

From Mastery to Utilisation: Appropriation of Tools for Collaboration in Learning Situations

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Abstract: Vocational students were invited to construct a project plan with the support of a graphical shared workspace. We describe the emergence of the use and effect of this technical artefact by building on Rabardel's (1995) concept of instrumental genesis. From this perspective, a tool or instrument is seen as a mixed functional unit composed of an artefact and a utilisation scheme. We view tool appropriation as a constructive utilisation of the artefact. In case of collaborative tool use this utilisation has to be coordinated. We examine tool appropriation in a collaborative setting as development over three stages. In order to construct their project plan the students had to arrive at a shared representational format. We hypothesized that they would make certain choices during a stage of personal utilisation, and would then coordinate these choices to arrive at a shared convention of use. Our analysis illustrates a transition from mastery to collective utilisation of the tool.

Tool appropriation

When a new tool is introduced in classroom practice, the students in that practice have to appropriate it. The students will try to appropriate by 'adapting' the technical artefact in a goal-directed activity. They will have to make sense of the properties of the artefact, master basic actions, and find a way to put it to the task. In the case of collaborative learning, the students have to coordinate this effort. The dyad or group has to arrive at some kind of shared convention on how to utilize the artefact. Tool appropriation does not simply refer to the acquisition of knowledge about an object, or to 'learning how to' do something with the aid of an artefact. The artefact-in-use is not a stable entity with fixed characteristics that are independent from the classroom practice into which it is introduced. We view tool appropriation as a constructive utilisation of the artefact. The artefact constitutes a 'proposal' to the students (Rabardel, 1995). It becomes an instrument or tool when it is brought into action. Commonly, artefacts are associated with uses and effects that are supposed to correspond with the intentions of its designers. These intentions are based on hypotheses about how the artefact (re)organizes the learning activity. However, there's always a degree of interpretative flexibility (Pinch & Bijker, 1987) in tool use. There are different ways to enact (Weick, 1979) the opportunities that are provided by an artefact, and in order to collaborate this enactment has to be coordinated among the students (Overdijk & Van Diggelen, 2008). This is achieved during a process tool appropriation.

Instrumental genesis

Rabardel (1995) proposes a generative model to account for the effects of an artefact-in-use through what he calls *instrumental genesis* (Rabardel, 1995; Rabardel & Bourmaud, 2003; Kaptelenin & Nardi, 2006; Bernard, 2006). In this view, a tool or instrument can be considered as a functional organ composed of elements from both the artefact and the subject. It is a mixed functional unit made up of an *artefact* component (an artefact, a fraction of an artefact or a group of artefacts) and a *scheme* component (in the Piagetian sense of the term: Piaget, 1964), comprising one or more associated utilisation schemes that organize the activity. An instrument emerges from a 'double development movement', relating to the two components: subjects adapt and give form to the proposed artefact through instrumentalization; and through instrumentation subjects develop and adapt utilisation schemes (Rabardel and Bourmaud, 2003; Rabardel, 1995).

Utilisation schemes

Rabardel (1995) discusses three classes of utilisation schemes. These three classes represent a relative hierarchy. The usage scheme holds the artefact itself as object of activity. This class of schemes comprises elementary utilisation schemes for handling controls or manipulating the interface of the artefact. Usage schemes constitute specialized modules which, in coordination with other schemes, assimilate and mutually adapt to constitute instrument-mediated action schemes. Instrument-mediated action schemes are oriented

towards the object of activity for which the artefact is a means of performance; that is, towards the goal or motive of the 'main' activity. This type of scheme constitutes an instrumental act. Instrument-mediated collective activity schemes specify the types of action or activity when a group of users shares an instrument to fulfill a common motive. They also concern the coordination of individual actions and integration of their results as a contribution to common goals (Rabardel, 1995). The mechanism that underlies the interrelated development of artefact and action scheme is (mutual) adaptation: between subjects and artefact, and between subjects.

An approach to analysing appropriation of tools for collaboration

We hold the following assumptions about tool-mediated collaboration. Firstly, an artefact may provide multiple opportunities for action to a single student. This student has to make choices, and hereby enacts a certain potential of the artefact. Secondly, the same artefact may provide different opportunities for action to different students. This means that in case of collaboration students have to negotiate their actions in order to arrive at a shared convention of use. Thirdly, there is mutual influence between student(s) and artefact. The opportunities for action that an artefact provides are not fixed, new opportunities may arise as a consequence of the actions of the student(s).

We describe the emergence of the use and effect of the artefact by building on Rabardel's concept of instrumental genesis. We address tool appropriation in a collaborative setting as a progressive development over three stages. We examine to what extent the interaction progresses from personal mastery, via personal utilisation, towards collective utilisation of the artefact (Figure 1).

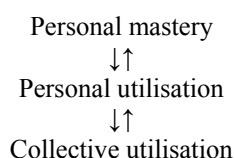


Figure 1. Three stages in appropriation of tools for collaboration.

(1) Personal mastery

When students are presented with a new artefact they first have to explore its features and learn how to operate its handles and controls. During the stage of personal mastery students learn how to perform basic actions with the artefact. We describe this activity as follows: subject one (S1) directs action oriented towards the artefact (A) by manipulating it. The artefact is the object (O) of the activity, learning how to operate its handles and controls is the motive. Subject two (S2) performs a similar activity. The stage of personal mastery is schematically represented like this:

S1 – O/A S2 – O/A

During this first stage, conscious, goal-directed actions oriented towards performing basic actions with the artefact become routinized and are then transformed into non-conscious operations (Leont'ev, 1981).

(2) Personal utilisation

When the students have mastered sufficient basic actions, their attention shifts towards the object for which the artefact is a means of performance, in our case, the instructed task. The students develop a personal utilisation scheme that couples operation of the artefact to a specific function. This utilisation scheme subsumes the mastery scheme. The artefact becomes a tool. We can describe this activity as follows: subject one (S1) directs action oriented towards the object (O), mediated by the tool (T). Subject two (S2) performs a similar activity. The stage of personal utilisation is schematically depicted like this:

S1 – T – O S2 – T – O

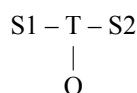
A prerequisite for the transition from personal mastery to personal utilisation is that basic actions become non-conscious operations. Instead of progressing from mastery to utilisation, the students may also regress. This happens when they lack directions of use, when a certain action has an unexpected effect, or when the students encounter ambiguity. During such a 'breakdown' non-conscious operations become conscious, goal-directed actions again.

(3) Collective utilisation

During the previous stages the students have learned how to utilize the artefact to perform the task. This does not necessarily mean that they are able use the artefact collaboratively. Note that up to now S1 and S2

have progressed through the stages in parallel, meaning that these stages are seen as personal. This conceptualization has some consequences. First, it implies that two students are not necessarily in the same stage; e.g. one student may have progressed to the stage of personal utilisation, while the other is still in the stage of personal mastery. Second, the outcome of the stages may differ between two students. During the stage of mastery, for example, students may develop different operational routines to achieve a similar effect, or one student may have simply explored the artefact more thoroughly than the other. During the stage of utilisation, two students may develop different ways to utilize the tool. Their utilisation may be complementary, competing, or even unrelated.

In order to collaborate via the artefact, the students have to arrive at a shared convention of use. They have to develop a collective utilisation scheme through which they coordinate their interaction with the artefact towards the common object. We can describe this activity as follows: subject one (S1) and subject two (S2) direct action oriented towards the object (O), mediated by the same tool (T). The stage of collective utilisation is schematically depicted like this:



In contrast, instead of progressing from personal to collective utilisation, the students may also regress. Regression occurs when they enter a state of conflict or disagreement about a convention.

The planning problem

To evaluate our model we focused on a specific task and supportive artefact, within a specific classroom practice. Our study was carried out within preparatory secondary vocational education. The class that was involved consisted of 12 third grade students aged 14-15. Within the school a pilot programme was initiated that induced a transition from a more traditional form of teaching and learning to a form in which the students had to perform project work, collaborate in dyads, and work relatively independent from the teacher. Moreover, these 'new' lessons contained far less structure than the former, traditional way of working. In the pilot programme the students had to structure their learning activities themselves. They had almost no experience doing this, and in order to cope with it they had to develop collaboration and planning skills.

Over the duration of the school year the dyads had to complete several projects. Each project had a runtime of two weeks, and every two weeks the students started a new project. Each project addressed a different theme, covering three knowledge domains (communication, technology and society). With each project the students were presented with a syllabus that contained a series of assignments, organised by domain. The dyads were expected to construct a plan that described in detail the actions that had to be undertaken for each day of the two weeks.

Planning comprises a sequence of steps from problem representation and plan construction, to plan execution (Pea, 1982). In order to represent the problem the dyads had to identify task requirements, sub-tasks, and constraints on the planning. Subsequently, they had to 'translate' their problem representation into an actual project plan. To get from problem representation to an actual plan, the dyads had to go through cycles of proposal, simulation, evaluation and revision (Pea, 1982). The 'translation' from problem representation to planning is a complex activity that required the dyads, among other things, to project the consequences of particular planning decisions. For example, they had to make estimations of the time that would be needed to complete a particular part of the plan, and they had to take into account interdependencies between parts of the plan.

The graphical shared workspace

The dyads were presented with a specific technical artefact to support the construction of their project planning: a graphical shared workspace (Figure 2). This shared workspace was deployed in the face-to-face classroom setting. It provides a drawing space and a configurable notation system that supports specific kinds of communicative acts. A student can select a contribution card from the notation system, and add it to the drawing space. The student can subsequently add a textual message to the title space of the card. By double-clicking on a card a comment window appears, where the student can elaborate his contribution. He can also move the cards through the drawing space. Once a contribution is placed in the drawing space, it can be related to other contributions through the use of links. Multiple students can work in the shared workspace simultaneously.

Method

We conducted three case studies, with a lapse of one month between each of them. In each case study five dyads participated. At the start of the first case, none of the students had ever worked with a graphical shared workspace, or with any technical artefact that was remotely similar. With the first case study the notation

in the workspace contained one card type, labeled ‘task’, and the possibility to link the cards. In order to construct their project plan the dyads had to arrive at a shared representational format. We hypothesised that the students would make certain choices during the stage of personal utilisation, and would then have to coordinate these choices in order to collaborate.

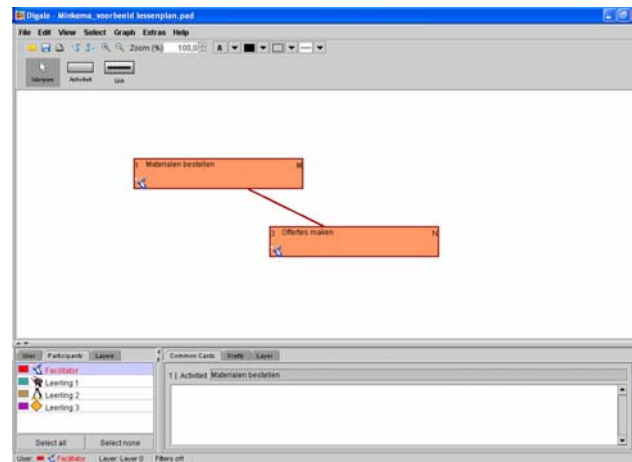


Figure 2. The graphical shared workspace.

Talk and action

The students’ communication was distributed: they talked, and acted in the shared workspace. Talk was often accompanied by actions in the workspace – and the other way around. Expression took place simultaneously in both modalities, or alternately, sometimes with a ‘seamless’ transition from one mode to the other. Moreover, as we will see, talk about the project plan and talk about the utilisation of the shared workspace was often entangled.

We had three data sources at our disposal: audio recordings of spoken interactions, the planning from the shared workspace, and the replay of the actions in the workspace. This data set allowed us to link talk and action. Recordings of talk were transcribed into a protocol that included all utterances, the speaker, and the time of the utterance. We used a coding scheme to categorise the utterances, and we marked them with colour. We segmented and coded the protocol on the sentence-level, using three parallel columns. In the first column we coded task- and non-task focused talk, in the second column we coded talk about mastery and utilisation of the shared workspace. Finally, in the third column we referred to the ‘actual’ actions in the workspace.

In order to code the first column we used a scheme that was adapted from the Rainbow framework (see: Baker, Andriessen, Lund, van Amelsvoort & Quignard, 2007). Our coding scheme distinguishes seven functional categories: three for non task-focused interaction: outside activity, social relation and interaction management, and four categories for task-focused interaction: task management, problem representation, plan projection, and plan construction (Table 1).

Table 1: The Rainbow framework adapted to the planning problem.

<i>Functional category</i>	<i>Brief definition</i>
OA = Outside activity	Talk that is not concerned with carrying out the researcher-defined task.
SR = Social relation	Talk that is concerned with managing the students’ social relations with respect to the task.
IM = Interaction management	Talk that is concerned with managing the interaction itself.
TM = Task management	Talk that is concerned with management of progression of the task; includes time management and status determination.
PR = Problem representation	Talk that is concerned with representing the problem; includes identifying goals and sub goals, feasibility and constraints.
PP = Plan projection	Talk that is concerned with simulation of parts of the planning.
PC = Plan construction	Talk that is concerned with formulating the plan; includes proposal, evaluation and revision.

In the second column of the protocol we coded all utterances that were manifestly related to mastery or utilisation of the shared workspace. These categories captured talk about actions in the workspace. We

developed two categories for this. ‘Mastery’ captures talk that was concerned with exploration of properties and basic actions, e.g. ‘hey, I can add a link between two contributions!’ or ‘how did you do that?’. ‘Utilisation’ captures talk that was concerned with performance of task-focused actions in the workspace, that is, actions oriented towards plan construction, e.g. ‘so we have to open a box and type in what we need to do?’ or ‘we need a different color for each type of assignment. Do we have three colours?’ (Table 2).

Table 2: Coding of talk about actions in the shared workspace.

<i>Functional category</i>	<i>Brief definition</i>
MA = Mastery	Talk that is concerned with mastery of the shared workspace; includes talk about the exploration of properties and basic actions in the workspace.
UT = Utilisation	Talk that is concerned with utilisation of the shared workspace; includes talk about task-focused actions and about the coordination of these actions.

Finally, in the third column of the protocol we indicated the actual actions in the shared workspace by referring to the corresponding frame numbers from the replay. This allowed us to inspect, at different stages of the planning activity, the actions that took place in the workspace.

Episodes

Transitions between the stages of tool appropriation may not always be manifest. However, they are implied during certain critical events, for example, when students lack directions of use, when a certain need arises, or when some use has an unexpected effect. We selected those episodes from the protocol that reflect such a critical event. An episode corresponds to a duration of coherent activity demarcated by the students’ behavior (Roschelle, 1992). Interaction that is concerned with exploration of properties and basic actions in the workspace indicates mastery of the artefact. Interaction that is concerned with performance of task-focused actions in the workspace and/or with coordination or regulation of these actions indicates utilisation. The selected episodes were subjected to a more detailed analysis. Hereby we made a link between talk and actions.

In the remainder of this paper we present three episodes from our first case study. With each episode we present an excerpt from the protocol, and describe the corresponding actions that were performed in the shared workspace. We conclude the paper by making some inferences about our model of tool appropriation.

From personal mastery to collective utilisation

The excerpts below contain parts of a dialogue between Twan (A) and Nando (B). At one point it includes the researcher (R). Twan and Nando had no experience with the graphical shared workspace. Before the start of the session the students had oriented themselves on the assignments in the syllabus, and they were ready to construct their plan.

‘You took that from here, right?’

This episode starts when both students had submitted a contribution card to the shared drawing space [Frame 45]. Lines 20-24 in the protocol illustrate how the students explore the properties and basic actions in the workspace. The excerpt shows how they explore the possibility to move a card through that space. They encourage each other to clarify their actions, and they make inferences from these actions, e.g. in line 20-21 [B: where did you get that from? You took that from here, right? You can move it].

20		B	Where did you get that from?		MA	
21	13.09	B	You took that from here, right?		MA	
22		B	You can move it.		MA	Frame 45
23	13.17	A	Yes, and can I now...		MA	
24	13.21	B	You can put it back, yes.		MA	

During the sequence in line 20-24 the object of activity is the shared workspace itself, and the motive is learning how to operate it. The episode illustrates the stage of mastery (MA). In the episode hereafter the object of activity shifts from learning how to operate the workspace towards carrying out the task.

‘Like this I’ll put it’

After a brief period of silence during which both students explored basic actions, such as typing text in a card and moving a card, they started to discuss utilisation of these basic actions. This stage of utilisation (UT) is illustrated in lines 25-32. With the statement in line 25 [A: Like this I’ll put it] Twan proposes a specific usage of the contribution cards. Frame 56 reveals that Twan submitted a card, resized it, and typed ‘technology’

– one of the knowledge domains - in the title space of the card. In line 26 Nando encouraged Twan to elaborate on his action [B: You put it like that?]. When Twan doesn't respond directly to Nando's request for elaboration, Nando proposed a way of utilising the workspace, incorporating an interpretation of Twan's statement and tool-action. He encourages the researcher to evaluate his proposal [line 28; B: So you have to like open an activity and then you put in there what is finished or has yet to be finished..., something like that?]. The researcher avoided to impose his own conceptions about the workspace, and responded minimally [line 28].

25	13.40	A	Like this I'll put it.	PC	UT	Frame 56
26	13.41	B	You put it like that?	PC	UT	
27	14.00	B	So you have to like open an activity and then you put in there what is finished or has yet to be finished..., something like that?	PC	UT	
28	14.09	R	Yes, something like that.			

The students are talking about how they can construct their planning and use the shared workspace to do this. In this episode, both students have made a proposal for utilisation. However, their proposals are on a personal level. Note that their talk simultaneously addresses the representational format of the planning (coded as plan construction) and ways to utilize the features of the workspace in order to represent the planning (coded as utilisation).

'And then he says...'

The interaction in lines 29-32 illustrates a transition from personal utilisation to collective utilisation. In line 29-30 Nando elaborates his proposal by suggesting that for every topic both students can type in what has to be done, and what has been finished [B: Then you put for every topic what you need to do, you put this and this and this needs to be done, and then he says that needs to be done? And then he says: this is done and..]. Twan takes up this proposal and elaborates it further by proposing that the amount of time needed to complete an assignment could be put in there as well [line 31; A: And the number of hours has to go in there as well?]. However, this proposal is rejected by Nando [line 32; B: No, that's not necessary], and Twan, for now, complies with this rejection.

29	14.18	B	Then you put for every topic what you need to do, you put this and this and this needs to be done, and then he says that needs to be done?	PC	UT	
30	14.22	B	And then he says: this is done and..	PC	UT	
31	14.27	A	..and the number of hours has to go in there as well?	PC	UT	
32	14.29	B	No, that's not necessary.	PC	UT	

Later during the activity [line 83-87] Twan again mentions the possibility to represent time. And again it is rejected by Nando [line 86-87; B: That has no use at all, how does that help you? How is it helpful putting time behind it?]. Twan feels that they should represent a time dimension in the cards, whereas Nando thinks this is not necessary. The students end up not displaying time in their plan.

In line 36 Nando contributes to a further development of collective utilisation when he proposes to represent the chapters from the project syllabus by means of different colors [B: I think the best thing to do, eyh Twan, is to give those chapters a color]. Twan accepts the proposal, and elaborates by stating that they would need three different colors to represent the three chapters. In line 42, he continues to propose the use of specific color by each of them, based on a division of work (we have to assume that this division of work was negotiated prior to the session, because it was not discussed during the session). Subsequently, Nando starts working on communication, while Twan focuses on the technology assignments.

36	15.08	B	I think the best thing to do, eyh Twan, is to give those chapters a color.	PC	UT	
37	15.13	A	Yes.	PC	UT	
38	15.48	A	Which color, we only have three colors, eyh?	PC	UT	
39	15.51	B	Huh, what?			
40	15.52	A	We need three different colors.	PC	UT	
41	15.54	B	Oh, yes, yes..	PC	UT	

42	15.57	A	I' ll do blue, ok, you green and orange or something, green and red.	PC	UT	
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At this point the students end up with three cards, representing the three different knowledge domains: communication, technology and society. For each knowledge domain they list their tasks in the comment window of the card. Behind each task in the list they indicate whether it is completed or not (Figure 3).

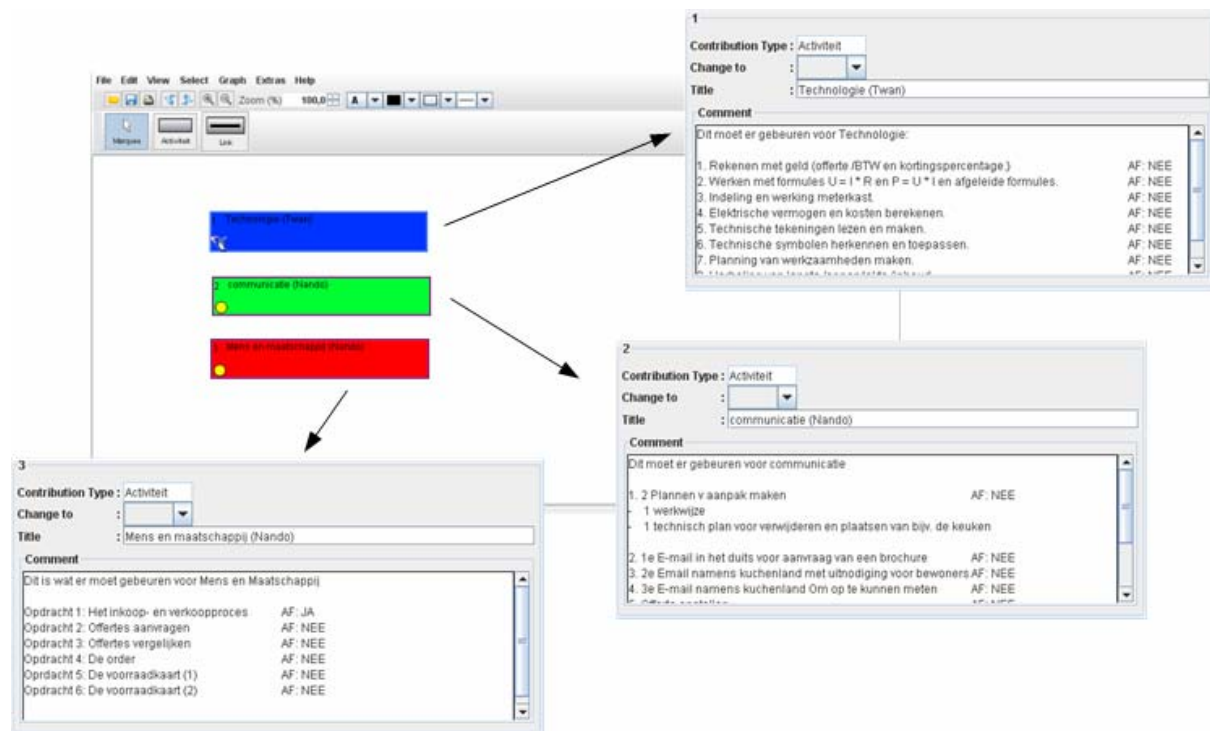


Figure 3. Actions in the shared workspace: use of the comment window.

'You should do it as well'

Early on in the process it was brought to the fore that the workspace could also be used to keep track of progress during execution of the plan [line 27-30]. Later on Nando encountered an unexpected effect: he found out that he had no writing access into a card that was submitted by his fellow student. He realised that, as a consequence, he could not mark an assignment as 'completed' in a card that he had not submitted himself. To overcome this problem, he proposed to add a second card for each domain. Also, he proposed to add a distinct name to each card, in order to distinguish two cards with the same title. Not until line 184 Twan notices that Nando has added an extra card [A: Hey, but you've build one extra for technology?]. Nando then clarifies [B: I can type in there, you should do it as well. What I've done, so to say, know what I mean?]. Somewhat later he explains 'Because I've put in there that I haven't finished any of the assignments, once I've completed some, I can put it in, and you can see it'.

184	37.50	A	Hey, but you've build one extra for technology?	PC	UT	
185			I can type in there, you should do it as well.	PC	UT	
186	37.53	B	What I've done, so to say, know what I mean?	PC	UT	
187	38.01	A	Yes.	PC	UT	

This final episode indicates that students at times regressed from utilisation to mastery. It also illustrates how the students came up with creative solutions to overcome constraints that were imposed by certain features of the graphical shared workspace.

Conclusion

So what did we learn about the appropriation of tools for collaboration? Our analysis illustrates a progressive movement from personal mastery to collective utilisation of the artefact. We started by providing an example of a transition from personal mastery to personal utilisation. The object of activity hereby shifted from learning the basic actions towards utilisation of the artefact in order to construct a project plan. Thereafter, we provided an example of a transition from personal utilisation to collective utilisation. In order to use the artefact collaboratively, the students influenced each other, and (mutually) adapted their behaviour. The transition from personal to collective utilisation was achieved through a process of negotiation. The students negotiated by proposing and evaluating actions, and by making inferences about the use and effect of the artefact. We ended our analysis by presenting an episode that showed a regression from personal utilisation to mastery.

The analysis has revealed some manifest transitions in the progressive movement from personal mastery to collective utilisation. However, we did not always unambiguously recognize distinct stages. Specifically, the separation of personal utilisation from collective utilisation may not be as straightforward as we conceptualized it. The students' orientation towards the artefact is rooted in personal experiences with similar tasks and artefacts, but develops in a social context. The students did make certain choices in their utilisation, but where these personal or collective? Overall, the progressive movement appears to be less linear than we envisioned it.

As we hypothesised, the students made certain choices during utilisation of the graphical shared workspace. Some of these choices had important consequences, and resulted in the realization a specific potential of this artefact. For example, one of the reasons to present the workspace for the planning task was based on the expectation that the students would use the spatial qualities of the drawing space to represent an implementation order in their plan. It turned out that none of the groups in our first case met this expectation. In fact, the students' choice to list all tasks in the comment window of the cards prevented this type of spatial organisation to occur. As a consequence, the structure of the project syllabus was maintained and transformed into the shared workspace. Choices such as these influence the mediating effect of the artefact: actions become reified in the drawing area, and are then recursively implicated. This mediating effect, in other words, depends partly on the process of appropriation.

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