Interaction-Level Support for Collaborative Learning: *AlgoBlock* — An Open Programming Language

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Abstract

In this paper, the role of computer-based educational tools is discussed from the standpoint of situated learning theory (e.g., Brown et al. 1988, Lave et al. 1991), which considers learning to be a process of enculturation in a community of practice (Lave et al. 1991). The authors propose, as one possibility, the role of computer-based educational tools as supporters of a "community of learners". "Community of learners" is a community maintained by "learners" who are trying to establish their identities in a certain community of practice. It works as an interface to full participation in the community of practice. Both facilitating interactions among learners and making links between activities within the community of learners and practices in the real world are crucial for supporting the community of learners. As the first step to this goal, the authors focus on interaction-level support of the community of learners, and mention AlgoBlock, a tangible programming language developed by the authors, as an example of computer-based educational tools for facilitating interactions among learners.

Keywords — Community of learners, Software Education, Open Tool, Situated Learning.

1. Situated Cognition and Education

The main claim of situated cognition is; "one's actions are interactively achieved through a relationship with the external world". The word "interactively", mentioned here, implies that one is not simply influenced by the external world. It is an interdependent relationship: the external world would appear as one attempt to participate in the world, and then the action would be formed by that world. The relation between one's action and the external world is inevitably mediated by "artifacts": tools, symbols, words, etc.. In other words, one's action is achieved as a result of interaction with the external world by utilizing some kinds of artifacts as a medium (Cole et al. 1980). It is important that the artifacts carry a history of some culture of practice, and they can be understood only when observed through that culture of practice which is creating and maintaining them. The artifacts are continuously reproduced in activities of the communities through works, and one consequently can "acknowledge" the meaning of artifacts through participation in the activities.

Given that one's action is considered to be achieved through utilizing artifacts as media, learning cannot be separable from artifacts. Furthermore, if artifacts cannot be dissociated from the practice of a community, learning should be considered to be a process of participating in a culture of practice (Brown et al. 1988). Thus learning is considered to be a process of enculturation. Based upon this idea, Lave et al. (1991) proposed a concept of legitimate peripheral participation, i.e., LPP. LPP is a learning principle in which one's learning is described as process of development of participation in a community that proceed gradually from peripheral to full.

2. Community of Learners as an Interface to Full Participation

In this section, the authors discuss how new community members become full participants of the community, based on the ethnographic investigation on learning of new staff nurses (Suzuki et al. 1994b). The new staff members assigned to the ward are first assigned to peripheral work such as resupplying articles on the nurse's cart and assisting with treatments provided by senior staff nurses. Through this process, they gradually learn medical terms and learn how to use nursing tools and they expand accessibility to their working environment, thus eventually they participate in the

nursing community fully. This process is really LPP-like. Moreover, the authors would like to point out that establishing one's identity in nursing community is not easy experience. In this research, the authors observed a scene in which one of new staff members who failed to properly prepare a test was ridiculed and made fun of by senior nurses. Sometimes, involvement in the nursing community is very stressful to the new staff members. Furthermore, the authors found following report in an informal "circulating diary" which new staff members were circulating; "the senior nurses look like geniuses. I have no confidence that I can be like that in the future". Even if the new staff members were accepted warmly by the senior members, their participation would be still difficult because the nursing community is an unimaginable distant world for the new staff members and they are unable to see how to establish their own identities in it.

In such circumstances, the new staff members form their own community: community of new staff members, and help each other. Thus they overcome difficulties which occur in their practices. The new staff members are monitoring each other, paying attention to who has already experienced what, or who is going to experience what. Consequently, they ask other new staff members who have previously experienced some new procedures for help with these procedures. Those who have learned a new thing eagerly give the information to the other new staff members. They try to share their knowledge mutually with the others through making and circulating memos in which they record procedure of treatments and important numbers, e.g., time of a treatment, quantity of dose. They are also circulating an informal diary in which they write about their daily experience, including both vocational and private concerns, and they respond to the others' descriptions. This diary is one way to make their experiences shared.

Community of new nurses, which is a sub-community within the nursing community, is a "community of learners" through which its members are becoming regular staff members in the nursing community. When facing senior nurses, the new nurses feel overwhelmingly "incompetent". In such a circumstance, it is not easy for new nurses to establish their own identities and sense of competence. On the other hand, in their own community of new staff nurses, the new nurses can position each other as "a little more senior" and "a little more junior" in relation to each other. Therefore, it is easier for them to establish their identities in the relation. It is supposed that the new staff members establish their own positions within their junior community first, then they gradually establish their own position within the nursing community through using the community of learners as an interface to enter into the practicing community of nursing. Of course, it should not be forgotten that the new staff members' community can function as an interface toward the full participation in the nursing community only when the members of the community keep and share an intention to be nurses in their future.

The result of this investigation seems to suggest the possibility that, "places prepared for learning", e.g. schools, can be designed and used as an interface to see actual practice in the real society and to prepare people for entering into the community. The knowledge learned through the educational activities within the school, which is a socially closed community, can be used only within the school community. However, the school can be re-designed to be a place that becomes and is maintained as a community of learners aimed at practice in the real society.

3. CSCL Environment as an Interface Toward Practices

3.1. An educational tool which supports community of learners

If learning is the process of establishing a certain position in a community of practice, computer based educational tools have to be designed so that they support the learners' participation in a culture of practice. There might be many ways to do this, not just one. However, when focusing on a function of the learners' community as an interface toward the practicing culture, one direction for designing of the computer based educational tools can be drawn. It is educational tool for supporting a community of learners. The role of the tool should be to accelerate interaction among the members for forming, maintaining and reproducing the community of learners, and to support the linkage to the actual practicing world from the community of learners.

Two levels of design will be necessary for educational tools to support the community of learners. One is the interaction level design and the other is the social level design. The former is to design educational tools for accelerating the interaction among learners. For the community of learners would be generated, maintained, reproduced and transformed via the interaction among learners. The latter is to design the social settings which set up how the community of learners should be formed, and then link the activities of learners within the community to the outside world.

3.2. A designing for interaction-level support

In this discussion, the authors focus on the interaction level design, i.e., facilitation of the interaction among learners through the design of educational tools, and consider the necessary requirements for that purpose. One important design principle is to let the interaction among learners be controlled by natural rules. If unnatural rules, far from everyday life, are forced for interaction control, active interaction is not possible; thus, activities of the community of learners will be

stagnated. In everyday life, one achieves interactions among members through utilizing eye lines and body movement and its positioning as resources of interaction control. Therefore, it is noteworthy that the interaction in the learning environment is facilitated through allowing learners to utilize these resources.

The eye lines display persons' intention socially. Goodwin (1981) showed, through a study of conversation, that human beings dynamically achieve interaction by monitoring the other person's eye lines mutually. In addition to eye lines, setting one's body toward a certain thing is also a social display of one's intention. Kendon(1990) presented the idea that there is space called transactional space around one's body. According to his idea, trying to fix one's body toward a certain object is equal to trying to set one's own transactional space upon the object. When people's transactional spaces are overlapped shared collaborative space is generated. Furthermore, Kendon introduced concept of "F-formation", which is a physical configuration of bodies that produce overlapping of transactional space. In such a way, eye lines and body movement and its positioning are important resources for social interaction

The other principle is to design the tool as an "open tool" (Hutchins 1990) which openly displays the process of collaborative work to the members. It allows members of collaborative work to monitor each other regarding what the other members are thinking and the present condition of the work. Thus, the conversation and discussion among members in the community are induced and overall performance in the community of learners as a functional system is heightened.

Here is an example of an open tool. In the previously mentioned investigation on learning of nurses, the authors found that nurses are utilizing a tool called "order bar" (Shiji-bou, in Japanese). It is a plastic marker which can be slipped between pages of the clinical records. It is placed there when the physician gives some order to the nurse. The length is arranged so it can be seen from outside even when the records are closed. By simply looking at the clinical records, the staff nurses can know if there are any orders by physicians or not. Upon completing the treatment ordered, the staff nurse who provided the treatment can take the bar out of the clinical records. The order bar functions as an open tool showing whether or not any orders are given by physicians to the whole staff and enabling the whole staff to monitor the status of task execution. The order bar functions as an open tool, but it is not only because of the physical reason that its length comes out of the clinical records. In the observation, the authors saw a scene in which one new staff nurse was blamed by a senior nurse for taking away a clinical record which had the order bar in it from a certain desk. The openness of the order bar is maintained by an unwritten arrangement shared among the staff nurses: clinical records with order bars have to be placed on the desk so that the whole staff can monitor the order bars. It is very important to notice that designing a tool as an open tool should essentially include not only designing the tool itself but also designing social settings in which the tool will be used.

4. AlgoBlock: A Tool for Collaborative Learning

4.1. The concept of AlgoBlock

Here, the authors introduce an educational tool: AlgoBlock (Suzuki et al. 1994a), which facilitates the interaction among learners. AlgoBlock (Fig. 1) is a program language which has an actual physical existence. Each tangible block is assigned a command of logo-like program language, and the program can be made by connecting those blocks to each other.

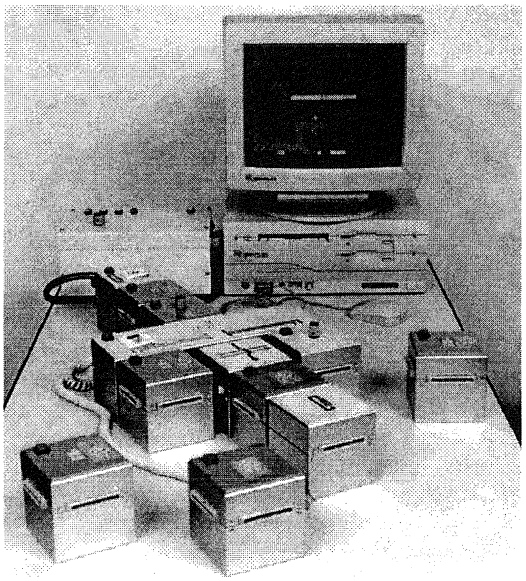

Figure 1. AlgoBlock: It is an open programming language.

The result of running the program is indicated on a CRT screen in the form of an animated submarine (Fig. 2). The age of expected use will be from higher year elementary school students to junior high school students. This tool was designed to allow learners to improve skills of problem solving through collaborative programming work.

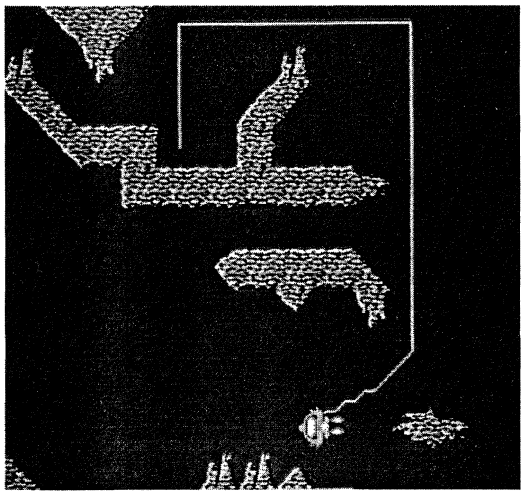

Figure 2. Screen design of AlgoBlock.

One can not suppose the existence of general skills of problem solving. Actually, human beings carry out a variety of problem solving activities in a variety of situations. The skills are strictly context dependent. One possible way of "problem solving education" would be to show students how real practitioners in a variety of fields are solving their real problems, and to give them opportunities to go through some parts of their practice. There are many practices worth seeing in terms of problem solving skills. The authors are focusing on the practice of programming because it is one of practices in which problem solving skills are considered to be very important. Thus, the authors are trying to make an educational environment in which the community of "programming learners" is created and learners can know how programmers solve problems, and they can simulate the practice of programmers. AlgoBlock was designed as a tool to give interaction-level support for the community of programming learners. In the following discussion, the authors will focus on how AlgoBlock facilitates interactions among learners.

As opposed to conventional programming which is done using a personal input device such as keyboard and mouse, making the process of programming difficult to share, AlgoBlock allows the process of programming to be open. By working on this tangible tool which can be shared in collaborative space, manipulations to the program are converted into external activities that can be observed as body movements and changes of body settings, and results of the manipulations are also easily grasped as change of configuration of the physical blocks (Fig. 3).

Therefore, children can monitor each other as to what kind of work the other group members are doing, what they are thinking and how the work is going. Moreover, doing the work against the physical blocks makes it easy to control the interaction by utilizing gaze, body movement and positioning as resources of communication. These features of AlgoBlock are expected to activate interaction among learners

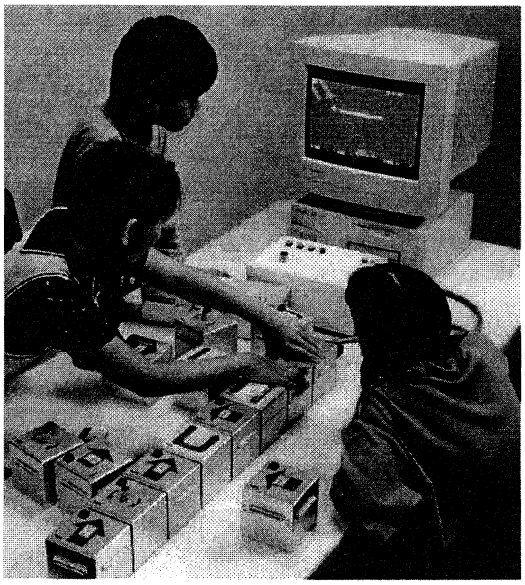

Figure 3. Collaborative work with AlgoBlock.

4.2. Evaluation experiment

The authors have carried out an evaluation experiment in which a group of three 12-year-old children engaged in group programming works using AlgoBlock. The purpose of this experiment was to see how AlgoBlock affects the interaction among learners. The children had no preceding experience in programming or manipulating computer based tools with the exception of video games. In the experiment, three tasks in which the children were required to move the submarine towards the goal were given after a 3-minutes introductory phase. In the introductory phase, they were instructed to observe the operations made by instructors for a while. Two instructors attended the session for the purpose of switching tasks and assisting children in case of system trouble. The instructors were encouraged to minimize interventions in children's works. Conversations and non-verbal actions during the experiment were videotaped.

Following is the setting of the experiment room: The command blocks and the controller, a personal computer, and a large size CRT monitor are placed on one table, and children are situated in a semicircle surrounding the command blocks on the table. Each child is given a chair, but is free to sit or not. There are five commands used: GO-FORWARD, GO-RIGHT, GO-LEFT, ROTATE, and LEG-FOLD. LEG-FOLD is a command to make the submarine fold its legs for

landing. When the legs are folded, the submarine can jet to the right or left and then proceed direction of left or right. The controller is a device which connects the command blocks and the personal computer. When children push the start switch on the controller connection-information of blocks is sent to the personal computer to run the program.

Throughout the session, it was observed that the children interacted with each other vigorously, and they could operate AlgoBlock without difficulty after the 3 minutes of introduction phase, although it was the first experience for all children manipulating programming language.

4.2.1. A Fragment of conversation from the experiment

Following is a fragment of conversations and actions during the experimental session. The conversation is originally in Japanese. In this fragment, the following notations are used: " "=conversation, I=interrupted, {}=body movement, ()=notes by the authors, []=explanation number, /=indication of simultaneous utterance or action with previous one.

Record of conversation and action (1)

Child 2	[101]:	"(the submarine) folded its legs so that it kept going sideways"
	[102]:	{points out LEG-FOLD block}
Child 1	[103]:	"See, isn't this opposite?"
	[104]:	/{leans body towards the blocks, then points out LEG-FOLD and ROTATE block}
Child 2	[105]:	"I got it."
Child 1	[106]:	"First, we should fold the legs, and then 90 degreesI
Child 2	[107]:	"No, we should make it (program) this way."
	[108]:	/{tries to set the parameter of the GO-FORWARD block}
	[109]:	/{Its elbow prevents child 1 from attempting to reach the block}
Child 1	[110]:	"No, first we should fold the legs and then rotate 90 degrees, shouldn't we?"
	[111]:	{leans body, making voice rough.}
	[112]:	/{points out the ROTATE block}
Child 3	[113]:	"I think so."
Child 1	[114]:	"But this doesn't turn 90 degrees, so the legs don't come out."
	[115]:	{tries to switch the LEG-FOLD and ROTATE}
Child 2	[116]:	"No, this should be .(not clear)."
Child 1	[117]:	"I guarantee."
	[118]:	/{switches the LEG-FOLD and ROTATE}
	[119]:	{sits down.}(after Child 2 and 3 completed the program)
Child 2	[120]:	"This (block) is attached here. That's why it didn't work."{still standing}
Child 3	[121]:	"there, there, let's try it."
	[122]:	{press the execution switch}
Child 2	[123]:	{sits down.}

(The program was run. The submarine didn't reach the goal and the run ended)

Child 1	[124]:	{stands up}
	[125]:	"This"
	[126]:	/{points out a block}
Child 2	[127]:	"Shouldn't this be 45 degree opposite direction?"
	[128]:	/{points out the block.}
Child 1	[129]:	"Oh, I understand".
Child 2	[130]:	{stands up}
Child 1	[131]:	{changes the parameter of the ROTATE block to 45 degrees to leftward.}
Child 2	[132]:	{sits down.}
Child 1	[133]:	{sits down.}
Child 3	[134]:	{presses the execution switch}

4.2.2. The control of collaboration by body movement and positioning

Working around the physical blocks induces children to turn their bodies toward the blocks and point them out. Through these movements, as previously stated, the direction of their attention is displayed to the other participants as apparent physical actions, thus each calls the others' attention. In [104], child 1 pointed out the LEG-FOLD block and ROTATE block. This pointing-out showed the direction of her attention to the other group members, and induced the other participants' attention to the same thing. By this pointing-out, the direction of each participant's eye lines were focused upon the same point, then the discussion over these blocks was begun. Also, in [104], child 1 leaned her body toward the blocks. Just as with the pointing-out, this action of leaning her body also can be considered as showing the direction of the attention of child 1 and to draw the other's attention there. Setting-body has the same function as pointing-out, however, being different from the action of pointing out a certain block, the range of the intention becomes slight wider. Boldly stated, the transactional space (Kendon 1990) would be set by setting-body, furthermore, the focus of the discussion would be set by pointing-out.

Also, through this record, it can be seen that the start and close of the discussion are achieved by their bodies movement. While running the program, child 1 and child 2 were watching the screen sitting down [119], [123]. However, when the run ended, they stood up [124], [130]. When standing up, the children's bodies were set toward the blocks. This made individual transactional spaces overlap on the blocks to form the F-formation (Kendon 1990). In other words, standing

up and placing their bodies in position surrounding the command blocks makes them enter the space for group work. Conversely, when children sit down, their bodies are off the block, therefore this changing in the configuration dissolves the F-formation. Sitting while the program is running shows that their attention toward the blocks are released at that point, and they are in another phase of collaboration, such as looking at the screen together.

In [117]-[119], after presenting her own idea, child 1 was getting out from the shared transactional space by sitting down[119]. Against this, child 2 said, still standing up, "This is attached here. That's why it didn't work" [120]. It could be interpreted that, here, child 2 is trying to keep the shared work space by continuing her body set toward the block, then trying to continue the discussion. Child 2 sat down after child 3 had said, "there, there, let's try it" [121], and then had pressed the start switch [122]. After pressing the start switch, the program can not be changed. With this, the discussion is forced to end, then child 2 finally removed her body-set from the blocks.

In [131]-[134], you can see the completion of discussion generated by all children smoothly. After child 1 finished operating the blocks [131], child 2 first sat down [132]. As previously stated, sitting down could be interpreted as getting out of the space of group work, so it could be considered, through this action, that child 2 has no intention to make objections against the decision of child 1. After that, child 1 sat, too. It seems that she saw child 2 sitting down and realized that no new argument would occur. The two of them sitting at the same time indicates their intention: to not manipulate the blocks anymore, to child 3. Therefore, child 3 could press the start switch without asking anyone [134]. Here, the control of the collaborative work is achieved by mutual monitoring of body movements.

Control of collaboration by body movement and positioning is made possible through the tangibility of AlgoBlock which necessarily requires users to manipulate the program language surrounding the blocks physically, and it naturally draws body movement while manipulating the blocks. By using AlgoBlock, body movement and its positioning become usable as resources for the control of collaborative works. Here, the authors do not mention eye lines, however, AlgoBlock which is used by facing each other within the shared space, of course, can make it possible for children to use eye line as a tool for interaction. Summing up, AlgoBlock allows learners to utilize these familiar resource for interaction control, and through this, it enables active interaction among learners which is a crucial foundation for supporting community of learners.

4.2.3. AlgoBlock as an open tool

In [108], it can be said that child 2 operated the blocks by following her own idea. At first, the idea should be conceived as a result of her inner process and belonged to her. However, as soon as she tried to manipulate AlgoBlock, the idea was displayed to all of the participants through her body movement [108] which is necessarily generated by operating AlgoBlock and through visual change of the physical blocks as a result of her operation. Therefore, child 1 could instantly disagree [110], and then show her own idea as an alternative plan [110]-[115]. The child 1's idea was externalized to the other children for the same reason, then this induces the next response [113], [116]. In such a way, by using a tool which has actual substance, children can monitor the work the other participants are doing, what they are thinking and what their work situation is. They then can use each other's ideas as material for discussion. It can be said that AlgoBlock functions as an open tool which facilitates interaction among learners.

Furthermore, the following fragment suggests that openness of AlgoBlock improves ability of the group as a whole.

Record of conversation and action (2)

(The submarine is moving on the screen. Children are looking into CRT monitor while remaining seated)

Child 2 [200]:	"Ah, you don't have to use it there."
[201]:	{stands up pointing at the screen.}
Child 2 [202]:	{stands up and points out GO-FORWARD block which is tracing} (Each command block has a tracing lamp on its surface which indicates a block that is executed "now" by its blinking)
Child 3 [203]:	{Stands up}
Child 2 [204]:	"No, this won't be needed" {looks at GO-FORWARD block which child 1 pointed out, then points out ROTATE block located right after the forward block in the program}

This record shows that children recognized a programming error through the movement of the submarine, then pointed it out. In a glance, child 2 seems to resolve this problem alone. However it should have been impossible for child 2 to instantly point out the unnecessary ROTATE block among the row of blocks which was built longer at that time because when child 2 stood up, she was watching the screen, not programming [201]. In spite of it, child 2 pointed out the unnecessary block very promptly. It should be because she made use of the movement of child 1. At the same time that child 2 stood up, child 1 stood up pointing out GO-FORWARD block which is being traced. Through this movement, child 2 could promptly pick up the "doubtful" part in among the long programming and find the unnecessary block within the part. This immediate finding of the unnecessary block can be considered to be performed by the group collaboration be-

tween child 1 and child 2, and it is hard to say that it was due to individual's ability. By openness of AlgoBlock which allows each child to monitor each other's actions, the performance of the whole group, i.e., the community of learners, is improved.

4.3. Social designing of AlgoBlock: Conversation between communities

In this experimental setting, the social framework connecting the activities of using the AlgoBlock to the activities of the external world was not intended. Because of this, the activities of the children were closed in a special setting. In the experiment, it could be observed that children were forming and managing the temporary community with the purpose of working together by using the AlgoBlock. However, there would be no further development there. How to design a social situation that makes linkage between students' activities in the classroom and practices of the real world should be considered in a further study.

In regard to this, there was a very suggestive incident during the experiment. It was the questioning by an instructor to the children. During the experiment, the instructor asked the children twice "Is everything going according to your plan?" This instructor is one of the developers of AlgoBlock and has the ability to program; that is, he is one of the members of the community of programming. This question could be considered as being based upon the value of the programming community which admires thinking logical and solving problem under a plan. Regardless of whether the questioning was intentional or unintentional, its meaning for the children is the same. Actually, the question was ignored by the children both times, however, these questions had the potential of connecting the children's activities to the practice of the community of programming. It is because questions constrain persons who are questioned to respond to them. With these questions, children are forced to reconsider their method of solving problems which was adopted naturally through their practice, thus they are opened toward the change. The change is not necessarily considered to be happening only on the children's side. Children's responses, such as "Why is the plan needed?" also have a potential to force the instructor to reconsider the clear value of the programmer. Of course, these changes can not be expected to be inevitably occurring, though setting up a field for the dialogue between learners and the members of a community of practice can be a way to connect the children's activities to the outer social world.

5. Conclusion

The authors have presented AlgoBlock as an example of an educational tool to support forming and maintaining the community of learners, and then have shown the result in an evaluation experiment. It became clear that the essential feature of AlgoBlock was very effective in facilitating the interaction among learners. That should be a foundation for supporting activities in a community of learners. However, it is also clear that social designing of the tool is also required to make children's community function as an interface to programming community. Based upon these points, we are going to seek a design of the learning environment which will allow interactions within the community of learners to progress into the external world.

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