Chapter 14

THE ROLES OF SCRIPTS IN PROMOTING COLLABORATIVE DISCOURSE IN LEARNING BY DESIGN

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Abstract: Using the design of Learning by Design (LBD) for illustration and results of its enactments as evidence, I make an argument about the roles Schank and Abelson's (1977) kind of scripts can play in promoting collaborative discourse and present a way of promoting the kind of script learning that results in productive collaborative discourse. LBD's way of promoting script learning has three parts to it: (i) a set of scripted activity structures and sequences (classroom scripts) that promote productive and appropriate participation in classroom practices (including collaborative discourse), (ii) an approach to instruction that focuses on repeated, deliberative practice of each of these classroom scripts, and (iii) an approach to getting started through *launcher units* that introduce the scripted activity structures, their sequencing, and how to participate in each. I argue that scripts students learn for participating in classroom practices can play three roles in promoting collaboration and collaborative learning: (i) they help students participate in whole-class discussions and in discursive practices by proposing sequencing for their discourse, (ii) they help students participate in whole-class discussions and discursive practices by proposing content for their discourse, and (iii) they provide focus for small group discourse as students aim their discussion toward fulfilling a script's expectations in order to be able to participate in the script later. Learning by Design is a design-based approach to science learning.

Example 1: Children in an 8th grade class are presenting their experimental investigations in a poster session – investigations aimed at determining the effects of different characteristics of a balloon engine on the distance a vehicle will go. Their balloon engines are made by gluing a drinking straw to a balloon. They attach the engine to the vehicle by securing the drinking straw to a tower, and they use the straw to blow up the balloon that powers the vehicle. In their experiments, they compare the distance the vehicle travels under different conditions. During the poster session, they present their research question, their procedure, their results, a rule of thumb describing the trends in their results, a set of four force diagrams, each representing a different stage in the vehicle's motion, and the best explanation they can make of their results using what they've learned about combining forces. Group 1 (a group of 3 students) reports on an experiment investigating the effects of the length of the straw on how far a vehicle will go. After the presentation, a child in the class notices that the arrow representing friction in the last stage, when the car has stopped, is larger than the one representing friction earlier and asks why. The child who drew the arrow responds that it's long only because he was in a hurry. But he continues thinking about how long the gravity arrow should be and goes on:

> CF: But really uh, it should be shorter, because there (gestures to poster) wasn't any like, air mass in the balloon.

Other students in the class talk among themselves about this, and others continue to explain and clarify, spontaneously participating in a sense-making discussion. Sense making continues, moving on to consideration of the force of friction at stage 1, before the vehicle begins moving, with argument about whether there is a friction force at all if the vehicle isn't yet moving. Discussion continues. A child asks for clarification of why the shorter straw results in the vehicle going a longer distance. A member of the group describes it as a traffic jam. But another child in the class is worried about that explanation. After all, the engine with the shorter straw also had a smaller mass. She raises her hand, and one of the presenting students calls on her.

> JG: Don't you think when you're cutting the straw it's changing the mass?

The class spends some time trying to make sense of what she is trying to say. Discussion continues considering if there's a different way to run the experiment without changing two variables at the same time. Someone notices a way to do it, but then someone else notices that that procedure would be answering a different question. Someone in the presenting group notices that the problem with their experiment might be a problem in other experiments too, e.g., when comparing engines with different diameter straws. Nine students in all take part in this discussion, and the teacher doesn't contribute a word.

Example 2: A group of boys who had not had a chance to participate in a presentation of their ideas to the class (a pin-up session) nonetheless prepared a plan and discussed it thoroughly before moving forward to construct their best parachute. As they would have done had they participated with the class in a pin-up session, they drew a chart of their ideas, taped it to the wall, and stood around it discussing with each other the pros and cons of constructing their parachute a certain way. Our researcher asked the teacher what role she had played in the boys' decision to utilize the pin-up. The teacher responded, "Oh, they did that on their own. I didn't assign them to work on anything. ... They did the pin-up because they know that is part of the design process.... Now, it wasn't pretty or anything, but they did the sketches of their ideas." (Fasse, field notes, fall, 1999)

Example 3: The group we're looking in on here was getting ready for the poster session in Example 1. They had investigated the effect of the circumference of the balloon on the distance a vehicle would go, decided that their rule of thumb was that the larger the circumference of the balloon, the farther the car would go, and that they needed a scientific explanation. At the same time, they were drawing the force arrows that show the forces on their vehicles, and they were worrying about whether they would finish on time. Their dialogue isn't fluid, but it interweaves discussion of the three things they need to consider before presentation – their rule of thumb, the forces on their vehicle, and their scientific explanation of their results. Each member of the group is assigned a different task – coming up with the rule of thumb, drawing the force diagrams, or developing the scientific explanation – but they think out loud and all help each other with their tasks, sometimes completing each other's sentences, and often stopping to ask each other clarification questions and to grapple with a hard concept. For example:

> AB: Well, there's... Well the force coming out of the end of the balloon.
>
> ...
>
> KK: When you have a larger circumference, there, is more air...
>
> ...
>
> KK: ...Ok, so does this make sense? When you have a larger circumference, there is more, um, force of the air being pushed out of the balloon?
>
> ...
>
> JG: (at same time as CW) When you have a larger circumference, there is more in the... Engine...

These are examples typical of the kinds of discussions heard among children in Learning by Design (LBD) classrooms (Kolodner, Camp, et al., 2003; Kolodner, Gray, & Fasse, 2003). They aren't exactly the discussions learned adults would have; they aren't as fluid, and they get off track, but they represent quite sophisticated discourse for eighth graders (14 years old). The first example is of a typical *poster session*, a formal presentation session in which each small group in the class reports about its investigation. Each group prepares a poster showing the question they were trying to answer, their investigative procedure, their data, their interpretation of the data, and if they can, a "rule of thumb" representing trends they see in their data. They take turns making presentations to the class, pointing to the data on their poster. After each presentation, students in the class ask questions – about the validity of the procedure, about validity of the data, about trends extracted, and so on. Then the next group presents. And so on. At the end, the class summarizes the trends in the data together, in a whole-class discussion, and then attempts to apply science they've learned to explain those trends. This poster session happened in mid-November, approximately 3 months into the school year, and it was the children's fourth or fifth poster session. The second example happened approximately 2 months into a school year, after students had engaged in several of these presentation forums, and it is a description of an informal discussion between two students. I've used it before to show that students are indeed learning skills and practices of science and project work in transferable ways (Kolodner, Camp, et al., 2003), but it also shows an example of LBD students using learned scripts (Schank & Abelson, 1977) to guide their own conversation. The third example is of several students in a small group getting ready for the poster session in Example 1. Here, they are focusing their discussion on the points they will have to present to the class.

Students engage in several kinds of scripted presentation activities during their project-based inquiry work in LBD – in poster sessions, they present investigations and their findings; in pin-up sessions, they present ideas about how they will solve the challenge they've been given and justifications for those ideas; and in gallery walks, they present solutions in progress and talk about how well they work, why they might not be working as well as expected, and how they might make them better. In each, groups take turns presenting to the class, and after each presentation, class members question their peers and provide advice. In each, the sequence of events, the purpose of each event in the sequence, and some of the how-to's of carrying it out are told to the students before the first time it is enacted. Then students enact the sequences several times with coaching, sometimes reflecting on what they did well and what could be improved, almost always reflecting in some way on what they learned from the session. The content of the discourse during these sessions can be quite sophisticated, as illustrated in the first example. In addition, as they prepare for these sessions, they spend time discussing the things that they need to present – the science content and processes they are learning – as shown in the third example. Finally, they are able to engage in similar sessions on their own, and in these sessions, their discourse is guided directly by the scripts they learned, as shown in the second example.

My goal in this chapter is twofold: to make an argument about the roles Schank and Abelson's (1977) kind of scripts can play in promoting this kind of collaboration, and to present a way of promoting the kind of script learning that results in productive collaborative discourse. Our way of promoting script learning has three parts to it:

1. A set of scripted activity structures and sequences (classroom scripts) that promote productive and appropriate participation in classroom practices (including collaborative discourse)
2. An approach to instruction that focuses on repeated, deliberative practice of each of these classroom scripts
3. An approach to getting started through *launcher units* that introduce the scripted activity structures, their sequencing, and how to participate in each (in some sense, providing training at participating in the classroom scripts)

I will argue that scripts students learn for participating in classroom practices can play three roles in promoting collaboration and collaborative learning: (i) they help students participate in whole-class discussions and in discursive practices by proposing sequencing for their discourse (as in Example 2), (ii) they help students participate in whole-class discussions and discursive practices by proposing content for their discourse (as in Example 1), and (iii) they provide focus for small group discourse as students aim their discussion toward fulfilling a script's expectations in order to be able to participate in the script later (as in Example 3).

I begin with the definition of script that I am using; it is one that is consistent with Schank and Abelson's (1977) original script definition but more fully incorporates the notions of participation and practice from the sociocultural tradition. I follow that with a description of Learning by Design, some of the scripted activity structures (classroom scripts) that comprise its practice, and our intentions with respect to the roles of several of those activity structures in promoting productive collaborative discourse. I move on to a description of how LBD tries to promote the learning of the scripts (instructional strategies, including launcher units) that enact these activity structures and sequences and then show examples that illustrate the roles LBD's scripted activity structures might play in promoting collaboration and collaborative learning. I end with discussion of lessons learned about how to design and enact classroom scripts to promote collaborative discourse.

1. CONCEPTUAL BACKGROUND ON SCRIPTS

1.1 Scripts as cognitive structures that promote productive participation

Schank and Abelson's (1977) theory of scripts and other knowledge structures proposes that people learn the sequences of events in common activities through participating in those activities. According to Schank and Abelson, one way people naturally learn how to participate in commonly occurring situations is to experience those situations repeatedly, generalizing a routine sequence of events and roles they and others play in those situations. We might observe, try out simple roles ourselves, get instruction or help from others in playing those roles, have sequences explained to us, and so on, gradually becoming more expert and better participants over time. We learn about the sequencing of events in a restaurant, for example, by going to restaurants and experiencing that sequencing. We learn how to participate in social events, such as going to a restaurant, by going with others who know the sequencing and roles, observing their actions, and eventually playing roles in the same ways we've observed, sometimes with some instruction. As we participate repeatedly in the same scripted events and experience the variations, we become expert at the common sequence of events and some of their variations, and we learn connections between events in the script, the purposes of some, what to expect from others, and the roles we should play and how to play them. In this way, we become fluent at being restaurant customers or at buying things in stores, getting up and dressed in the morning, going to birthday parties, entertaining guests, and so on, constructing in our memories cognitive structures that we call scripts (Schank & Abelson, 1977), each associated with a common kind of activity we participate in.

Schank's (1982, 1999) focus on dynamic memory attempts to explain how that learning happens; he, in essence, suggests a computational account of Piaget's accommodation and assimilation, proposing scripts as specific types of schemas that play a role in learning about activities in the context of participating in, observing, and hearing about those activities. According to his account, we pull out the regularities and make them into scripts while we notice the differences (things we were not expecting) and use explanations of those differences to index events that are different from the script. In this way, we create knowledge structures that specialize scripts to particular situations, combine scripts together to describe more complex situations, and provide access to experiences that violated those conventions. We can thus use scripts, cognitive artifacts derived from participation in culturally-common events, to get around in the world, anticipating what comes next, playing our roles appropriately, and anticipating and knowing how to deal with common script violations and variations (even scripting those). Activities we are familiar with become easy to participate in through creation of these knowledge structures.

It is not hard to wed Schank and Abelson's cognitive notion of scripts to Lave and Wenger's (1991) accounts, from a socio-cultural viewpoint, of learning through participation. Lave and Wenger's (1991) accounts of apprenticeship and legitimate peripheral participation focus on the social interactions and environmental factors that allow new members of a community to learn community practices through participation (directly and through observation). Apprentices participate first peripherally but observing the whole process and gradually taking on more responsibilities and adding to their repertoire and expertise, within the bigger context of the "shop". According to this viewpoint, and similar to Schank and Abelson's conception of scripts, we learn as a consequence of engaging with others in carrying out cognitive and social practices. Schank and Abelson concentrate on the cognitive structures that allow individuals to do the reasoning they need to do to participate; Lave and Wenger (1991) concentrate on the social interactions and ways of participating that would lead to such learning.[1] We have taken lessons from both cognitive and socio-cultural accounts to design ways for children in LBD classes to learn to participate in and prepare for participating in collaborative classroom and small-group activities.

Both the cognitive and socio-cultural views of learning tell us that an individual's conception of that repeated sequence of events is necessarily incomplete to begin with, but over time, and with participation and/or observation, especially when that participation is reflected upon or informed by others, the scripts an individual comes to know become fleshed out with more specifics – about, e.g., variations in events and scenes in the sequence and the effects of those variations; the purposes of different events in the sequence; the actors in the script, the roles they play, and the effects of their actions; causal connections between events and scenes – to the extent that the individual can figure out or is informed by others. According to this notion, one could help participants learn a script for a targeted collaborative activity by having them observe and participate in its enactment repeatedly and, to speed the learning process, helping them identify the specifics of events, scenes, sequencing, and roles they might play, variations on those things, and purposes of each.

1.2 Scripts as classroom practices

Another notion of scripts is used in most of the other chapters of this book, and we also refer to that notion when we discuss ways of designing the learning environment to promote script learning as described above. Under this second notion, a script is a designed activity structure or sequence used for an instructive purpose; a *classroom script* is a designed event sequence for the classroom that learners engage in repeatedly; an *instructional script* represents strategies and tactics for sequencing classroom scripts and speci-

[1] Our intention here is not to argue about what exactly is in the head (Lave and Wenger would certainly argue against the full representation of the script residing in an individual's head); rather, our aim is to present a notion of learning about how to participate in commonly repeated activities.

fying teacher roles (and sometimes student roles) so as to promote student learning of the classroom scripts. The hope is that through repeated participation in a classroom script guided by means of enactment suggested in an instructional script, students will internalize expected behaviors and construct cognitive structures (scripts) that will allow them to productively participate in learning activities.

Learning by Design, too, has the equivalent of classroom scripts and instruction scripts in its enactment. In each of the scripted activity structures and sequences (classroom scripts) designed for LBD classrooms, students play certain roles; the teacher plays other roles; software may play other roles, and there is a sequence of events that defines the activity structure. Some, which we've called *rituals* (Kolodner, Camp, et al., 2003; Kolodner et al., 2003; Kolodner & Gray, 2002) and *scripted activity structures* (Kolodner & Gray, 2002) in the past, are quite detailed (see Table 14-2), while some, which we've called *scripted activity sequences* in the past (Kolodner & Gray, 2002) specify the sequencing of activity structures (see Figure 14-1) at a more macro level. Scripted activity structures and sequences provide structure to the classroom and are designed, like other classroom scripts, to afford student learning of the ins and outs of classroom practices that will allow them to participate productively in discourse and other activities.

LBD also has the equivalent of what others have referred to as instructional scripts – the how-to's of making things work in the classroom, though I prefer to call these *instructional strategies* rather than instructional scripts. In particular, Learning by Design promotes a cycle of activities (as seen in Figure 14-1) that sequences classroom scripts with respect to each other in the context of attempting to achieve a design challenge. Each project-based inquiry unit includes several embedded go-throughs of that cycle. For example, designing a vehicle that can navigate several hills on its own begins with activities that help learners understand what the challenge entails and identify some of the science they will have to learn; then, for each science topic, includes at least one go-through of investigating in order to be able to complete some aspect of the design and then several go-throughs of redesign in order to both make the design solution work better and identify and revise science understandings; and then a set of design iterations that bring together what's been learned to perfect the solution to the challenge. The full *Vehicles in Motion* unit includes at least three poster-sessions, three pin-up sessions, and several gallery walks and often includes many more.

Two other instructional strategies are important in LBD. One is adopted from cognitive apprenticeship (Collins, Brown, & Newman, 1989) and specifies teacher roles over time. As each classroom script is being learned, the teacher helps students learn their roles by modeling those roles, coaching them through and providing scaffolding as they do it, and afterwards, guiding the kind of reflection on the activity and articulation of the reasoning that will allow the reasoning to become visible and conscious so as to allow revision over time. The second is the launcher unit, a set of activities designed to introduce learners to the classroom scripts that are so important for their science learning, successful design, and productive discourse. Launcher units (one for each science discipline studied in middle school) are done at the beginning of the school year, and each has a sequence of activities that engages learners in classroom scripts in ways that afford their construction of a cognitive framework representing their understanding of each script.

2. SETTING THE CONTEXT: MORE ON LEARNING BY DESIGN

Learning by Design (LBD; Hmelo, Holton, & Kolodner, 2000; Kolodner, Crismond, Gray, Holbrook, & Puntambekar, 1998; Kolodner, Camp, et al., 2003; Kolodner et al., 2003; Kolodner & Gray, 2002) is a project-based inquiry approach to middle-school science (grades 6 to 8; ages 12 to 14) that focuses on learning science and scientific reasoning in the context of attempting to achieve design challenges. For example, students learn about motion and forces (and about designing and running experiments, justifying with evidence, explaining scientifically, collaborating, and so on) by spending eight weeks iteratively designing, building, and testing a miniature vehicle and its propulsion system. They learn about mechanical advantage by designing and building machines for lifting heavy objects. Each design challenge provides reason for learning some targeted science content, and attempting to achieve the challenge provides a natural and meaningful venue for engaging in both science and design thinking. The need to make one's design ideas work provides opportunities and reasons for students to identify their incomplete and poor conceptions of the science content and to debug those conceptions; the iterative nature of design provides them opportunities to apply and test their new conceptions; and the collaborative nature of design provides learners the need to communicate ideas and results well and opportunities for team work, public practice and presentation of their scientific reasoning.

Figure 14-1 shows LBD's macro level[2]. Activities in the design/redesign cycle (on the left) afford achieving a design challenge, while successful engagement in those activities often requires engaging the investigative cycle (on the right) and its activities. Results of investigations, in turn, provide

[2] Kolodner et al. (2003b) provides the rationale for the different aspects of the design of LBD.

content for application to the design in progress. Individual activities in each cycle are designed to move learners towards successful achievement of a challenge and integrate a variety of science, design, collaboration, and communication practices. Within this framework, students learn the concepts and skills that are needed for success through identifying a need to learn them, carrying out investigations, trying out those conceptions by applying them to the design challenge, questioning their accuracy when the design doesn't work exactly as predicted, and revising.

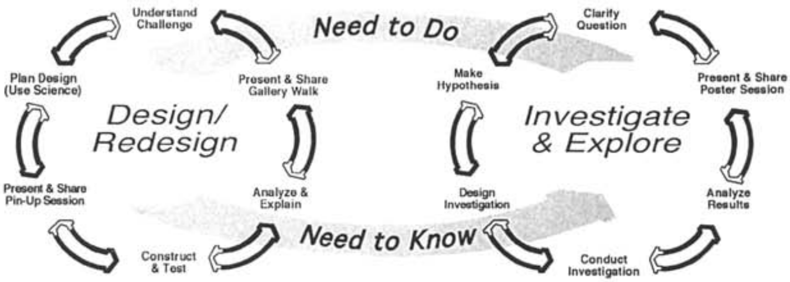


Figure 14-1. Learning by Design's Cycles. From "Promoting Transfer Through Case-Based Reasoning Rituals and Practices in Learning by Design Classrooms," by J. Kolodner, J. Gray and B. Fasse, 2003, *Cognitive Science Quarterly*, 3. Reprinted with permission.

Enactment of LBD's cycles of activities involves participation in a variety of carefully constructed scripted activity structures and sequences (classroom scripts) designed to contextualize important skills with respect to each other and with respect to their usefulness in a project's success. Table 14-1 shows a representative set. These classroom scripts are designed so that they allow success at carrying out the tasks in the cycles in Figure 14-1 at the same time that they provide practice at scientific reasoning and use of newly-learned science concepts.

There are two types of classroom scripts represented in the cycles: action and discourse. Action-based activities, such as *messing about* and *designing an experiment*, are associated with skills and practices of science and design and promote methodological habit and rigor. Students carry out action activities in small groups, dividing up responsibilities for investigations across teams when much needs to be investigated in order to achieve a successful design solution. The focus in action-based scripted activities is on the actions themselves, but as I shall discuss later, these classroom scripts provide context for discourse. Discourse activities have discourse as their major activity, and they sequence who has the floor and specify the content of discussions.

Table 14-1. A selection of LBD's scripted activity structures.

Function(s) in cycle	LBD scripted activity structure	Type and venue	Description
Design investigation	Design an experiment	Action: small group	Given a question to investigate (in the form of discovering the effect of a variable), design an experiment where variables are controlled well, with appropriate number of trails, etc.
Analyze results; analyze and explain, present and share	Creating and refining design rules of thumb	Action, discourse: small group	Identify trends in data and behaviors of devices; connect scientific explanations so as to know when the trends apply (small groups suggest new rules of thumb and the need for changes in existing ones)
Analyze results; analyze and explain, present and share	Creating and refining design rules of thumb	Action, discourse: whole class discussion	Identify trends in data and behaviors of devices; connect scientific explanations so as to know when the trends apply (whole class discusses the suggestions of small groups and chooses new ones and modifies existing ones based on commonalities across small-group experiences)
Present and share (investigate cycle)	Poster session	Discourse, present and share: whole class	Present procedures, results, and analysis of investigations for peer review; followed by rules of thumb
Plan design	Plan design	Action: small group	Choose and integrate design components to achieve the design challenge, basing choices on evidence
Present and share (design / redesign)	Pin-up session	Discourse, present and share: whole class	Present design ideas and design decisions and their justifications for peer review; followed by plan design or by construction and test of design
Construct and test	Test design	Action: small group	Run trials of constructed device, gathering data about behavior, attempt to explain; followed by gallery walk
Present and share (design / redesign)	Gallery walk	Discourse, present and share: whole class	Present design experiences and explain design's behavior for peer review and advice; followed by whiteboarding and rules of thumb

Each discourse activity is inserted into LBD's sequencing at a time when listening to others might help in achieving the project challenge. By sequencing them this way, the need to make a presentation encourages students to reflect on and interpret important aspects of their experiences during action activities, e.g., what they are doing, how successful they are at that, what science content they are using, what they know about that science content, how the science connects to their project goals, how their reasoning connects to their project goals, and so on. The ultimate purpose of this sequencing is to promote the kinds of deliberation that will result in students recognizing and debugging their understanding, skills, and practices. Many discourse activities are done in whole-class configurations; some are done as small groups. Usually, small groups perform actions and make a first pass at reflecting, while whole-group activities provide a venue for presentations from small groups, sharing advice and concerns, struggling together to understand some phenomena, pulling out abstractions and generalizations across what small groups have presented, and discussing the how-to's of next actions.

Each scripted activity structure includes a sequence of events, and each is sequenced with respect to the others. For example, designing an experiment, running an experiment, analyzing results, and presenting them to the class form a scripted sequence of activities, with scripted activity structures associated with experiment design (*design an experiment*), analysis of results (*creating rules of thumb*), presentation of results (*poster session*), and the discussion afterwards (*creating and refining rules of thumb*). Designing an experiment, done in a small group, involves identifying what values to give the variable that is being tested, which variables need to be controlled, how many trials to run, what needs to be measured and how, and variables that might be hard to control, and then generating a procedure. In a poster session, students present their procedures and results to the class and query each other about those results, followed by a full-class discussion of investigative and analysis procedures, implications of what was discovered, and so on.

3. DESIGN OF SCRIPTED ACTIVITY STRUCTURES (CLASSROOM SCRIPTS) AND THEIR SEQUENCING TO PROMOTE COLLABORATION AND DISCOURSE IN LBD

Recall from the discussion about scripts that our notion of script learning is that individuals will learn scripts through observation and participation in commonly-repeated scripted activity sequences (classroom scripts) and that learning can be promoted and sped up by helping them identify the specifics of events, scenes, sequencing, and roles they might play, variations on those things, and purposes of each (instruction strategies). LBD's classroom scripts were designed to be those commonly-repeated activity sequences we wanted students to learn and participate in as scripts. For purposes of discussion about promoting collaboration and learning through scripts, there are three things it is important to notice about the design of LBD's classroom scripts.

1. The classroom scripts that frame discourse were designed specifically to promote the kinds of discourse important to learning science and scientific reasoning.
2. Placement of these classroom scripts in the sequencing matches the design and investigative needs of learners. For example, whole-class discourse activities are inserted into the sequencing at points where there is authentic reason for public discourse – students have had experiences that it is worth sharing with their peers, and they can learn something from their peers' presentations.
3. LBD's iterative approach to achieving design challenges ensures that learners get repeated chances to engage in each scripted activity structure and sequence. During the four to eight weeks working on each project challenge, they have multiple opportunities to refine their understandings, capabilities, and design solutions as they work in small groups and then participate in each kind of public discourse forum.

Our claim is that the sequencing of these sessions and the expectations set about participating in them helps learners engage in interesting discourse as well as learn scripts for doing science and for participating with each other in scientific discussion. In this section, I provide additional detail on the design and sequencing of LBD's activity structures, and in the next section, I move on to how script learning is promoted in LBD.

I focus here on three particular scripted activity structures – LBD's three *public discourse forums* – poster sessions, pin-up sessions, and gallery walks – all designed not only to promote public discourse at times when it is helpful for achieving a project challenge, but also to encourage students to actively reflect on what they've been doing and why they did it the way they did, and to make their thinking transparent. Table 14-2 shows the purposes and sequencing in each.

Table 14-2. LBD's 3 (Scripted) Public Discourse Forums.

	Poster-Session	Pin-up Session	Gallery Walk
Purpose (with respect to achieving the project challenge)	Present and discuss investigative procedures and findings; attempt to draw out trends from the data	Present and discuss alternative solutions to a challenge, along with the strengths and weaknesses of each and what might be expected	Present solution in progress, to what extent it fulfills the challenge, why it might not be working as well as it should, and what might be done to fix it
Purpose (with respect to scientific reasoning and discourse)	Make reasoning and practices associated with designing an investigation and interpreting data visible.	Make reasoning and practices associated with making evidence-based decisions and predictions visible.	Make reasoning and practices associated with testing solutions and explaining scientifically why things behave as they do visible.
When?	After designing and running experiments or other investigations	After trends have been identified from investigations run previously and groups have spent time making sense of what the data, trends, and science they understand implies about achieving the challenge	Solutions have been constructed and tested; they might be complete or need revision
Artifacts/Props used in the presentation	Poster showing research question, procedure, data, trends	Poster showing proposed solution, and for each piece of it, why it was chosen (with references to previous investigations, trends identified across investigations, and science understanding)	Solution artifact

(continued)

	Poster-Session	Pin-up Session	Gallery Walk
Step 1: Presentations: Each group makes its presentation and opens up the floor for questions and advice from peers and teacher			
Group Presentation	Of procedures used, data collected, and trends in data	Of solution ideas, evidence that justifies each	Of solution in progress, what happened when it was tested, explanations of why, ideas about moving forward, areas where the group wants help from the rest of the class
Discussion	Clarification of procedures, appropriateness of procedure for answering posed question, trustworthiness of data, trustworthiness of analysis, …	Pros and cons of each solution idea, why particular evidence is the right evidence to use, validity of evidence, …	Possible explanations for the behavior of a tested solution, shortcomings of those explanations, ideas about moving forward, pros and cons of different ideas
Step 2: Making sense together: Teacher led discussion across presentations, first focusing on the content of what was presented to make visible and debug science conceptions, then focusing on the reasoning and practices of groups to make successful reasoning and practices visible and articulate their how-to's			
Content focus	Extract trends from across data, begin to try to explain those trends, identifying science content that needs to be read, discussed, and/or investigated; beginning of those discussions, including demos, short lectures, reading	Particular data trends and targeted science and what they imply with respect to achieving the project challenge	Using targeted science to explain behavior of solutions in progress; identification of confusions/misconceptions, further discussion of each
Reasoning and practice focus	How-to's of managing variables, getting to trustworthy data, drawing out trends, measurement procedures, …	Using evidence to justify claims and inform decisions	Which explanations are better ones and why; ins and outs of good testing procedures and fair tests

Notice that LBD doesn't simply have a *present and share* activity; it has three such activities. Poster sessions come after carrying out and attempting to explain results of an investigation; pin-up sessions come after planning a design and attempting to justify design decisions; gallery walks come after testing a design and trying to explain its behavior. Each presentation type shares its activity sequence, but in each, the discourse is different. That is, a different kind of presentation is required and different practices and content are targeted in discussions afterward. When presenting experimental results, it is important to report on procedures used and trends in the data; when presenting ideas, it is important to justify them with evidence; when presenting solutions in progress, it is important to report on procedures, what happened, and to explain why things didn't work as planned. By separating out these three kinds of presentations and calling them by different names, LBD calls attention to the fact that each requires different discourse. Discussions after presentations of the three types are quite different from each other. Separating present and share activities into three different discourse structures with different expectations about the content of that discourse has been particularly useful in helping students and teachers focus on scientific reasoning and discourse appropriate to what they are doing at the time of a presentation (Kolodner, Camp, et al., 2003).

As discussed, each scripted public discourse activity structure in LBD is placed in the sequencing of class activities at points where there is authentic reason for engaging in it – students have had small-group experiences that it is worth sharing with their peers, and/or they have a need to learn something from the presentations or discussions. These scripted discourse activities in LBD were designed to provide a public venue for participating in scientific reasoning, in this way promoting repeated deliberative practice needed for deep learning of science content and scientific reasoning (Kolodner, Camp, et al., 2003; Kolodner et al., 2003; Kolodner & Gray, 2002). But their placement also appears to play two other essential roles in promoting productive collaborative discourse. First, students prepare for discourse activities in their small groups, reflecting on their activities in ways that allow them to present to the class. The need to present certain specifics about their work and their reasoning causes them to have discussions about that work and reasoning. We see that in Example 3 at the beginning of this chapter. That is, while there is no script for participating in this preparation, the script for participating in a pin-up session, poster session, or other whole-class discourse activity provides focus for discussion during preparation. Second, the movement from small-group to whole-class and back again promotes observing the discourse of others and participating in discourse in multiple ways. During presentation in discourse forums, the reflection students have attempted to do as a small group can be discussed and scaffolded and taken to the next level through interaction with teacher and peers. Sequencing tends to move students from small social configurations to big ones and back again, so that groups can learn from each other and bring each other up to pace.

4. PROMOTING SCRIPT LEARNING IN LBD – INSTRUCTIONAL STRATEGIES

There are two parts to LBD's instructional strategy:

1. Its scripted activity structures and their sequencing (classroom scripts) are enacted over and over again in the context of new situations, within single units and across units, their enactments are scaffolded, and their enactments include reflection on how to participate in them productively. This repeated deliberative scaffolded practice implements a kind of cognitive apprenticeship (Collins et al., 1989).
2. Its launcher units, enacted at the beginning of the school year, introduce each of the important scripted activity structures – individually and in the context of its sequencing with other classroom scripts and in full design challenges (Holbrook & Kolodner, 2000).

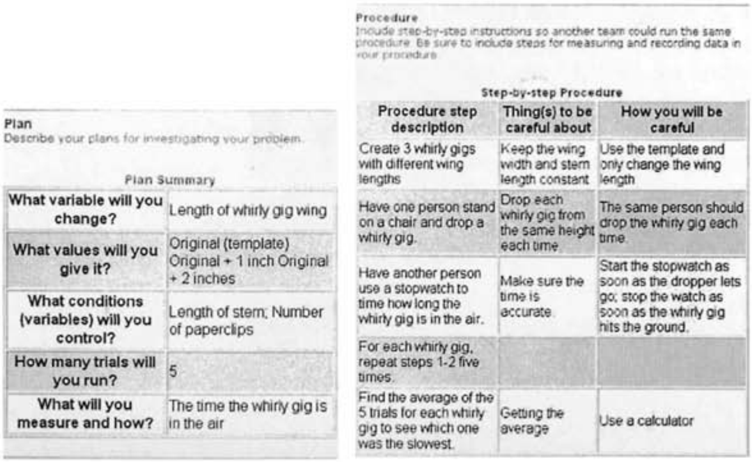
4.1 Repeated deliberative scaffolded practice of scripted activity structures (classroom scripts)

Repeated practice works in two ways – within and across projects (curriculum units). Each designed activity structure and sequence is repeated several times in the context of each project, providing opportunities for participating in each close enough in time to other enactments that previous opportunities are remembered. This way, students not only experience small variations in sequencing but also remember enough about previous enactments to be able to draw parallels between enactments. The same activity structures and sequences are then used across projects, providing ongoing opportunities for repetition and for experiencing broader variation. A student might participate in three different poster sessions during the Vehicles unit – one focusing on what effects the distance a vehicle will travel on its own and culminating in a discussion of friction and gravity and how forces interact with each other; another focusing on what effects the force produced by a balloon engine, culminating in discussion of propulsion force and continuous and one-shot forces; and another focusing on what effects the functioning of a rubber-band engine, culminating in additional discussion about forces in pairs. In the next unit, focusing on mechanical advantage, a poster session will focus on the effects of increased mass on different kinds of simple machines, culminating in discussion of the relationship between force and mass in creating mechanical advantage. And so on. In each, they use what they already know about managing variables and obtaining trustworthy results to help each other continue to be able to design experiments and obtain trustworthy results as the relationships between variables become more complex.

Deliberation, i.e., thinking about their reasoning in a way that will allow them to learn how to reason better, is achieved in LBD classrooms by tactics used before and after enactment of each scripted activity structure. When an activity structure is introduced to students, they read text about the sequencing and purpose of the activity and how best to participate. They again read text about sequencing and participation when new variations are introduced. Then, after each experience with each activity structure, the teacher initiates reflective discussion about it, encouraging students to articulate the sequencing, the roles of each part of the sequencing, how they participated, what they gained from it, how it built on activities that came before, how it prepares them for activities to come, and so on. Additionally, as is typical of cognitive apprenticeship (Collins et al., 1989), the teacher has a role of modeling what is expected of students during early enactments and then later when more is expected of students in their enactments.

Figure 14-2. A Design Diary page: "My Experiment." Notice that it prompts learners for some of the important issues they need to discuss and/or plan for (See Puntambekar & Kolodner, 1998, 2005, for more detail)

Scaffolding during small-group work in LBD takes the form of design diary pages (Kolodner et al., 2003; Puntambekar & Kolodner, 2005) and/or software prompting (Kolodner et al., 2004) made available during each important activity. A design diary page is a kind of worksheet with prompts about what to focus on while doing the activity and questions to answer while engaging (see, e.g., Figure 14-2). Software pages provide more detailed prompting and hinting and sometimes templates that suggest what needs to be done and/or discussed. Figure 14-3 shows filled-in templates for the *plan* and *procedure* parts of the software-based design diary page (implemented as part of SMILE (Kolodner et al., 2004)). The posters students make for use during poster and pin-up sessions serve as scaffolding during whole-class activities – they remind them of what they need to be presenting and then discussing.



Plan

Describe your plans for investigating your problem.

Plan Summary

What variable will you change?	Length of whirly gig wing
What values will you give it?	Original (template) Original + 1 inch Original + 2 inches
What conditions (variables) will you control?	Length of stem; Number of paperclips
How many trials will you run?	5
What will you measure and how?	The time the whirly gig is in the air

Procedure

Include step-by-step instructions so another team could run the same procedure. Be sure to include steps for measuring and recording data in your procedure.

Step-by-step Procedure

Procedure step description	Thing(s) to be careful about	How you will be careful
Create 3 whirly gigs with different wing lengths	Keep the wing width and stem length constant	Use the template and only change the wing length
Have one person stand on a chair and drop a whirly gig.	Drop each whirly gig from the same height each time	The same person should drop the whirly gig each time.
Have another person use a stopwatch to time how long the whirly gig is in the air.	Make sure the time is accurate.	Start the stopwatch as soon as the dropper lets go; stop the watch as soon as the whirly gig hits the ground.
For each whirly gig, repeat steps 1-2 five times.		
Find the average of the 5 trials for each whirly gig to see which one was the slowest.	Getting the average	Use a calculator

Figure 14-3. Additional prompting for "My Plan" and "Step-by-Step Procedure" in the software templates for "My Experiment" found in SMILE (See Kolodner et al., 2004, for more detail)

4.2 Launcher Units for introducing scripted activity structures

Experiences in the classroom show that, in addition to what cognitive apprenticeship suggests about repeated deliberative practice, learners needed help getting started with each practice (Kolodner et al., 2003; Holbrook & Kolodner, 2000). Asking students to learn the scripted sequences of activities and the purposes of each step in their sequencing at the same time they were learning new and difficult science concepts, was difficult for students to achieve and difficult for teachers to facilitate (Kolodner, Camp, et al., 2003). At the request of teachers the LBD research group worked with, the research group created introductory *launcher units* (Holbrook & Kolodner, 2000; Kolodner et al., 2003) with four weeks of activities in them that introduce students to scripted activity and discourse structures and sequences (classroom scripts) in the context of a series of science activities that require only simple content. Launcher units are intended to help students quickly learn basic scripts for each activity and discourse structure that include sequencing and purposes.

For example, in their first activity in the year, students attempt a simple design challenge in small groups and show their results to the class in a gallery walk (after reading about what a gallery walk is). They get to work and create something very quickly, usually with little deliberation about what the options are. During the gallery walk, they notice that not everyone had the same understanding of the challenge, providing the teacher with an opportunity to point out what it means to understand a challenge and its importance before going off and trying to achieve it. They continue by defining the challenge better, this time in terms of criteria (goals to be achieved) and constraints (limitations and availability of resources, time, and so on). Then, the teacher asks them to attempt it again. As they engage in planning their designs this time (*plan design*), each group deliberates about how well they are achieving the criteria and keeping within constraints, and when they do their next gallery walk, each group presents not only its solution but why they think it is a good solution. This second time through, however, students notice that they've copied from each other. They also notice how much better their designs are as a result of considering the criteria more deliberately, considering the goodness of options they considered, and integrating in the ideas of others. The teacher helps them recognize how much they learned from each other but that fairness requires giving each other credit. At the conclusion of this second gallery walk, they discuss what they've learned about planning a design (specify and consider criteria and constraints) and how to participate well in a gallery walk, articulating how important it is to give credit to others for their work. A major addition most students make to their personal scripts for gallery walks (which can be observed next time they participate) is that while one is showing off a solution, one must discuss what work that solution builds on and who was responsible for that work.

Students engage in similar mini-challenges to introduce them to the need to control variables, measure accurately, run procedures in a consistent way, and so on. They also watch a movie where they have a chance to observe scientists, engineers, or designers engage in these same kinds of activities – collaborating, investigating an unknown, making a well-formed scientific argument, designing an experiment, and so on. Other activities go into more depth in different parts of the design and investigation cycles, introducing the range of scripted activity structures (e.g., pin-up sessions, poster sessions, designing an experiment) and the scientific reasoning and practices they include (interpretation of data, scientific explanation, and so on). As their last activity in a launcher unit, students tackle a relatively simple but full design challenge, in which they participate in the full LBD cycle (as in Figure 14-1). In the physical science launcher, they spend 8 days designing parachutes and learning a bit about combining forces; in the earth science launcher, they spend 3 weeks designing a way to manage erosion in a designated area and modeling their solutions in a stream table, learning about earth's surface processes and interactions between people and the environment.

By the time they've finished a launcher unit (4 - 6 weeks), students have engaged several times in each of LBD's classroom scripts, and they've had one full run-through of the LBD cycle. Students come away from these launcher activities with the want to collaborate, basic ability to participate in each classroom script, and an appreciation of many of the practices scientists engage in (Gray, Camp, Holbrook, & Kolodner, 2001; Kolodner et al., 2003).

Each additional unit, lasting 3 to 10 weeks, makes at least one run through the entire LBD cycle and several runs through each of the classroom scripts. Discussions before small-group activities remind students of the ways they've carried out these activities previously, and discussions after each of the discourse activities focus on both content that is being learned and their added sophistication in carrying out the scientific reasoning and science practices that they've worked on in their small groups. There is often reference back to experiences during the launcher unit, as these are the activities that classroom scripts were originally learned from.

5. DISCOURSE, COLLABORATION, AND LEARNING

The examples at the beginning of this chapter show that at least some students in LBD classrooms are able to participate productively in LBD's classroom scripts and the collaborative discourse that goes with them. A variety of evidence of development of student discourse capabilities has been collected, most reported in research articles. Three very robust findings with respect to scientific discourse fall out of analyses:

1. Using performance assessments and comparing learners in LBD classes and learners in matched inquiry science classes, we find that LBD students consistently participate more and with better quality than non-LBD students in science practices and discourse. This comparison holds as early as right after the launcher unit and continues throughout the school year after students engage in additional LBD units (Kolodner et al., 2003; Gray et al., 2001).

2. When comparing the performance of LBD students early in the school year and later in the school year on these same performance assessments, their participation in discourse increases both in quantity and quality. The more LBD units they've engaged in, the more their discourse capabilities increase (Kolodner, Camp et al., 2003).
3. The more attention teachers focus on whole-class discussions at the end of discourse forums, the more participation in discourse increases over the school year. (Ryan, 2003; Ryan & Kolodner, 2004)

The first two results are consistent in data collected over a 5-year period – across matched classes, and with average ability, honors, rural, suburban, urban, low-income, and high-income populations. The third is based on less data but is no less significant. All of these results come from performance assessments in which students are asked to work in small groups, first to design an investigation, then to carry out an investigation, and then to interpret results and apply them. The science content in performance assessments is purposely at a basic level so that all participants have adequate science understanding to be able to participate. Data are coded for degree of collaboration, remindings of previous experiences, and quantity and quality of scientific discourse. Results pertaining to scientific discourse come from three coding categories: science content talk, science practice talk, and self-checking of science practice. Performance assessments are done in LBD classes after each unit, and those same performance assessments are done in classrooms matched to each LBD class later the same week or the week after. Content in performance assessments has always been covered in non-LBD classes.

The discussion below, for example (extracted from Kolodner et al., 2003), happened midway through the school year as students were deriving a procedure for measuring the speed of a battery-operated toy car. While the discourse certainly isn't fluent, it's quite good for middle-school students (grade eight; age 14); all of the students in the group participated, and they talked about science content (what is speed) and several science practice issues – what is expected of them, how to measure, what to measure, how to collect data, and what it would take to get trustworthy results ("three times and it will come about the same. ... it's got batteries.").

B2- We must have the measurements of the distance the car travels and the time that it took to travel. The average speed of the car. What if the car is not stopping? The car keeps going.

B1- You don't have to put how far it went. Just put the speed of it. Just put how fast it goes.

B2- I know but I am trying to figure out speed.

B1- Distance divided by time.

B2- We must have a measuring device.

B2- That wouldn't be the average speed.
B3- We just have to do it a couple of times.
B2- Just a couple of times and then divide by that number of times.
B1- You can find the speed of an object.
B3- It says average speed, John (name changed).
B1- Okay, just turn it on and let it go for about five seconds and then you'll get the same thing about every time.
B3- How about we make it start here[indicates one side of the table] and end it here [points to the other end of the table].
B1- You can just write. Do the test about two or three times and it will come about the same. Cause it is not like your balloon cars, it's got batteries.

In general, discourse among eighth graders doesn't look a lot like discourse among mature and knowledgeable grownups. The transcripts that go with the three examples at the beginning of this chapter have the same qualities as the discourse shown above – it is not always possible to figure out what the children mean, they interweave several conversations with each other, they intersperse real science discourse with discussions about hair, who has better handwriting, romantic interests, and the like. They don't always get to the depth we would like. And their discussions are often quite disconnected. For example, the discussion from the first example about straw length effecting mass looks like this:

JG: Don't you think when you're cutting the straw it's changing the mass?
AB: Uh, yeah.
MY: MV: (at same time) Yeah, that's the straw length.
KD: Yeah but that's the...
KD, KK: (at about same time) Straw length.
KD: You can't make it shorter, and not cut it, without changing the mass.
...
?: (at same time as KD) You could tape it.
CF: (at same time as KD) Yeah, but...
JG: (at same time as CF) You but it, you can just put the 10 cm through it in the, that part.
AB: (at same time as JG) But that's still not, that's not. something they tested.
...
KD: (talking over JG) (gesturing) Wouldn't it change the the mass of yours too?
JG: Yeah all the different air...
KD: All of the masses would change, in yours.

AB: Yeah, our mass changed too.

On the other hand, it is notoriously difficult to get eighth graders to participate in these kinds of discussions. LBD students participate far better than their matched counterparts in science discourse, and, in general, in scientific activity, and their participation gets better over time with additional practice. LBD students come to know the scripts for the classroom, and they come into the classroom ready to participate. During performance assessments, they move directly into the activities they are asked to do with little or no time needed to figure out what's expected (Kolodner et al., 2003).

6. CONCLUDING THOUGHTS

Many of the chapters in this book are about providing scripts to collaborators to help them carry on a conversation, and almost all are about on-line collaboration and instructional scripts that can be used to promote productive discourse on-line – all quite different from LBD's model. Nonetheless, the analysis of LBD, I think, can contribute several things to discussion about the potential role of scripts in promoting good collaborative discourse. First, LBD contributes the notion (a reminder, really) that while one can design sequences of events or activities to be used as scripts, it is important to remember that their use will depend on how well they are learned as scripts. Both the cognitive and socio-cultural literatures emphasize this. Such learning requires a combination of observation, participation, repetition, identification of the sequencing, understanding of the purposes of steps in the sequencing, and experience with and understanding of variations in the classroom scripts that promote discourse. Such learning may not happen quickly, and learners need a variety of opportunities for practicing to learn the basics of scripts and the variety of ways of engaging in each.

Second and related, it seems that learning how to participate in discourse is like learning how to participate in other cognitive activities and practices. Because the reasoning involved in participating is invisible, and because learning to participate requires reflective practice, there's a need for facilitating the learning of discourse practices that will be used in collaboration in the same way the learning of other reasoning activities and practices are facilitated. As such, as Collins et al. (1989) propose with respect to promoting learning of cognitive skills, promoting learning of discourse skills and practices might require such things as modeling behavior for observation, coaching, prompting, scaffolding, facilitating reflection and articulation of the steps, and so on. That is, participating in classroom scripts that promote certain kinds of discourse isn't enough. Classroom scripts need to match discourse needs, and instructional strategies need to include ways of introducing each classroom script and of promoting reflection on and articulation of their sequencing, purposes, variations, and so forth (making the invisible visible).

Third, effective collaboration is always about something. Our mode of encouraging good collaborative discourse in LBD has been to help learners learn how to engage proficiently in targeted reasoning. This gives collaborators tools they need for doing and critiquing reasoning together. LBD's activities don't directly teach ins and outs of collaborative discourse; rather, they teach children to reason scientifically, giving them reason to hold each other to high standards of scientific reasoning. This is probably not enough for all collaborative discourse, but it can go a long way.

How does this advice translate into design of computer-supported scripts for interaction? Computer-supported scripts, as any other kind of script, need to be designed to promote students taking on appropriate goals, to match perceived needs of learners, and in a complete system that takes into account what scripts need to be learned by learners, the kinds of scripted activities that would afford such learning, and the instructional strategies to promote targeted learning. Each designed classroom script needs to be enacted repeatedly and deliberatively and with modeling, coaching, and/or scaffolding in contexts of authentic need and use; each script needs to be introduced as a way of achieving perceived goals and deliberated over repeatedly so that learners will develop more embellished cognitive structures over time and with practice; and learners need scaffolded experience with the major variations of each script. Most importantly, I believe, is that the system of classroom scripts and instructional strategies needs to include opportunities for small-group as well as public (whole-class/large group) practice. Similar to what Vygotsky (1978) claims about learning in individuals, LBD's results show that small groups and individuals get better at collaborative discourse to the extent that they get to participate in, observe, reflect on, and identify the ins and outs of similar collaborative discourse that happens in public forums.

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