# Distance Education

## Effective peer interaction in a problem-centered instructional strategy

M. David Merrill [ab]; Clark G. Gilbert [c]
[a] Florida State University, Tallahassee, FL, USA
[b] Brigham Young University-Hawaii, USA
[c] Brigham Young University-Idaho, USA

PLEASE SCROLL DOWN FOR ARTICLE

Routledge
Taylor & Francis Group

# Effective peer interaction in a problem-centered instructional strategy

M. David Merrill[a, b]* and Clark G. Gilbert[c]

*[a]Florida State University, Tallahassee, FL, USA; [b]Brigham Young University–Hawaii, USA; [c]Brigham Young University–Idaho, USA*

This article suggests that peer interaction is most effective when orchestrated around a progression of problems. Problem-centered learning is enhanced by carefully structured peer interactions. Problem-centered instruction is a form of direct instruction wherein instructional components are taught in the context of problems. An effective problem-centered instructional strategy involves (a) facilitating learners' activation of relevant mental models, (b) demonstrating problem solutions to learners, (c) enabling learner application to the solution of new problems, and (d) facilitating integration into activities beyond the classroom by critique, discussion, and reflection. Instruction is most effective when there is appropriate peer interaction during each of these instructional phases: peer-sharing during activation, peer-discussion during demonstration, peer-collaboration during application, and peer-critique during integration.

**Keywords:** peer-collaboration; peer interaction; principles of instruction; problem-centered instruction

A colleague recently asked the lead author, 'Which is best: problem-centered instruction or learner-centered instruction?' Problem-centered learning, as described in this article, is a form of direct instruction and is often contrasted with learner-centered instruction, which involves a great deal of peer interaction. The question suggests that these two approaches are somehow competitive. There appears to be some debate, both in research and in practice, as to which strategy is more effective. But, must we choose one or the other?

Our analysis reveals that the question itself is misdirected. We find that peer interaction is most effective when thoughtfully orchestrated around a progression of problems to be solved. On the other hand, we find that the best problem-centered learning is enhanced by carefully structured peer interaction. This article will explore the relationship between problem-centered and learning-centered instruction. While we will not focus specifically on their application in online settings, we make the argument that online education that focuses primarily on peer interaction will be less effective than more collaborative strategies involving peer interaction in the context of a progression of problems to solve.

We believe that both problem-centered learning and peer-instruction are forms of learner-centered instruction. While the former is content focused and the latter is process focused, both require active engagement on the part of learners and, when effectively combined, learning is more effective than with either approach used in isolation.

---

*Corresponding author. Email: mdavid.merrill@gmail.com

## Peer-learning

For the past couple of decades there has been an increasing emphasis on peer-instruction (Crouch & Mazur, 2001; King, 1992; Mazur, 1997; Slavin, 1994). This pedagogical approach can be summarized as a teaching method where faculty design experiences that allow students to teach and learn from each other. Contrary to common perceptions, this definition implies that faculty are not only involved in the process of enabling peers to learn from each other, but that faculty design a reasonable degree of direction and structure in the peer-learning process itself. For example, the literature suggests that peer-instruction is most effective when there is some form of peer-scaffolding, which can take the form of worked problems, structured questions, and even evaluation rubrics (King, Staffieri, & Douglas, 1998; van Merriënboer & Kirschner, 2007).

Peer-learning communities are often justified by comparing them with communities of practice. However, there is a significant difference. Communities of practice are most often comprised of a community of experts who already have considerable skill in the area of interest. The primary purpose of a community of practice is to share this skill with one another. On the other hand, communities of learners are often composed of novices in the area under consideration and while learners have different skill sets often the community must seek the desired skills from some source outside the community. A recent review of the research over the past several decades shows that providing guidance in learner-centered instructional strategies is necessary if effective learning is to occur (Kirschner, Sweller, & Clark, 2006). How can the necessary guidance be provided in a learner-centered strategy while retaining the advantages that such a strategy provides?

## A problem-centered instructional strategy

The lead author has identified first principles of instruction from instructional design theories and models (Reigeluth, 1999; Reigeluth & Carr-Chellman, in press). When implemented in instructional products and learning environments, these principles facilitate effective, efficient, and engaging learning of complex real-world problems and tasks (Merrill, 2002, 2007a, 2007b, in press). These principles have been updated for this article to reflect our concern with peer interaction. They are listed in Appendix 1 at the end of this article.

A problem-centered strategy is central to a first-principles approach; that is to say, *learning is promoted when learners are engaged in a task-centered instructional strategy involving a progression of whole real-world tasks* (Merrill, 2007b). Figure 1 illustrates one version of such a task-centered instructional strategy.

*Problem-centered instruction* is contrasted with *problem-based instruction*. Many types of problem-based instruction have minimal guidance and often consist of giving a group of students a problem, providing resources that can be used to solve the problem, and then having the learners collaborate in finding a solution. In contrast, problem-centered instruction provides a carefully sequenced progression of problems. Early in the sequence learners are taught component skills and the problem solution is demonstrated for learners. Learners then work through the sequence of problems, doing more and more of the problem-solving process until they are able to complete the solution of conventional problems without further guidance. Conventional problems are those which provide the givens and the criteria for a solution but leave the problem-solving process and the solution to the students (van Merriënboer & Kirschner, 2007; see especially pp. 46–48).
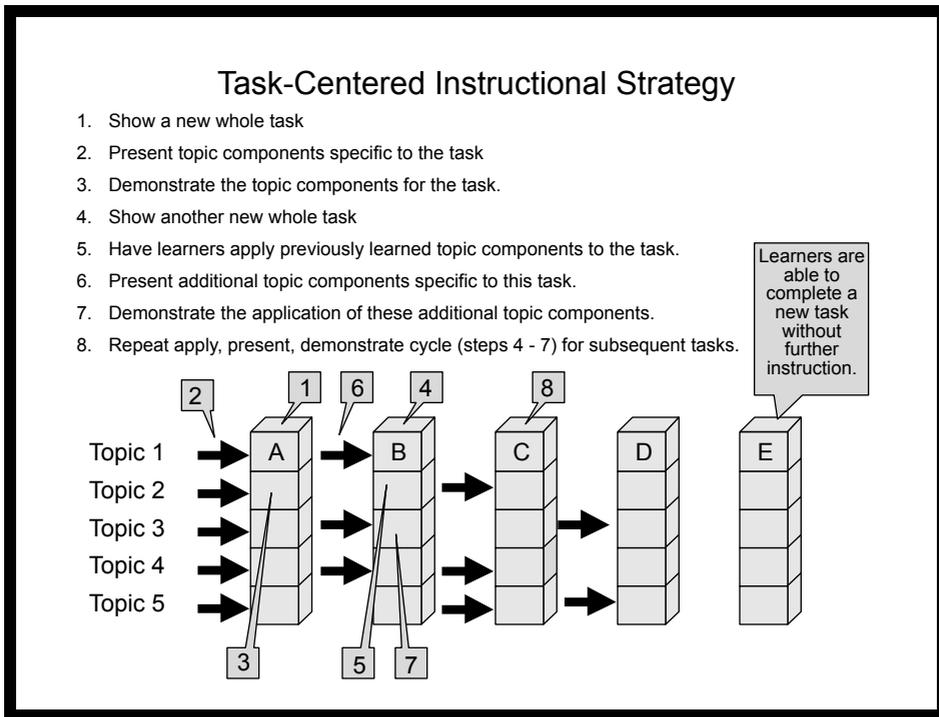
## Task-Centered Instructional Strategy

1. Show a new whole task

2. Present topic components specific to the task

3. Demonstrate the topic components for the task.

4. Show another new whole task

5. Have learners apply previously learned topic components to the task.

6. Present additional topic components specific to this task.

7. Demonstrate the application of these additional topic components.

8. Repeat apply, present, demonstrate cycle (steps 4 - 7) for subsequent tasks.

Learners are able to complete a new task without further instruction.

Topic 1  A  B  C  D  E

Topic 2

Topic 3

Topic 4

Topic 5

Figure 1.   A task-centered instructional strategy.

## Rationale

Why is a problem- or task-centered instructional strategy more effective than a topic-centered instructional strategy? Before we move to how peer interaction works in the context of a problem-centered instructional strategy, we must first make the case for problem-centered learning. There is not room in this article for an in-depth discussion of cognitive psychology but the following is a brief explanation for the role that problems or whole tasks play in the learning process. It is generally agreed that there are at least two distinct cognitive processes involved in learning. One process might be characterized as *associative memory*. In this type of learning items are linked together in memory such that when one item is presented the learner can recall the other item. We have all experienced this type of learning when we memorize a set of facts or relationships for later recall on an exam. This type of learning is highly subject to forgetting and requires considerable rehearsal to establish stable associations. With significant practice such associations can become automated.

The other process might be characterized as *mental models* (Gentner & Stevens, 1983; Johnson-Laird, 1983; Oakhill & Garnham, 1996), which are more holistic representations of phenomena that occur in the learner's world. In a mental model, a set of ideas are related together in a meaningful way in a holistic representation of the parts, relationships, conditions, actions, and consequences of a complete problem or task. Mental models tend to be more stable and resist forgetting. Some authors refer to mental models as transient whereas schemas are felt to be stable. We used the term mental model for either of these mental constructs. When a new situation is confronted, the learner attempts to relate the

new phenomena to an existing mental model. Without guidance learners often choose previous models that may not be appropriate for the new situation. The activation principle states that *learning is promoted when learners activate relevant cognitive structures by being directed to recall, describe, or demonstrate relevant prior knowledge or experience*. The implementation of this principle in an instructional situation is an attempt on the part of the instructor to help the learner activate a relevant mental model that can be adapted, modified, or expanded to apply to the current problem or task. The result of interacting with the problem and the component skills involved in the problem is the development of a new mental model or a significantly modified existing mental model that integrates the component skills of the problem or task into some kind of holistic representation.

A topic-centered approach to instruction often fragments the components of a whole problem or task by presenting these components one by one often with the caution, 'You may not understand this now but later it will be very important to you.' Only at the end of an instructional sequence, after a number of component skills have been presented, is the learner required to put all the component skills together to solve a problem or do a whole task. It isn't until this point in the instruction that the learner is able to activate a relevant mental model. As the components are presented learners are often forced to rely on associative memory to remember the component skills until they are required to use them for the final project. Too often by this time some of the component skills, because they were not related to an appropriate mental model, have already been forgotten.

On the other hand, a problem- or task-centered approach to instruction enables the learner to adapt an existing mental model, activated early in the instructional sequence, to the new phenomena. The component skills can then be integrated into the mental model in a meaningful way. The learner is not forced to rely only on associative memory for a period of time before the skills are required for the whole problem or task.

In short, a problem- or task-centered approach facilitates the adaptation of an existing mental model or enables the learner to form a new mental model that integrates the various component skills into a meaningful whole.

### Why does peer interaction facilitate learning in a problem-centered approach?

While the initial instruction consisting of activation, demonstration, and application enables the learner to form a mental model, the appropriate interaction with peers (integration) enables the learner to tune this model, helping to stabilize the mental model and making it more flexible and adaptable to new situations. Mental models are most appropriate for complex phenomena, where there is not a single solution or a single path to a solution. When learners are required to collaborate with a fellow student or to critique the work of a fellow student they are required to test their mental model of the phenomena against the process or product resulting from the mental model of a peer. When there is a discrepancy learners have to examine their own models more carefully and either make accommodation to the variations they observe or defend their own view as a more adequate interpretation of the phenomena under consideration. Both of these activities require them to adjust or tune their mental model.

Most students are motivated by the reaction of their peers. Peer-collaboration requires deeper processing for students to make their intent clear to their collaborators. In doing so it encourages students towards a deeper processing of the information and a more careful examination of their assumptions. Furthermore, more and more real-world problems are solved by teams of people rather than by individuals working in isolation. Peer interaction

in a problem-solving situation replicates more closely the environment learners are likely to encounter in their world following instruction.

### *Why is peer interaction less effective when not in the context of a progression of problems to solve?*

Many forms of peer interaction are possible. When one thinks of peers teaching peers it is tempting to consider this activity as the dissemination of information, *peer-telling*. We see this form of peer-telling when learners are asked to read papers and present them to the rest of the class or when learners are asked to each select a chapter and present the information to a study group. Having peers present information is perhaps the least effective form of peer interaction much as having a teacher dispense information is perhaps the most ineffective form of teaching. The learning involved in peer-telling often requires only associative memory rather than the activation of mental models. Peer-telling may help learners remember the information but does little to help them learn to solve problems or complete complex tasks. Except in rare situations where an expert may be explaining a new concept or procedure that has not previously been documented, such dissemination of information is better handled by other forms of communication. In an instructional situation providing new information is always better when communicated in ways other than merely telling.

Not only do problems help prevent peer-telling, but also they provide needed structure and guidance for effective peer interaction (Kirschner et al., 2006). The effective use of well-structured problems in the context of peer interaction directs that discussion toward a specific learning objective and forces the tuning of mental models described earlier. Problems also provide a way of measuring learning outcomes as they emerge from a peer interaction. For example, peer-instruction in Physics teaching uses concept tests, conceptual problems presented to students prior to a process of peer-discussion, where they are then allowed to try to convince fellow students why they have the right solutions (Crouch & Mazur, 2001; Hake, 1998). What is interesting about this example is that even though the approach is described in the literature as 'peer-instruction,' the empirical data supporting this effective learning always demonstrates the use of a 'problem' in the context of the peer interaction.

### Progression of real-world problems

The central principle for effective instruction is that *learning is promoted when learners are engaged in a task-centered instructional strategy involving a progression of whole real-world tasks* as illustrated in Figure 1. This same principle is a key to effective peer interaction. Having peers interact with peers is far more effective when this interaction is in the context of acquiring the ability to solve a progression of real-world problems. If problems are carefully selected and specified then this progression and the accompanying component instruction provide the necessary learner guidance to enable learners to develop a new mental model or adapt an existing mental model appropriate for doing the tasks or solving the problems. Peer interactions are also facilitated when there is a carefully designed progression of problems because tuning each new problem forces learners to accommodate their mental model to the new situation and the peer-collaboration or critique causes them to tune their mental model to be more flexible to adapt to the variations that may exist for doing each task or solving each problem in the sequence.

In the remainder of this article we will describe different forms of peer interactions that are most appropriate at various stages during a task-centered instructional strategy.

### Peer-sharing – Activation Principle

*Learning is promoted when learners activate relevant cognitive structures by being directed to recall, describe, or demonstrate relevant prior knowledge or experience.* Having learners share relevant experience with one another is an appropriate way to provide this activation experience. The learners who are relating their experience are activating their previously acquired schema. Learners who are listening to these experiences are being provided new vicarious experience which in turn activates their previous experience and the associated mental models.

### Peer-discussion and peer-demonstration – Demonstration Principle

*Learning is promoted when learners observe a demonstration of the skills to be learned that is consistent with the type of content being taught.* The best form of problem for this demonstration are case studies or worked examples 'including an acceptable solution for the problem, and, if possible, the problem solving process that can be used for generating the solution' (van Merriënboer & Kirschner, 2007, p. 44). For complex problem cases a set of carefully constructed questions that require learners to examine the case in considerable detail and to challenge their understanding significantly improves the value of the case. Having learners discuss these questions with one another is another form of effective peer interaction that requires those involved in the discussion to tune their mental models representing the case(s). After seeing a demonstration of the task to be learned having learners find and demonstrate another case study or worked example of the problem is an effective peer-instructional activity. Finding another worked example of the problem expands the number and variety of instances for both those finding the new examples and those seeing the demonstration of the new examples.

### Peer-collaboration – Application Principle

*Learning is promoted when learners engage in application of their newly acquired knowledge and skill that is consistent with the type of content being taught.* Having demonstrated the problem with cases the students should then have the opportunity to solve conventional problems. These problems should be complex, ill-structured problems. Assigning learners to work in groups and to collaborate in the solution of these problems is another form of effective peer interaction. This is similar to the type of peer-collaboration that occurs in more open problem-based learning but in this situation learners have had an opportunity to acquire the required component knowledge and skill and to interact with demonstrations of cases illustrating the whole task before they are asked to engage in the solution of conventional problems.

### Peer-critique – Integration Principle

*Learning is promoted when learners integrate their new knowledge into their everyday life by being directed to reflect on, discuss, or defend their new knowledge or skill.* Having engaged in collaborative problem solving the appropriate form of peer interaction in this final stage of a problem-centered strategy is to engage in peer-critique. Learners critique each other's work. An effective rule for this type of interaction is constructive criticism, that is, any criticism must be accompanied by recommendations for improving the solution or problem-solving process. Another effective peer interaction at this stage in the

strategy is to have students collaborate to extend the problem solution to situations they are likely to encounter in their everyday life. This creative extension can also include peer-critique.

Although we have presented each of these principles in turn it is important to realize that in an actual instructional situation there is a flow among the various stages in the learning cycle described by first principles. Peer-sharing during the activation phase should flow smoothly and perhaps overlap peer-discussion and peer-demonstration in the demonstration phase. Peer-demonstration and peer-discussion should also overlap peer-collaboration. And peer-critique from the integration phase should obviously take place simultaneously with peer-collaboration in the application phase. From learners' point of view the phases should be a seamless flow of activities leading to mastery of the problem-solving or complex tasks that are the focus of the instruction.

## Summary

In this article we have suggested that the most effective form of peer interaction in learning communities is for this interaction to take place in the context of a progression of real-world problems where learners are engaged in sharing experience early in the sequence, are engaged in discussing and demonstrating cases to each other as a second stage in the sequence, are engaged in collaborative problem solving after the demonstration phase, and are involved in peer-critique and collaborative problem extension later in the process. We have suggested that a progression of real-world problems provides the structure for learners to develop appropriate mental models for solving these types of problems. We have further suggested that engaging in peer interaction enables learners to tune their mental models to accommodate the variety of processes and solutions that may be appropriate for solving a given class of problems.

## Notes on contributors

M. David Merrill is a volunteer at Brigham Young University–Hawaii (2008–2009) in the Center for the Improvement of Instruction and Outreach (CITO). He is also a visiting professor at Florida State University.

Clark G. Gilbert is the managing director of Student Activities and Peer-Instruction at Brigham Young University–Idaho.

## References

Crouch, C.H., & Mazur, E. (2001). Peer instruction: Ten years of experience and results. *American Journal of Physics, 69*(9), 970–977.

Gentner, D., & Stevens, A.L. (Eds.). (1983). *Mental models.* Hillsdale, NJ: Lawrence Erlbaum Associates.

Hake, R.R. (1998). Interactive engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics, 66*(1), 64–74.

Johnson-Laird, P.N. (1983). *Mental models: Toward a cognitive science of language, inference, and consciousness.* Cambridge, MA: Harvard University Press.

King, A. (1992). Facilitating elaborative learning through guided student-generated questioning. *Educational Psychologist, 27,* 111–126.

King, A., Staffieri, A., & Douglas, A. (1998). Mutual peer tutoring: Effects of structuring tutorial interaction to scaffold peer learning. *Journal of Educational Psychology, 90,* 134–152.

Kirschner, P.A., Sweller, J., & Clark, R.E. (2006). Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. *Educational Psychologist, 41*(2), 75–86.

Mazur, E. (1997). *Peer instruction: A user's manual.* Upper Saddle River, NJ: Prentice Hall.

Merrill, M.D. (2002). First principles of instruction. *Educational Technology, Research and Development, 50*(3), 43–59.

Merrill, M.D. (2007a). First principles of instruction: A synthesis. In R.A. Reiser & J.V. Dempsey (Eds.), *Trends and issues in instructional design and technology* (2nd ed., *Vol. 2,* pp. 62–71). Upper Saddle River, NJ: Merrill/Prentice Hall.

Merrill, M.D. (2007b). A task-centered instructional strategy. *Journal of Research on Technology in Education, 40*(1), 33–50.

Merrill, M.D. (in press). First principles of instruction. In C.M. Reigeluth & A. Carr-Chellman (Eds.), *Instructional design theories and models (Vol. III).* Mahwah, NJ: Lawrence Erlbaum Associates.

Oakhill, J., & Garnham, A. (1996). *Mental models in cognitive science: Essays in honour of Phil Johnson-Laird.* Hove: Psychology Press.

Reigeluth, C.M. (Ed.). (1999). *Instructional-design theories and models: A new paradigm of instructional theory (Vol. II).* Mahwah, NJ: Lawrence Erlbaum Associates.

Reigeluth, C.M., & Carr-Chellman, A. (Eds.). (in press). *Instructional design theories and models (Vol. III).* Mahwah, NJ: Lawrence Erlbaum Associates.

Slavin, R.E. (1994). *Cooperative learning: Theory, research and practice* (2nd ed.). Boston: Allyn & Bacon.

van Merriënboer, J.J.G., & Kirschner, P.A. (2007). *Ten steps to complex learning.* Hillsdale, NJ: Lawrence Erlbaum Associates.

## Appendix 1. First principles of instruction
### *Task-centered principle*

- Learning is promoted when instruction is in the context of **whole real-world tasks**.
- Learning is promoted when learners are engaged in a **task-centered** instructional strategy involving a **progression** of whole real-world tasks.

### *Activation principle*

- Learning is promoted when learners **activate** relevant cognitive structures by being directed to recall, describe, or demonstrate relevant **prior knowledge** or experience.
- Activation is enhanced when learners **share** previous experience with one another.
- Activation is enhanced when learners recall or acquire a **structure** for organizing new knowledge, when this structure is the basis for guidance during demonstration, is the basis for coaching during application, and is a basis for reflection during integration.

### *Demonstration principle*

- Learning is promoted when learners observe a **demonstration** of the skills to be learned that is **consistent** with the type of content being taught.
- Demonstrations are enhanced when learners are **guided** to relate general information or an organizing structure to specific instances.
- Demonstrations are enhanced by **peer-discussion** and **peer-demonstration**.
- Demonstrations are enhanced when learners observe **media** that is relevant to the content and appropriately used.

### *Application principle*

- Learning is promoted when learners engage in **application** of their newly acquired knowledge or skill that is **consistent** with the type of content being taught.
- Application is effective only when learners receive intrinsic or corrective **feedback**.
- Application is enhanced when learners are coached and when this **coaching** is gradually withdrawn for each subsequent task.
- Application is enhanced by **peer-collaboration** and **peer-critique**.
- Application is enhanced when learners observe **media** that is appropriately used.

### *Integration principle*

- Learning is promoted when learners **integrate** their new knowledge into their everyday life by being directed to reflect-on, discuss, or defend their new knowledge or skill.
- Integration is enhanced by **peer-discussion** and **peer-critique**.
- Integration is enhanced when learners create, invent, or explore **personal ways** to use their new knowledge or skill.
- Integration is enhanced when learners **publicly demonstrate** their new knowledge or skill.