computer-based scenario designed to create and structure collaborative learning settings by associating groups of learners with specific tasks, roles, or resources, and/or constraining the mode of interaction among peers (Kollar et al. 2006). The computer-supported dimension is that some or all learners' actions and/or interactions take place via technological means such as communication tools, on-line resources, or software to perform the task at hand. The objective underlying the design of these scripts and the design or selection of their associated technology is to improve the likelihood that learners engage in knowledge-generating interactions (e.g.,

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explanation, argumentation, negotiation, conflict resolution, or mutual regulation) and/or the quality of these interactions.

A large set of empirical works has shown that CSCL scripts generally support learners and lead to positive learning outcomes, and has studied the conditions for these outcomes (e.g., Baker and Lund 1997; Kollar et al. 2007; Rummel and Spada 2005; Schellens et al. 2007; Schoonenboom 2008; Slof et al. 2010; Stegmann et al. 2007; Weinberger et al. 2005; Weinberger et al. 2010; see also Fischer et al. 2013 for an extensive review). Different works have also studied operationalization aspects, e.g. (Tchounikine 2008). However, a coherent general theory of the phenomena at stake when learners enact CSCL scripts still appears to be missing.

We attempt to contribute to an elaboration of a Theory of CSCL Scripts by developing the following argument. When engaged in a collaborative situation structured by a CSCL script, what learners consider is not "the script", but *their appropriation* of the script, i.e., how learners have perceived, understood, and made the script theirs. The difference is not to be seen in terms of possible misunderstandings only, i.e., as an issue related to the "correct" or "incorrect" understanding of instructions by learners, and how this discrepancy may be avoided or repaired. Appropriation is a complex cognitive process, which is influenced by different factors, and plays a role in both the recognition/conceptualization of the task to be achieved and its enactment. In particular, appropriation of scripts' technical aspects, which we will define as the way learners, while interacting with the tasks they consider, attribute functional values to software artefacts, influences both how learners perceive the task and how they use technologies. Through previous interactions, users may have associated ways of doing which will influence how they perceive and enact the setting. As a consequence, part of the explanation for learners' cognitive processes may lie in these constructions. Institutional aspects of the teaching setting, which include how the domain is taught, may also influence appropriation and enactment.

In this paper, we develop our arguments in reference to the Script Theory of Guidance (SToG; Fischer et al. 2013). SToG is a cognitive theory stating that how learners enact scripts finds its explanation in the way they dynamically select, configure or induce "internal collaboration scripts". Although it acknowledges that learners' processes may be influenced by "perceived situational constraints and affordances", SToG, as presently defined, downplays and does not analyze sufficiently appropriation concerns. Our point is that any theory of CSCL scripts should consider appropriation issues. The rationale for developing our arguments specifically in reference to SToG is three-fold. First, SToG is (according to its authors) the first and, so far, only theoretical framework addressing CSCL scripts as such. Second, our analysis is not intrinsically incompatible with SToG, and may cohabit and/or extend it. Finally, our general perspective is that CSCL scripts create complex situations which can only be addressed by looking at them from several angles, and thus require the articulation of knowledge originating from different points of view. Therefore, we develop our point by analyzing if and how it challenges SToG rather than as a standalone theoretical construction. This being said, let us make it clear that, actually, we are agnostic with respect to the SToG cognitive model. We do not argue for or against it; we refer to it because it is the present theory.

An important consequence of developing our arguments in reference to SToG is to keep the individual as the entry point. SToG considers the cognitive model of individual learners (it considers the "internal scripts of individuals", not the "internal scripts of groups"). It acknowledges that external factors such as group phenomena may have an influence on script selection, but its entry point is the individual. The point of view we adopt is different: we consider scripts

as designed artefacts and study appropriation, which requires bringing social interaction considerations into the picture. However, in this paper, we will present these elements while sticking to the individual as the entry point, as a way to preserve the potential articulation with SToG. As we will discuss in "Discussion" section, this is not a claim that all aspects of CSCL script enactment may be understood by taking the individual as an entry point.

The logical organization of the rest of the paper reifies the line of argumentation we develop. Scripts as artefacts section presents the perspective to CSCL scripts we adopt, i.e., considering scripts as artefacts. SToG's conceptualization of script enactment section presents SToG's conceptualization of script enactment and how it may be analyzed when considering scripts as artefacts. In "Introducing appropriation in the analysis" section we introduce the notion of appropriation, study how SToG acknowledges it, and develop our personal analysis, introducing technology-related aspects, institutional aspects and domain aspects. In "Discussion" section we synthesize the implications of these insights for the elaboration of a theory of CSCL scripts, how these proposals converge / diverge / extend SToG, and the necessity of considering individual and group perspectives. In line with a cumulative approach to research, the paper is centered on its contribution to avoid (re)introducing and (re)discussing aspects addressed in other works. Background information on CSCL scripts and SToG is kept to a minimum to ensure a stand-alone paper. For details related to CSCL scripts, see the (Fischer et al. 2007) reference book and/or the papers cited in this introduction.

Our argumentation is theoretical only. To illustrate it, we will use two running examples. The first, which we will refer to as the "argumentation script", is as follows: a group of three learners is asked to produce an argumentation relative to a topic, where each learner is asked to produce a claim, an argument, and a counter-argument, respectively. The second, which we will refer to as the "jigsaw script", is as follows: first, participants individually work on a topic; second, learners having worked on the same topic meet in "expert groups" to exchange ideas; finally, "jigsaw groups" are formed by grouping learners who worked on separate topics in the preceding phase. These argumentation and jigsaw scripts are prototypes of the two families of scripts usually referred to in the literature, namely micro- and macro-scripts; we will come back to the importance of this distinction in the discussion in "Discussion" section.

Scripts as artefacts

We define the enactment of the script S by learner l (denoted $E_l(S)$) as the behavioral and cognitive activities that l develops in relation with his/her engagement in the script.[1] Based on this definition, the general research question underlying the development of a script theory is: what is the explanation for the way $E_l(S)$ develops?

Our focus is on the perception of scripts by learners. Given this focus, we consider the script as an artefact (i.e., something designed by humans, in this case, instructional designers, psychologists and/or computer scientists) and take as the entry point of our analysis learners' perspective and, more precisely, learners' input.

[1] In order to define notions and contrast perspectives, we use in certain paragraphs a simple mathematical-like formalism. This is, of course, in no way an implicit claim that all aspects which may play a role in script enactment may be enumerated, or that learners' cognitive processes may be modeled as a formula; it is simply a way to identify notions and processes, which will help us contrast approaches. This formalization completes the textual presentation and its illustration with examples, and may thus be skipped without major prejudice.

Scripts, as the input provided to learners, are descriptions of what they are supposed to do and how. This includes the more or less explicit description of tasks, resources (including computer-based systems), roles and scaffolds/constraints. A script S may thus be defined as S = {I, T}, where I is the set of instructions and T is the technology used. For example, from a learner's perspective, the argumentation script may be considered as: I = {"provide an argument for the claim" (…)}, and T = {specific editor featuring three different "claim", "argument" and "counter-argument" editing boxes}.

However, technology associated with CSCL scripts is usually meant to contribute to the transmission of instructions and/or the reification of some script principles. The argumentation script is a good example: when learners are presented with a communication device offering three different "claim", "argument", and "counter-argument" editing boxes, this is meant as a means of guidance, and not a way to allow learners to merely communicate. Similarly, software managing jigsaws' data-flow and work-flow (e.g., the fact that groups have phase-by-phase access to resources) is part of the guidance.

A script S, as the input that learners receive, may thus be more precisely modeled as S = {I, T-I, T-F} where I is the set of instructions, T-I is the set of instructions carried out by the technology, and T-F is the set of technical features offered by the technology.

Let us illustrate this using the Concept Grid implementation of the jigsaw pattern (Dillenbourg 2002). Learners are provided with instructions I = {*first produce an individual definition of a list of concepts; then collaboratively write a few lines that relate or discriminate two concepts*}. For the collaborative phase, the associated technology proposes the features T-F = {*means to collaboratively fill a grid's cells to edit a common definition of each concept; means to collaboratively edit a description of the relations between notions placed in adjacent cells*}. However, the technology also comes with non-functional features (constraints) including: the number of cells is limited so as to prevent learners from placing all notions in non-adjacent cells. In other words, the technology carries out instructions (T-I) which corroborate (*edit a common definition, edit a description of the relations between notions*) and complement (*identify notions which may be put into relation [as you will not be able to escape this]*) the general instructions.

Considering scripts as artefacts also draws attention to the fact that a script is the result of a design process. This design process is based on educational and/or psychological hypotheses. For instance, the hypothesis underlying the argumentation script could be formulated as, "learners applying the argumentation pattern will be supported in shaping arguments and will internalize the argumentation pattern", while the hypothesis underlying the jigsaw script could be formulated as, "learners confronted with a problem they cannot solve individually but can solve collectively by sharing knowledge will learn from one another". These hypotheses act as a design rationale, i.e., the basis for the definition of script principles: "during the argumentation script, learner-1 must produce claims and learner-2 must produce arguments"; "during the jigsaw phase, individuals must have participated in different expert groups". These principles are then implemented in instructions given to learners and/or the technology: an editor proposing specific "claim" and "argument" editing boxes; a workflow scheduling individual phases and collective phases, and managing the groups and the individual/collective data accordingly.

Considering the design rationale of scripts has been identified as an important issue for managing script flexibility and, in particular, for dissociating intrinsic constraints (core principles that must be respected in order for the script to remain consistent with its underlying learning hypotheses) and extrinsic constraints (contingent decisions that may be reconsidered

if necessary); (Dillenbourg and Tchounikine 2007). It is also an important issue when considering appropriation as it may play a role in the didactic contract perceived by learners, i.e., somewhat implicit instructions. We will come back to this in "Analyzing institutional and domain-related aspects of CSCL script enactment" section.

SToG's conceptualization of script enactment

We will now synthesize the explanation for $E_l(S)$ that provides SToG.

SToG posits that learners have "internal collaboration scripts". These internal scripts govern the way learners perceive and act in collaborative settings: "When participating in a CSCL practice, the learner's understanding of and behavior in this situation is guided by dynamically configured and re-configured internal collaboration scripts" (Internal script guidance principle; page 57). These internal scripts evolve (are induced and/or reconfigured) through the practice of collaboration activities, where activities may be induced, guided, and supported by the "external" CSCL script. In other words, CSCL scripts ("external scripts" in SToG terminology) act as "representations that may guide CSCL practices by either facilitating or inhibiting the application of internal collaboration script components of the participating individuals" (page 61). SToG argues that both learners' internal scripts and CSCL "external" scripts may be modeled in terms of play, scene, scriptlet, and role components. These different claims are supported by a review of different empirical studies conducted by the authors and other researchers.

In terms of general conceptualization, SToG builds on a perspective of the enactment of CSCL scripts as the implementation of the instructions by learners: learners consider the script, i.e., the instructions, and mobilize their internal scripts to carry out the instructions. This may be written as: $E_l(S)$ = implementation (I, T-I). Actually, SToG's *raison d'être* is to propose more than a general conceptualization: it proposes an *explicative model* of the implementation function. To do so, SToG first introduces the notion of learner internal scripts (IS_l), which may evolve, e.g., by induction of new internal scripts. Second, it states that the implementation of the script (which we denoted by the implementation function) is fundamentally the application of dynamically selected, configured, reconfigured and/or induced internal scripts (IS_l). The SToG explicative model may thus be expressed: $E_l(S)$ = application (configuration (IS_l), I, T-I), which may be phrased as: when a learner l enacts a script S, he/she applies his/her internal scripts to the setting defined by the instructions I and T-I; these internal scripts, however, are not to be seen as a static set: they are dynamically selected, configured, reconfigured or induced (configuration function).

Let us illustrate SToG's conceptualization and explicative models with our two running examples. Within a SToG perspective, through preceding argumentative experiences, learners may have developed a play "Argumentative dialog", with which they have associated a sequence of "scenes" (as a scene example: "development of a counter-position to a claim") and "roles" (as a role example: "advocating a position"). Such scenes are associated with "scriptlets", i.e., knowledge of sequences of activities (as scriptlet examples: "first state a claim and then provide evidence for it"). When given a learning scenario such as the argumentation script, learners' enactment finds its explanation in the way learners select, configure and apply these different pieces of knowledge. Large-grained scripts (macro-scripts) such as jigsaw may be explained in the same way: play-level scaffolds prompt learners to engage in the collaborative activities of the expert- and jigsaw-groups (e.g., discussing an issue or finding a joint

solution for a problem), while scene-level scaffolds, if any, prompt learners to achieve the individual activities required by the play (e.g., proposing arguments or criticizing the solution).

In this section we only sketched SToG from the perspective adopted in this paper. It should be noted that, in SToG, guidance is not seen as a transfer through which external scripts are "copied" by the individual learner and stored in his or her long-term memory. SToG considers internal scripts as highly adaptive and thus dynamically changing entities that guide the understanding of, and behavior in, social situations. It is presented as moving beyond earlier schema theories (e.g., Schank and Abelson 1977) by addressing internal scripts as transient internal regulation structures which emerge in a specific situation through recruitment of script components on different hierarchical levels, rather than large fixed sequences of activities stored as inflexible structures residing in long-term memory "waiting" to be activated. SToG also posits statements with respect to the relation between how learners configure/reconfigure/induce internal scripts and learning, but this aspect is not a matter of concern in this paper. As already mentioned, we are agnostic with respect to this model.

In terms of script (taken as artefact) representation, one may note that modeling scripts using SToG's notions of plays, scenes, scriptlets, and roles is rather limited. Using such modeling primitives would only allow a very general model of complex macro-scripts including (for example) loops or conditions. As examples, the representation models proposed by Miao et al. (2005) or Kobbe et al. (2007) allow modeling of more complex scripts and, also, more details. We see SToG's modeling choice as guided by the objective of the authors to use coherent models for describing scripts as pedagogical scenarios ("external scripts" in SToG) and describing learners' "internal scripts", where the latter are the main matter of concern.

Introducing appropriation in the analysis

In this section, we first introduce the notion of appropriation and how SToG acknowledges it. Then, we develop our personal analysis of appropriation, and in particular, the role of technology aspects, institutional aspects, and domain aspects.

The notion of appropriation

An artefact is not unequivocal, nor is it "transferred" into the head of humans: humans develop an understanding of it. What learners consider and enact is thus not the script assigned to them, but their appropriation of this script.

As a general definition, we consider *appropriation* as the process by which (in this context) learners perceive, understand and make the script theirs.

Why do we use the term "appropriation" rather than "perception"? There are two main reasons. First, perception is usually defined as the process by which an individual establishes an internal representation of something. This process is influenced by the individual's concepts, expectations, and/or knowledge. Based on this definition, "perception of the script" points to the representation of the script that a learner may develop. This is central to SToG, which proposes a cognitive model. However, as pointed out in our introduction, we are not specifically interested in this representational aspect, and, to develop our arguments, we do not need to make any assumptions as to how learners represent scripts. Second, we use the term "appropriation" to insist on the fact that the most important thing to be considered is not the script (i.e., the instructions and technical features) as perceived by the learner. The most

important thing to be considered is *what the learner constructs in relation to this perception* (and not necessarily from this perception only), which has to do with other aspects than the script, such as crystallized ways of considering/using technology, institutional aspects, or domain aspects (see the following subsections). Although the definition of "perception" may be stretched to include these aspects, in our opinion, "appropriation" is a preferable term.

Let us call S' the script S as appropriated by learner l and introduce an "appropriation" function denoting that what l implements is not the script S, but the result of l's appropriation of S: S' = $\text{Appropriation}_l(S)$.

Taking into account appropriation leads to the two following questions: what aspects may play a role in this appropriation process, and what is the impact on how script enactment should be conceptualized and explained?

SToG's approach to appropriation

SToG addresses appropriation issues (via the notion of perception) as a factor that may influence learners' enactment of scripts: "How an internal collaboration script is dynamically configured by a learner from the available components to guide the processing of a given situation is influenced by the learner's set of goals and by perceived situational characteristics (internal script configuration principle; page 57-58)". These "situational characteristics" include the role of technology. With respect to these aspects, SToG refers to Norman's take on affordances, i.e., affordances as the perceived possibilities for activities in a given situation (Norman 1993).

Let us frame SToG's approach in relation to our perspective, i.e., considering scripts as the input that receives learners.

SToG acknowledges the role of technology as carrying out part of the instructions (T-I). As examples (proposed by the authors) that match our argumentation script: an empty text field with a blinking cursor is likely to be perceived as an opportunity to enter text via a keyboard; a text entry window of only two lines [excludes] activities such as formulating an elaborate counter-argument. With respect to macro-scripts, we may take the following illustrations: a Webpage integrating three frames recalling the three involved learners' individual productions and a fourth edition collective frame is likely to be perceived as a suggestion to produce a synthesis; a graphical tool visualizing as nodes the individual statements of learners and proposing means to draw connections with relations such as "is coherent with", "is in opposition to" or "argues for" is likely to be perceived as a suggestion to elaborate a concept map; in such a graphical tool, offering a relation labeled "to-be-customized" is likely to be perceived as a suggestion to define ad-hoc semantic relations as necessary.

SToG's reference to the affordance notion rightly points out that technology (and, thus, the instructions carried by the technology T-I) as perceived by learners may differ from designers' expectations. For instance, learners may be unaware that they can define ad-hoc relations, or define a single and poorly semantic "is-related-to" relation.

SToG thus answers as follows the two key questions we introduced in "The notion of appropriation" section. The aspects that may play a role in the learners' appropriation process are "situational characteristics", including technology. The impact on how script enactment should be conceptualized and explained is: appropriation possibly introduces a discrepancy between script S as seen by designers and script S' considered by learners. Learners' enactment of the script may thus be dissociated into two processes. The first process is appropriation: learners consider the script S = {I, T-I, T-F} and, possibly, develop a personal

appropriation S' = {I', T-I', T-F'} which may differ from S on important or unimportant aspects. I' and/or T-I' may differ from I and/or T-I because learners interpreted differently from expected the explicit instructions I and/or perceived the technological affordance in an unexpected way, which led then to interpret the instructions carried by the technology (T-I). Their perception of the technological affordances may also lead them to consider technology features (T-F') which do not correspond to the effective ones. The second process is implementation as depicted in "SToG's conceptualization of script enactment" section: learners consider S' and mobilize their "internal scripts" in relation to it.

Our point is that SToG does not sufficiently push forward analysis of the aspects that may play a role in this appropriation process and, as a consequence, the impact on how script enactment should be conceptualized. In the next subsections we will show that, in particular, considering appropriation of technology and institutional/domain aspects requires changing the conceptualization of how appropriation impacts script enactment.

Analyzing appropriation of technology in more detail

The way users[2] use technology may be addressed in terms of how the relationships between humans and the world are mediated by artefacts. Activity Theory (see for example (Engeström et al. 1999)) provides a theoretical explanation by dissociating artefacts and instruments. Artefacts are mobilized by users in the context of their finalized activities. They become instruments for users in the context of these activities in that they allow users to achieve the tasks they consider, and in the way they consider these tasks. Designers create artefacts, i.e., technological affordances. It is the user who turns an artefact into an instrument in the context of his/her activity, by developing a way of using the artefact according to his/her tasks and the way he/she considers them. In other words technology, as a means for users to perceive and/or achieve tasks, has an influence on users' activities and, at the same time, users are not simply passive recipients of task prescriptions and technology.

The artefact/instrument duality allows for a more precise definition of appropriation in the case of software: software appropriation is the way users, while interacting with the tasks they consider, attribute functional values to software artefacts, i.e., attribute artefacts a utility for achieving the tasks or goals as perceived by them (Tchounikine 2016). The underlying line of thinking is that users do not interact with the software, but with the task at hand (which may differ from the task they are asked to complete). The actual task they consider and the way they consider it determines their use of the software.

This perspective to appropriation as related to how users turn artefacts into instruments raises the question of the nature of this process. The Instrumental Genesis Theory (Rabardel 2001, 2003) proposes a developmental perspective according to which users turn artefacts into instruments via a dual process of instrumentation (i.e., user adaptation to the constraints of the artefact) and instrumentalization (i.e., attribution of functions to the artefact, that may or may not match those anticipated by the designers, and/or the technical transformation of the artefacts by the user). From this perspective, an instrument may be seen as an abstract notion that has a technical dimension, namely the artefact, and a psychological dimension, namely the usage schemes. Schemes are the invariant organizations of behavior for a certain class of

[2] In this section, as the arguments we develop look at how users (and not specifically learners) use technologies, we will use the term "user" when remaining general, since learners are considered here as the users of the technology associated with the CSCL script.

situations or, in other words, more or less stable ways of addressing specific situations or tasks within which technical and conceptual aspects are intertwined (Vergnaud 1998), and relate to the functions that users assign to the artefact. Instrumental geneses develop within the context of user activities – aspects with both individual and social dimensions, in particular through work-practices. The analysis may also be anchored in other different theoretical backgrounds, e.g., the way the genre approach – in the sense of Bakhtin's notion of genre in rhetorical and literary analyses - considers typified social actions; see (Tchounikine 2016) for a review and a discussion.

Coming back to CSCL scripts, the general implication is that technology does not only play a role in the way learners will use it; it also affects their very conceptualization of the task and the task-technology relation. Learners' appropriation and enactment processes of the script are related to (a) cognitive processes related to previous interactions with the task as it is effectively considered by the learner, which include more or less stable ways of addressing it with or without technology, and (b) previous ways of using technologies (the one offered with the script and the ones that were previously used when interacting with the task). Phrasing this while taking SToG's perspective: the learner cognitive processes involved in understanding/recognizing/making sense of the situation and achieving the task are related to (partly caused by? influenced by? interplay with?) the constructions associated with the technology (this type of technology, other technologies) that he/she has previously developed.

This resonates in a particular way insofar that technology is intrinsic to CSCL, and is usually designed or selected to carry out part of the instructions, constraints and/or support. One may argue that, in some scripts, technology is thought of as "general", e.g., when learners are given the opportunity to use a generic framework such as a Learning Management System (e.g., Moodle) or the technology of their choice. However, the term "neutral technology" is an oxymoron. Any computational system offers some features and not others; any system presents some properties and not others, and conveys meaning.

Let us take the example of the jigsaw script implementation within which learners are offered a graphical tool for visualizing individual productions and drawing semantic relations in-between them. Let us first consider the task. Learners may already have interacted with such a task and, within these interactions, developed more or less stable ways of using semantic connectors. These crystallized constructions may or may not match the graphical tool features, in which case the offered tool may appear as an obstacle to the task. This may lead learners to adapt it to themselves (instrumentalization), if possible; this is the reason why designing for appropriation implies offering some flexibility to users (Tchounikine 2016). For instance, because they are used to organizing notions such as taxonomies, learners may attribute to the technology the functional value of editing hierarchies, which will lead them to define an "is-a" relation and use this one only (or, if the system does not allow such customization, attribute an "is-a" semantic to one of the tool's relations that seems close in meaning, which may be problematic). Let us now consider the technology. The graphical tool and its semantic relations are thought of by its designers as a support for constructing concept maps. However, if this software is considered at a more abstract level, it is a graphical tool that allows the elements represented in the interface to be displaced and tagged. Some learners may have used tools whose abstract description matches this one, and developed previous ways of using this type of technology, for example clustering notions by grouping them at one side or another of the editing interface. The fact that the technology has for these learners such an a priori functional value will impact their perception of the setting and, possibly, of the task they effectively consider. Previous ways of using this type of technology may also have a more subtle impact,

e.g., lead learners to minimize the number of relations that cross each other. While this is indeed an explicit objective when using some graph-tools, it may prove negative for the elaboration of a thoughtful concept map.

As can be seen from these examples, considering appropriation and the functional values learners may attribute to technology may be useful for understanding learners' processes more accurately than by simply considering whether or not they capture technology affordances. Typically, in the example above, the way learners use the graphical tool is not only related to the fact that they understand its functioning. More generally, considering appropriation issues requires not taking for granted that the support, which technology is supposed to offer, actually operates. For instance, the graphical tool may be given the functional value of "nicely-presented graphs" but not that of "helping to elaborate a concept-map thanks to its thoughtful relations and the possibility to displace notions on the screen and edit relations." Given such a functional value, it may be used to edit productions constructed elsewhere (e.g., in front of the computer but on a piece of paper) rather than to elaborate a conceptualization in a way that is structured by the interface notions, which is its raison d'être.

This analysis suggests the following answers to the two key questions we introduced in "The notion of appropriation" section. The aspects that may play a role in learners' appropriation process of the script include different types of pre-existing (and under development) constructions related to previous interactions with the task and to previous interactions with the technology. These elements may be coherent or in conflict with the script instructions and technology. The impact on how script enactment should be conceptualized and explained is: appropriation (in this case, software appropriation) should be seen as a process that plays a role in both the recognition/conceptualization of the task to be achieved and its enactment.

Analyzing institutional and domain-related aspects of CSCL script enactment

Studies addressing appropriation of technology highlight the key impact of crystallized pre-existing constructions and, in particular, pre-existing constructions related to work-practice. We suggest continuing this line-of-thinking and considering the following question: what aspects of learner "work-practices" may influence how learners appropriate and enact CSCL scripts? This leads to considering institutional and domain-related aspects.

Influence of the didactical contract

A CSCL script, just like any teaching construction, establishes a contract between the teacher and the learners (and, also, in this case, a contract between learners). To conceptualize this aspect, reference may be made to the notion of *didactical contract* as defined by Brousseau in the Theory of Didactical Situations (Brousseau 1984, 1997). The didactical contract is the set of mutual obligations that each partner in the didactical situation imposes or believes to be imposed on the others, and those that are imposed or that he/she believes to be imposed on him/her. For Brousseau, this contract is related to the knowledge in question. As an outcome of an often implicit negotiation of the setting up of the relationship between a learner, a certain milieu, and an educational system, it is partly explicit and partly implicit. For instance, although implicit, the teacher's expected answer to a question such as "Can you explain this?" is usually not "yes" or "no". By definition, the objective is that learners learn something that

they do not know yet, which partly relies upon aspects unknown to the learners. For some aspects, learners can only guess the content of teachers' expectations. Learners' interpretations are also, of course, related to pre-existing experiences, so he or she responds to the didactical contract and deciphers the teacher's intentions in different ways (due to differences between individuals but, also, possibly, teachers' variability (Sarrazy 2002)).

Taking a didactical contract perspective, the fact that CSCL scripts presented to learners are in fact the implementation of design principles (see "Scripts as artefacts" section) may play an important role. Part of the didactical contract perceived by learners may be the result of the design rationale and the teachers' expectations as they perceive it. For instance, a well-known phenomenon is that some learners focus on task achievement while others focus on the collective characteristics of the process (collective elaboration and/or agreed solution), which in some cases is even viewed as being more important than the quality of the achievement. Part of the didactical contract perceived by learners may also result from general considerations exceeding the teaching setting.

Let us first illustrate these ideas with the argumentation script. The instructions are crystal-clear: propose arguments for or against a claim and use the specific editor to do so. However, the script does not state if one should personally agree with these arguments. Is this part of the didactical contract? In the absence of any explicit statement, different learners may consider this question differently and, while not making their understanding explicit, enact the script in a way that complies with their view. As another example, what is a legitimate argument depends on the body of knowledge shared by all the members of the institution and its different perception by different actors (e.g., arguments of plausibility may be accepted in biology classes but not in mathematics classes, and what is taught and how differs according to countries (Cabassut 2005)).

Let us now illustrate these ideas with the jigsaw implementation prompting learners to use a graphical tool offering specific features such as a set of semantic relations. As explained earlier, this can be viewed as offering affordances. However, it may also be seen as elaborating with learners the implicit contract according to which they should use these semantic relations. Here again, this contract may be perceived and/or respected differently: some learners may perceive it and respect both the letter and the spirit; some learners may perceive it and respect the letter but not the spirit (e.g., elaborate their model on a piece of paper, with a pencil and an eraser, and then edit the elaborated construction with the graphical tool; see above); some learners may not perceive the contract, pretend they did not perceive it or consciously ignore it; and learners may also change their mind ("I have raised counter-arguments because I know that this is what I'm expected to do and/or it contributes to the production of a rich collective construction, but I don't really care personally and now I'm fed up").

These examples illustrate that the script as a set of instructions may only constitute part of the "obligations" perceived by learners. In other words, understanding how learners enact CSCL scripts requires taking a more holistic approach, in the same way that the use of software systems is explained by how users conceptualize and enact their work practice. Some authors introduce three levels to dissociate the macro-contract (related to the teaching objective and characterized by the meso- and micro-contracts it allows), the meso-contract (related to an activity, e.g., an exercise) and the micro-contract (related to an episode); for instance, collective solving of exercises may be analyzed in terms of several micro-contracts such as "collective production" (which includes "individual production" micro-contracts) or "agreement" (Hersant and Perrin-Glorian 2005).

Influence of the institutional context

Let us now take a wider perspective. CSCL scripts are not enacted in a vacuum. They are implemented as teaching strategies, in the context of institutions.[3] This perspective may be studied via the Anthropological Theory of the Didactic (Chevallard 2007).

This theory addresses a learner' relationship to knowledge and sheds some light on the influence of institutional aspects. It recognizes that learners develop a personal relationship to knowledge based on their conceptualizations. However, it introduces as a fundamental point the fact that learners act within a didactic organization which includes school-related aspects, pedagogical aspects and domain-specific aspects. Institutions define what is to be taught, along with what learners are supposed to do and how they are expected to behave. Learners thus develop an institutional relationship to this knowledge based on the institution and the institutional practices they are involved in. These different aspects of a learner's relationship to knowledge impact his or her interpretation of instructions, recognition of a situation and enactment of the task. Taking these aspects into account requires considering the structure and dynamics of the more or less fuzzy set of conditions and constraints that determine the controlled diffusion of knowledge and skills in institutions and society. This may be addressed using the notion of "levels of didactic codetermination", i.e., the idea that phenomena arising at general levels impact those arising at lower level (as a scale example: civilization, society, school, pedagogy, discipline, domain, sector, theme and issue; see (Bosch 2015), for an example of such an analysis in the case of algebra).

Let us first consider generic examples. Institutions (in the wide sense) and levels of codetermination may have to do with aspects such as: consideration of disagreeing as impolite and to be avoided; inability to or not wanting to play roles, e.g., to propose arguments which one does not agree with; inability to or not wanting to differentiate epistemological conflict and personal conflict; etc. Of course, these differences may also occur in relation to learners' personal characteristics; our point is that the institution within which the script is enacted also plays a role.

Let us now consider domain-related aspects. Institutions and their different levels of codetermination play a key role in how disciplines are taught (Artigue and Winsløw 2010). This results in learners developing types-of-tasks / technique associations (e.g., in mathematics, "solving an equation" / "developing algebraic calculus") related to the way the institution organizes teaching (in this case mathematics) more than proper knowledge. In other words, learners mobilize techniques as a kind of reflex originating from the way they were taught. Let's study such a phenomenon in the context of a jigsaw script. A first expert-group is trained to draw curves (which is useful to solve equations via a functional approach), a second expert-group is trained to manipulate algebraic constructions (which is useful to solve equations via an algebraic approach), and jigsaw groups are asked to solve equations. What phenomena will explain the knowledge mobilized by the learners in the jigsaw groups? The rationale of the script is to hypothesize that they will mobilize the knowledge practiced in their respective expert groups, but the constructions they have personally associated with equation solving may disturb this. This personal relation to the knowledge at stake may be identical for all learners (typically, when educated within the same institution) but may also vary for institutional reasons (different schools or different teachers) and, of course, for individual reasons.

[3] Institution is to be taken here in an extensive perspective including aspects such as the classroom as managed by the teacher, the school, the curricula and/or the local or national education system. These aspects are impacted by the society and the culture within which they develop.

Conclusion

The examples presented above illustrate that taking into account the influences of the didactical contract and the institutional context is useful for understanding learners' processes more accurately. It draws attention to more general phenomena than situational characteristics alone, and importantly, to analyzable phenomena. The way knowledge is organized and taught in a given institution is analyzable, e.g., via textbooks or lesson plans. The didactical contract that learners perceive and the reasons for this may be partly anticipated, and at least is analyzable a posteriori. As a consequence, the impact of these aspects may be studied.

These analyses thus suggest the following answers to the two key questions we introduced in "The notion of appropriation" section. The aspects that may play a role in learners' appropriation process of the script include institutional considerations, which are related to generic aspects, and, possibly, domain-related aspects (the epistemological aspects of the construction of meaning and the different relationships with knowledge that learners may have developed in this particular domain). The impact on how script enactment should be conceptualized and explained is, here again: these aspects may play a role in both the recognition/conceptualization of the task to be achieved and its enactment.

Discussion

In this section we first synthesize the implications of the arguments developed in "Introducing appropriation in the analysis" section for the elaboration of a theory of CSCL scripts, which leads us to highlight three aspects: the need for considering appropriation as a cognitive process that may interplay with the other processes involved in script enactment; the need for considering the multiple impacts of motivational aspects; and the need for taking into account script entropy. We then summarize how these proposals converge with, diverge from, and/or extend SToG. Finally, we discuss the methodological choice adopted in this paper of taking the individual as the entry point.

Considering appropriation as a cognitive process that may interplay with the other processes involved in script enactment

In "SToG's approach to appropriation" section we highlighted that SToG implicitly addresses appropriation as a process that may possibly introduce a discrepancy between script S as seen by designers and the effective script S' which is considered by learners. This conceptualization, which actually underlines many other, if not all, works related to CSCL scripts, is that the enactment of a script by learners is fundamentally seen as the implementation of the script instructions by these learners, instructions which, however, may be affected by the appropriation process.

The analysis we have developed in "Introducing appropriation in the analysis" section, however, leads to the conclusion that appropriation must be considered as an intrinsic part of the cognitive process by which learners enact scripts, rather than something that modifies the input of the script implementation process only. An analytical distinction may be introduced to denote appropriation, which relates to the process of making sense of the situation, and implementation, which relates to performing tasks. However, these mechanisms are dual and intertwined. They must be studied both as such and in a holistic way, i.e., as a system.

The formalization we introduced may be used to contrast these two perspectives. The first (SToG) perspective, which we call the "disentangled model" may be written: $E_l(S)$ = implementation (appropriation(I, T-I))or, if one prefers, $E_l(S)$ = implementation (I', T-I'), where I' and I-T' are the instructions as appropriated by the learner. Learners' appropriation process and learners' implementation process are considered separately, and the appropriation process impacts the input of the implementation process only (the implementation functions take as input the result of the appropriation function). In the second perspective, which we call the "interplay model", appropriation and implementation cannot be studied independently from one another. This requires introducing an operator (let's use the symbol ⊗) denoting the fact that the two processes are intertwined. This may be written: $E_l(S)$ = implementation ⊗ appropriation (I, T-I). Coming back to one of our examples: when learner l considers I = {edit a concept map}, T-I = {dissociate notions} and T-F = {graphical tool}, the functional values previously associated to graphical tools and the crystalized way of doing developed through previous interactions with the task and with the technology, the didactical contract perceived by l and the overall institutional context play a role in the overall appropriation and implementation process; they cannot be reduced to an impact on the input of the implementation process only.

Adopting this interplay model opens a set of general questions related to what this ⊗ operator corresponds to, i.e., the nature of the interplay. Is it to be seen as a fusion, i.e., appropriation and implementation are one process? Is it to be seen as an interaction, i.e., two different identifiable processes which, however, dialectically interact? And what aspects may play a role in this interaction?

Considering the multiple impacts of motivational aspects

As tasks to be achieved by humans, scripts are subject to motivation phenomena. Considering motivation aspects is of course not a new idea. The importance of motivational aspects has been addressed in a large volume of literature, and, as already mentioned, SToG acknowledges that the way learners configure their internal scripts is influenced by their goals ("internal script configuration principle", page 57).

The analysis we developed, however, calls for attention to a specific aspect of motivation: its impact on appropriation issues.

Motivation is at the very core of the definition of technology appropriation we introduced: appropriation is the way users, while interacting with *the tasks they consider*, attribute functional values to software artefacts, i.e., attribute to artefacts a utility for achieving the tasks or goals *as perceived by them*. This implies that motivations may lead a learner to appropriate and use technology in a way that differs from expectations, with some possible effects on the enactment of the script and/or the way technology scaffolds or constrains the learner. And, actually, the objectives and motivations of learners may be multiple, varying in nature, and evolving. As examples: contribute to the achievement of the task; receive a good mark; be proud of one's work; collaborate with peers; demonstrate one's superiority over a peer; impose oneself as a leader; prevent the group from failing in the task; avoid conflict within the group; participate just enough to be decently allowed to say one made some effort.

Motivation is also an aspect that plays a role with respect to the didactical contract and the institutional considerations. Let us take an example from an experiment related to implementation of the jigsaw-like Research-Structure-Confront script (Betbeder and Tchounikine 2003) at a university level. A group of online learners were asked to write a document together, and

offered specific technology to do so (a system offering forums and a collaborative editor). They were given several weeks to complete the assignment. The analysis revealed that use of the technology was significantly affected by the conflict between the didactical contract and the learners' motivations. Initially, all groups "played the game" of the didactical contract and used technology according to what they considered were the teacher's expectations. Toward the end there was some time pressure. The analysis revealed that motivation "to be efficient" became more important than motivation "to play the game". Groups that were reasonably efficient with the offered technology continued to use it; some groups that were not efficient continued to use it because of the didactical contract, and more generally the institutional pressure; some others simply switched to other means they were more efficient with.

Taking into account script entropy

In this paper we have taken as running examples the argumentation and jigsaw scripts. Actually, these scripts are prototypes of the two families of scripts usually referred to in the literature, namely micro- and macro-scripts (Kobbe et al. 2007; Dillenbourg and Tchounikine 2007). Micro-scripts are fine-grained learning scenarios, usually based on a psychological perspective, which consider the scaffolding of interaction processes with an objective of internalization by learners; as examples, see (Stegmann et al. 2007) or (Weinberger et al. 2010). Macro-scripts refer to large-grained scripts, usually based on a more pedagogical perspective. They introduce learners to a sequence of activities in which they are expected to engage in processes such as elaborating on content; explaining ideas, concepts and opinions; asking thought-provoking questions; elaborating and reflecting on each other's knowledge; constructing arguments; or resolving conceptual discrepancies. For examples of such macro-scripts, see (Hernández-Leo et al. 2010).

As already mentioned, SToG is presented by its authors as a model that may be applied to both types of scripts, and this difference is not central to the theory. Taking an appropriation perspective, we believe that the micro/macro-script differentiation should be given some importance. More precisely, our point is related to two aspects of scripts that usually correspond to different realities in micro- and macro-scripts: prescriptiveness and time span.

The degree of prescriptiveness of the script sets two overlapping aspects, the level of coercion (the place for acting in a way that differs from the instructions) and the level of ambiguity (the place for developing misunderstandings of the instructions). Low level of coercion and high level of ambiguity create more room for different appropriations to develop. For instance, the argumentation micro-script has a high level of coercion and a low level of ambiguity: it addresses one single task ("propose arguments"); there is a direct relation between the instructions and the task and between the task and the targeted learning objective; the technology (three specific boxes to edit claims, arguments and counter-arguments) is specifically designed to very directly support the achievement of the task at hand, and has little other uses. Learners may of course misunderstand instructions and/or use the technology in an expected way (e.g., type arguments and counter-arguments in the same box). However, the chances that they completely miss the instructions, and/or have already encountered and developed ways of performing this specific task and/or of using editing tools similar to this one, are rather limited. In direct contrast, a macro-script such as jigsaw, which sets more general tasks and uses more indirect ways, presents a lower level of coercion and a higher level of ambiguity. Macro-script instructions usually address the structuring of the setting (creating the reasons and opportunity for learners to interact), implicitly or explicitly avoiding "over-

scripting" (Dillenbourg 2002). For instance, presenting learners with the task "co-write with your peers a text explaining this phenomenon" is a rather general description of the task. The reason for this is that this task is in fact a pretext to create a setting that will lead the learners to consider the effectively targeted argumentation and synthesis tasks. "Co-write with your peers a text explaining this phenomenon" also opens space for different understandings, relating to interrelated causes: it is a general description; learners have already probably "interacted" with this task, with or without technology, and developed ways of addressing it. Finally, technology used in macro-scripts is often more general than in micro-scripts, e.g., using a generic graphical modeler or a Learning Management System such as Moodle, which augments the chances that learners may have developed ways of using these or similar technologies. As a consequence, elements that may lead learners to appropriate the script in different ways, such as the relation with preexisting conceptualizations (ways of doing things, uses of technology, etc.) are more likely to play a role in macro-scripts.

Another important aspect is the *time span*. For micro-scripts such as the argumentation script, the time-span is 30 min or so. For macro-scripts such as jigsaw, the time span may be 3 h, 3 days or 3 weeks. Here, the important aspect is not the time span as such but what happens during the time span and what the time span allows to happen. Repetition is another important aspect (typically, perception of the technology differs considerably depending on whether a script is run once or several times). At this level, with respect to technology appropriation, we would like to insist on the following. Appropriation, as a developmental constructive process, is a long-term phenomenon. In direct contrast, CSCL scripts usually take place as punctual episodes. This is of course the case for scripts run in non-longitudinal research studies, and may also be the case for scripts used in basic practices. With this in mind, the use of technology which is "discovered" and/or used for the first time in a CSCL script may be examined in terms of the development of new behaviors. However, it should also be examined in terms of alignment process, i.e., the way learners make software consistent with preexisting representations and organized ways of acting (Tchounikine 2016). With respect to the appropriation of technology, time matters.

Scripts' prescriptiveness (level of coercion, level of ambiguity) and time span may be seen as contributing, along with other aspects, to *script entropy*, i.e., the uncertainty related to the number of specific ways in which the script may be perceived/appropriated and enacted. Introducing the notion of script entropy is a way to recognize that scripts are complex artefacts whose enactments involve complex interrelated processes, including appropriation processes. The argumentation script's entropy is not null but is lower than the jigsaw script's entropy, for different reasons including the ones we listed above.

This analysis calls for analyzing script characteristics in more detail than present conceptual- or implementation-oriented conceptualizations (e.g., (Kobbe et al. 2007) or (Miao et al. 2005)) or the micro−/macro-script dissociation, which is fairly intuitive but mixes different aspects where disentanglement may be useful. For instance, macro-scripts may introduce a large number of activities in a prescriptive way, where each activity is itself scripted in a coercive way. In other words, the micro- macro-script dissociation may help consider some aspects but be confusing for others. Analyses must address the characteristics of the scripts on different planes such as the level of coercion, the level of ambiguity or the time span. These analyses must acknowledge that some aspects come from external-to-script considerations and/or may evolve. For instance, the level of coercion may be related to script granularity but, also, to the institutional dimensions, the a priori didactical contract and how this contract evolves through the repetition of sessions.

Convergences, divergences and extensions with respect to SToG

SToG takes the perspective of an individual learner's cognitive process, and aims at proposing a model that explains this process. We have taken the perspective of considering scripts as artefacts, with the aim of identifying appropriation aspects that may play a role in script enactment. These two analyses differ in nature. However, and this is the interest of adopting different perspectives, we may analyze what they say and whether it corresponds to convergences, divergences, or extensions.

From a general perspective, although it does not address the issue in this way, SToG is consistent with our point that the script, as considered by the learner, may differ from expectations, and that different aspects including learners' perception of technology may play a role. Actually, from our perspective, when taking the script as an artefact, the wording "the script as thought of by the designers" should be used rather than "the script" to avoid the implicit claim that there is a correct interpretation and an incorrect interpretation (of course, from a learning perspective, all interpretations are not equivalent).

We claim that some importance should be given to the role of external-to-script factors on learners' appropriation (usages of technology, institutional context and implicit didactical contracts) and, as a consequence, learners' enactment processes. This is not in contradiction with SToG's claims, but it calls for enlarging its initial and purely (individual) cognitive perspective. In our view, SToG presently downplays these issues because of its entry point.

SToG's major claim is that learners' engagement in CSCL scripts is based on preexisting (and evolving) constructions, namely "internal collaboration scripts". While we are agnostic with respect to this "internal collaboration scripts" notion, we agree on the role of preexisting (and evolving) constructions. However, we propose to analyze this while taking a wider perspective on learners' previous interactions with the task (to say it in our words). In particular, this perspective should include examining constructions related to usage of technology and the influence of the institutional milieu, in terms of both influence on the effective task that learners consider and crystallized ways of doing.

We have dissociated (1) a "disentangled model", featuring appropriation as a process that modifies the input of the script implementation process, and (2) an "interplay model", featuring these processes as dual and intertwined, and suggesting that they should be studied as a system. We have argued for the latter. At present, SToG is consistent with the disentangled model, but is not inconsistent with the interplay model. We believe it should evolve in this direction.

SToG claims that macro- and micro-scripts can be addressed similarly. We call for more precautions. Macro- and micro-scripts usually present different characteristics, in particular in terms of prescriptiveness and time-span, which may lead appropriation phenomena to be different. Our analysis is that SToG natively addresses micro-scripts and extends its claims to macro-scripts. In our perspective, however, this view to macro-scripts misses important aspects that may play a role in appropriation, and should be considered. (Actually, it also misses other aspects such as group dynamics.)

SToG proposes an explicative model featuring the notion of dynamic configurations of internal scripts, and different claims related to internalization and learning. These aspects are not in the spectrum of our analysis. In addition to the fact that considering appropriation according to the interplay model suggests questioning the explanation of learners' enactment process in terms of selection or configuration of "internal CSCL scripts" only, we may just comment that, in our view, appropriation is a developmental process and thus times matter.

Last but not least, SToG considers social phenomena as emergent and part of context. Taking an Activity Theory and Instrumental Genesis perspective to appropriation of technology and raising concerns such as the didactical contract or the institutional context, we ask to give more centrality to social phenomena. We develop this aspect in the next subsection.

Individual and collective aspects

By definition, CSCL scripts are enacted by groups. Moreover, in this paper, we have argued that appropriation is a sine qua non condition for understating CSCL script enactment and shown that this requires considering social level aspects. However, we have kept the individual as the entry point of the analysis. Is this completely wrong? And, as a consequence, are all the ideas and arguments presented in this paper (and in SToG) meaningless?

Let us first recall the reason for considering (in this paper) the individual as the entry point: preserving the potential articulation with SToG as the first construction that claims to propose a theoretical account for CSCL scripts. Let us now come back to our general perspective for the elaboration of a theory of CSCL script: scripts create complex situations, and complex situations can only be addressed by looking at them from several angles. The question with respect to taking the individual as the entry point of analysis is thus not if it is completely wrong, but rather, does it contribute to understanding some aspects? We hereafter consider this question with respect to our focus, i.e., appropriation concerns.

Appropriation, as we have studied it in this paper, is intrinsically related to social dimensions. Works related to software appropriation acknowledge its collective dimension and, where this applies, its relation to work practice aspects; see (Tchounikine 2016) for a review. In particular, when considering software as a media, part of the appropriation phenomena stands in how ways of doing develop and crystallize within a community. Socially recognized types of actions convey a worldview and lead to conceptualizing and addressing tasks in a certain way. We have also highlighted how social phenomena play a role in learners' perception of the didactical contract. Whatever the efforts to make this contract as explicit as possible through instructions, it will be interpreted / supplemented by learners in a way which is influenced by social phenomena.

Moreover, because our focus is appropriation, we have mainly highlighted long time span collective phenomena (e.g., crystallization of ways of doing). However, the collective phenomena that occur at the time of script enactment are also central. The importance of considering the group as the unit of analysis has been raised since the early stages of CSCL research, and the group cognition / individual cognition relationship is a core and hot topic issue; see (Stahl 2016) for a discussion, from which we extract the citation: "group cognition is not the same as individual cognition (…) one cannot say that all of the cognition is reducible to the individual units, because the work of assembling the high-level argumentative structure typically occurs at the group unit of analysis".

This being said, learners appropriate the script and its technology both as individuals and as a group. As individuals, they consider the script in a way which is influenced by their individual constructions (which they have shaped within processes influenced by collective phenomena). At the same time, in action, they develop collective sense-making processes and collective usages of technology, which constitute their collective enactment and influence in turn their individual constructions.

With respect to appropriation, we thus do not see individual and collective perspectives as incoherent. In particular, software appropriation develops both at individual and collective

levels, and these levels interplay (Tchounikine 2016). One cannot understand appropriation without taking into account social considerations, but at the same time, appropriation also develops at an individual level, and for individual reasons. Therefore, it makes sense to study how appropriation concerns may inform and help to extend individualistic perspectives. With respect to purely cognitive perspectives, consistently with our overall line of thinking, we tend to believe that mixing individual- and group-cognition perspectives is useful. This being said, as already mentioned, we are agnostic with respect to SToG as a cognitive model, and this paper is not primarily meant to contribute to this scientific debate.

Conclusions

Together with Fischer et al. (2013), we believe that the development of a general theory of CSCL scripts, i.e., an understanding of how they impact (structure, guide, constrain) learner activities, should be considered as a core objective of CSCL research. Such a general theory would inform (1) the design of scripts, (2) the implementation of scripts, i.e., what is to be taken care of when using scripts in effective settings such as classrooms or online/blended settings, and as part of the implementation in particular, (3) the orchestration of scripts by teachers, i.e., supporting teachers in understanding what happens at run time and reacting (Tchounikine 2013).

In this paper, we have provided some theoretical elements for considering appropriation as an important aspect of script enactment. Appropriation is not a problem to be solved; it is a phenomenon to be taken into account, which develops as an ontological property of human activity. Appropriation is thus not to be seen only as the issue of learners interpreting scripts differently than expected. Appropriation is to be seen as a cognitive process, which possibly interplays with the other processes involved in script enactment. From an instructional design perspective, considering "the script S" and its "support and constraints" as such makes sense. However, this has intrinsic limits when attempting to explain what happens when a learner l enacts S, because part of the explanation lies in the appropriation process. While empirical studies on the effect of CSCL scripts on engagement or learning may, using a large *n*, ignore appropriation concerns, a theoretical account should not.

Developing a theory of CSCL scripts requires (1) considering scripts as complex systems, the enactment of which involves multi-factor complex phenomena, and (2) adopting a holistic approach: taking a learner-based (and/or group-based) perspective; identifying direct and indirect inputs; understanding aspects that influence appropriation and implementation, and the interplay between them. Following the theoretical background of complex systems, this must be addressed on the basis of multiple points-of-view and models denoting different perspectives (including partially-redundant perspectives) on the considered objects. SToG proposes one perspective, featuring the notion of internal scripts. We have mentioned others such as instrumental, domain, and institutional perspectives. More generally, resources for thinking about the relationships between pedagogical settings and software have been proposed (Tchounikine 2011). The way these perspectives shed light on script enactment needs to be shaped, and the core issue is to understand how they interplay. For instance, domain aspects are related to institutional aspects (as an example, the organization of the mathematics that underlies what mathematics are taught at a given level, and how, differs from one country to another and from one period to another). The interpretative dimension of instrumental geneses is related to the recognition of a class of settings and, thus, to learners' domain

conceptualizations (Vergnaud 1998); it also has a social and institutional aspect. Motivation is also a key element of how learners perceive the offered technology and turn the artefact into an instrument. Enactments of CSCL scripts involve different processes, which interact with one another in a systemic way and cannot be reduced to one single aspect.

The output of a complex system is predictable if the different aspects that play a role and their interactions are known and predictable. This would be the case if CSCL scripts were considered as a set of univocal instructions, and learners as rational actors whose "internal scripts" may be identified. Considering appropriation introduces uncertainty. It is not possible to know in advance how the different learners will appropriate the script and the setting. As a result, it is not possible to know in advance what precise tasks they will consider, and how they will implement them. As a consequence, it is not possible to predict learner activity. Actually, many other aspects introduce uncertainty (e.g., group dynamics), and additionally, learners are not rational actors. This being said, a complex system, although not fully predictable, may be understandable. This is what a theory of CSCL scripts may be about, both a scientific objective and a means to inform design and practices.

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