Designing Constructivist Learning Environments

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论著选摘

Introduction引言

Objectivist conceptions of learning assume that knowledge can be transferred from teachers or transmitted by technologies and acquired by learners. Objectivist conceptions of instructional design include the analysis, representation, and resequencing of content and tasks in order to make them more predictably and reliably transmissible.

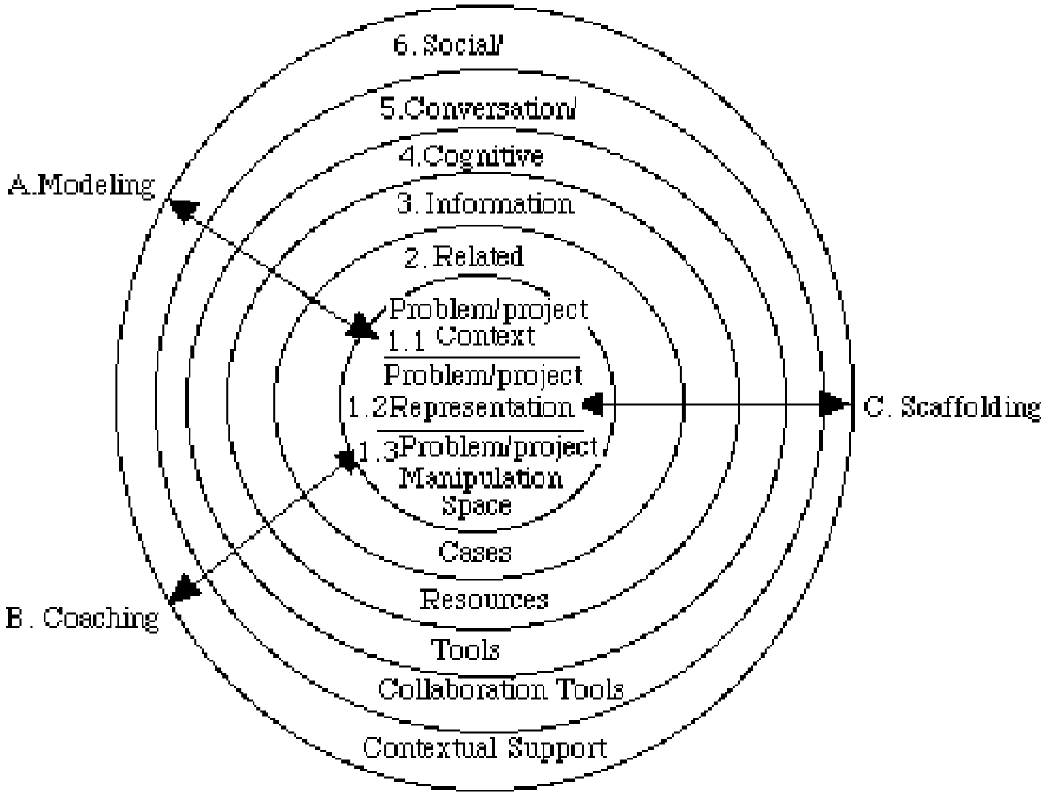
客观主义的学习观念认为知识可以通过技术手段由教师转化再为学生所吸收。教学设计的客观主义观念包括教学内容和任务的分析、表征和重组以期知识的可预测可靠传输。

Constructivist conceptions of learning, on the other hand, assume that knowledge is individually constructed and socially co-constructed by learners based on their interpretations of experiences in the world. Since knowledge cannot be transmitted, instruction should consist of experiences that provide interpretable experiences and facilitate knowledge construction. This chapter presents a model for designing constructivist learning environments (CLEs) that engage learners in meaning making (knowledge construction). For an elaboration of the assumptions and beliefs on which CLEs are based, see Duffy & Jonassen, 1992; Jonassen, 1991, 1995a, 1995b, 1996a; Jonassen, Campbell, & Davidson, 1994; Jonassen, Peck, & Wilson, 1998; Savery & Duffy, 1995.

另一方面，建构主义的学习观念认为学习者在对整个世界的经验解释的基础之上通过个体建构和社会化建构获得知识。既然知识不能进行传播，教学应该将经验考虑在内，同时应促进建构。这一部分提供了设计建构主义学习环境的模型使得学习者实现意义上的知识建构。欲参考CLE的理论基础以及有关观点，请参考Duffy & Jonassen, 1992; Jonassen, 1991, 1995a, 1995b, 1996a; Jonassen, Campbell, & Davidson, 1994; Jonassen, Peck, & Wilson, 1998; Savery & Duffy, 1995.

While objectivism and constructivism are usually conveyed is incompatible and mutually exclusive, that is not an assumption of this chapter. Rather, I believe that objectivism and constructivism offer different perspectives on the learning process from which we can make inferences about how we ought to engender learning. The goal of my writing and teaching is not to reject or replace objectivism. To impose a single belief or perspective is decidedly non-constructivistic. Rather I prefer to think of them as complementary (some of the best environments use combinations of methods) design tools to be applied in different contexts.

虽然客观主义和建构主义是互斥的，但并不作为本文的前提假设。而且，我认为客观主义和建构主义对整个学习过程提出了不同见解，依此我们能够领悟到应该如何促进学习，这两种观点在不同的情境中是互补的设计模型。



Model for Designing Constructivist Learning Environments

The model for designing CLEs (Figure 1) illustrates their essential components. The model conceives of a problem, question, or project as the focus of the environment, with various interpretative and intellectual support systems surrounding it. The goal of the learner is to interpret and solve the problem or complete the project. Related cases and information resources support understanding of the problem and suggest possible solutions; cognitive tools help learners to interpret and manipulate aspects of the problem; conversation/collaboration tools enable communities of learners to negotiate and co-construct meaning for the problem; and social/contextual support systems help users to implement the CLE.

模型以一个问题或项目为整个环境的焦点，周围有各种解释和智能支持系统。学习者的目的是解决问题或完成项目。相关案例和信息资源有助于问题理解和可行性方案的提出；认知工具帮助学习者解释和把握问题的各个方面；交谈/协作工具使学习群互相交流对问题进行意义建构，社会/情境支持系统帮助使用者实现建构学习环境。。

1. Question/Case/Problem/Project问题/案例/项目

The focus of any CLE is the question or issue, the case, the problem, or the project that learners attempt to solve or resolve. It constitutes a learning goal that learners may accept or adapt. The fundamental difference between CLEs and objectivist instruction is that the problem drives the learning, rather than acting as an example of the concepts and principles previously taught. Students learn domain content in order to solve the problem, rather than solving the problem as an application of learning.

与客观主义完全不同，建构学习环境是问题用来驱动学习，而不是象原来那样充当概念原理的例子。学习是为了解决问题而不是把解决问题看成是学习的一个应用。

CLEs can be constructed to support question/issue-based, case-based, project-based, or problem-based learning. Question- or issue-based learning begins with a question with uncertain or controversial answers (e.g., Should welfare recipients be required to work? Should environmental protection seek to eliminate pollution or regulate according to location-sustainable standards?). In case-based learning, students acquire knowledge and requisite thinking skills by studying cases (e.g. legal, medical, social work) and preparing case summaries or diagnoses. Case learning is anchored in authentic contexts; learners must manage complexity and think like practitioners (Williams, 1992). Project-based learning focuses on relatively long-term, integrated units of instruction where learners focus on complex projects consisting of multiple cases. They debate ideas, plan and conduct experiments, and communicate their findings (Krajcik, Blumenfeld, Marx, & Soloway, 1994). Problem-based learning (Barrows & Tamblyn, 1980) integrates courses at a curricular level, requiring learners to self-direct their learning while solving numerous cases across a curriculum. Case-, project-, and problem-based learning represent a continuum of complexity, but all share the same assumptions about active, constructive, and authentic learning. CLEs can be developed to support each of these, so for purposes of this chapter, which seeks to present a generic design model, I will refer to the focus of the CLEs generically as a problem.

问题/案例/项目均代表了连续性的复杂问题，均采用主动、建构、真性学习。本文以问题解决为例。

Since the key to meaningful learning is ownership of the problem or learning goal, you must provide interesting, relevant, and engaging problems to solve. The problem should not be overly circumscribed. Rather, it should be ill-defined or ill-structured, so that some aspects of the problem are emergent and definable by the learners. Why? Without ownership of the problem, learners are less motivated to solve or resolve it. Contrast ill-structured problems with most textbook problems, which require practice of a limited number of skills to find the correct answer without helping to shape or define the problem. Ill-structured problems, on the other hand:

?have unstated goals and constraints,

?possess multiple solutions, solution paths, or no solutions at all,

?possess multiple criteria for evaluating solutions,

?present uncertainty about which concepts, rules, and principles are necessary for the solution or how they are organized,

?offer no general rules or principles for describing or predicting the outcome of most cases, and

?require learners to make judgments about the problem and to defend their judgments by expressing personal opinions or beliefs (Jonassen, 1997).

作为建构学习的关键，提出的问题应具有很大的吸引力，不应过分局限，甚至可以是非良构的，问题的一些方面是自然出现的甚至可诱发学生自行定义。课本上有限技巧点的练习在的到正确答案的过程中学生并未构建或定义问题，而非良构问题具有以下特点：

无显示目标和限制条件；有多解、多解法或者无解；有多种评判答案的标准；问题的概念理论基础的必要性及其组织具有不确定性；描述和预测大量案例时没有通则；要求学习者对问题做出判断并通过发表自己的观点来维护判断。

建构主义学习环境中问题的界定不是该领域书本中的知识点而是该领域的工作者在实际工作中所要解决的问题。

How can you identify problems for CLEs? Examine the field of study, not for its topics (as in a textbook) but for what practitioners do. You need only ask experienced practitioners to describe cases, situations, or problems that they have solved. Newspapers and magazines are replete with problems and issues that need resolution. Ask yourself, "What do practitioners in this field do?" In political science, students may construct a viable constitution for an emerging third world democracy that can accommodate the social, cultural, political, and historical characteristics of the population and their relationship with other countries in the region. In philosophy, render judgments on ethical dilemmas, such as right-to-die cases or same-sex marriages. In science, decide whether a local stream can accommodate a new sewage treatment plant. You need to evaluate all suggested problems for their suitability. Do your students possess prerequisite knowledge or capabilities for working on this problem? Do not assume that they will produce solutions as elegant or efficient as experienced practitioners. That is not the goal. Rather the goal is to learn about the field by thinking like a member of that practice community.

教师要考虑问题是否合适，学生是否具有该问题的预备知识。解决问题的目的不是期望学生一定就给以恰倒好处的答案，而是让学生了解这个领域，成为其中的一员。

Problems in CLEs need to include three integrated components: the problem context, the problem representation or simulation, and the problem manipulation space. In order to develop a CLE, you should try to represent each in the environment.

建构学习环境中的问题有三个要素：

问题上下文：描述问题产生的背景，学习者的特点

问题表述及模拟：具有吸引力的表征（虚拟现实、高质量视频）

问题操作空间：学习者感知真实问题所需要的工具、信号等以构架一个真实的学习环境

1.1. Problem Context

An essential part of the problem representation is a description of the context in which it occurs. Tessmer and Richey (1997) have developed a conceptual model and set of processes for analyzing and mapping the physical, organizational, and sociocultural context in which problems occur. The same problem in different social or work contexts is different. CLEs must describe in the problem statement all of the contextual factors that surround a problem.

Performance environment. You should describe the physical, sociocultural, and organizational climate surrounding the problem. Where and in what time frame does it occur? What physical resources surround the problem? What is the nature of the business, agency, or institution in which the problem occurs? What do they produce? Provide annual reports, mission statements, balance sheets, and profit-and-loss statements if they appropriately describe the situation. What is the history of the setting? This information should be made available to learners in order to understand the problem.

Community of practitioners/performers/stakeholders. What are the values, beliefs, socio-cultural expectations, and customs of the people involved? Who sets policy? What sense of social or political efficacy do the members of the setting or organization feel? What are the skills and performance backgrounds of performers? Provide resumes for key players that describe not only their experience, but also their hobbies, traits, and beliefs. You can also convey this information in stories or interviews with key personnel in the form of audio or video clips. It is the community of participants who define what learning occurs in a context. Learning is not an isolated event. Rather it is an incidental by-product of participation in that community (Lave & Wenger, 1991), so knowing what that community believes is important.

1.2. Problem Representation/Simulation

The representation of the problem is critical to learner buy-in. It must be interesting, appealing, and engaging. It must perturb the learner. The Cognition and Technology Group at Vanderbilt (1992) insists on high-quality video scenarios for introducing the problem and engaging learners. Virtual reality may become the default method for representing problems soon. An effective, low-tech method for representing problems is narrative. The problem context and problem representation become a story about a set of events which leads up to the problem that needs to be resolved. The narrative may be presented in text, audio, or video. Effective examples of narrative forms of problem representations are the instructional design cases by Lindeman, Kent, Kinzie, Larsen, Ashmore, and Becker (1996; http://curry.edschool.virginia. edu/go/ITCases/). In these cases, characters are developed who interact in realistic ways to introduce the case problem. Stories are also the primary means of problem representation and coaching in goal-based scenarios (Schank, this volume). The problem presentation simulates the problem in a natural context. Stories are a natural means for conveying them.

Authentic. Nearly every conception of constructivist learning recommends engaging learners in solving authentic problems. What is authentic? Some designers insist that authentic refers to supporting the performance of specific real-world tasks. This restrictive conception of authenticity will render learning environments that are authentic in a narrow context. Most educators believe that authentic means that learners should engage in activities which present the same "type" of cognitive challenges as those in the real world (Honebein, et al, 1993; Savery & Duffy, 1996), that is, tasks which replicate the particular activity structures of a context.

Activity structures rely on the socio-historical context of Activity Theory (Leontev, 1979), which focuses on the activities in which community members engage, the goals of those activities, the physical setting that constrains and affords certain actions, and the tools that mediate activity. Activity Theory provides an effective lens for analyzing tasks and settings and a framework for designing CLEs (Jonassen & Rohrer-Murphy, 1998).

Another method for isolating required activity structures is cognitive task analysis using the PARI approach (Hall, Gott, & Pokorny, 1994). The PARI (precursor - action - result - interpretation) method uses pairs of experts to pose questions and think aloud while solving complex problems. It identifies not only the activities that are engaged in while solving a problem, but also the domain knowledge and strategic knowledge that enable solution of the problem. Activity structures can be evaluated within any community context for their relevance and importance to that community.

Authentic can simply mean personally relevant or interesting to the learner. The Jasper series, for instance, provides engaging problems, conveyed in high quality video, that middle school students identify with, even though most students have never experienced that kind of problem or context. Authentic problems, for purposes of designing CLEs, engage learners; they represent a meaningful challenge to them.

1.3. Problem Manipulation Space

A critical characteristic of meaningful learning is mindful activity. In order for learners to be active, they must manipulate something&emdash;construct a product, manipulate parameters, make decisions&emdash;and affect the environment in some way. Activity theory describes the transformational interactions between the learner, the object that the learner is acting on, and the signs and tools which mediate that interaction. The problem manipulation space provides the objects, signs, and tools required for the learner to manipulate the environment. Why? Students cannot assume any ownership of the problem unless they know that they can affect the problem situation in some meaningful way.

The form of the problem manipulation space will depend on the nature of the activity structures the CLE is engaging. However, it should provide a physical simulation of the real-world task environment&emdash;that is, a phenomenaria (Perkins, 1995). Phenomenaria or microworlds present a simplified model, along with observation and manipulation tools necessary for testing their hypotheses about their problems (Jonassen, 1996a). Learners are directly engaged by the world they explore, because they can experiment and immediately see the results of their experiment. If constructing a constitution, show the social, political, and military results of each of the articles included. Ethical judgments might be tested with briefs from real court cases. Stream models can be created to graphically illustrate the effects of contaminants and clean-up activities. Problem manipulation spaces are causal models that enable students to test the effects of their manipulations, receiving feedback through changes in the appearance of the physical objects they are manipulating or in the representations of their actions, such as charts, graphs, and numerical output. They should be manupulable (allow learners to manipulate objects or activities), sensitive (ensure the environment responds in realistic ways to learner manipulations), realistic (have high fidelity of simulation), and informative (provide relevant feedback). Later, I will describe dynamic modeling tools (a combination of problem manipulation space and cognitive modeling tools) that enable learners to construct and test their own models of task worlds.

In creating problem manipulation spaces, it is not always necessary for learners to manipulate physical objects or simulations of those objects. It may be sufficient merely to generate a hypothesis or intention to act and then to argue for it. When engaging learners in solving ill-structured problems, requiring learners to articulate their solutions to problems and then develop a coherent argument to support that solution is often sufficient (Jonassen, 1997). The argument is an excellent indicator of the quality of domain knowledge possessed by the learner. However, argumentation skills in most learners are underdeveloped, so it will be necessary to scaffold or coach the development of cogent arguments, perhaps using argument templates or checklists (described later under conversation tools).

2. Related Cases相关案例

Understanding any problem requires experiencing it and constructing mental models of it. What novice learners lack most are experiences. This lack is especially critical when trying to solve problems. So, it is important that CLEs provide access to a set of related experiences to which novice students can refer. The primary purpose of describing related cases is to assist learners in understanding the issues implicit in the problem representation. Related cases in CLEs support learning in at least two ways: by scaffolding student memory and by enhancing cognitive flexibility.

任何问题的理解都需要经历之或对它构建了对该案例的脑图示。新手缺少的是经验，而这又是解决问题所不可或缺的。建构学习环境在为新手提供相关经验上起着举足轻重的作用。描述相关案例的主要目的是帮助学习者理解这个问题中隐含的论题。建构学习环境中相关案例以两种方式支持学习：排挤学生记忆和增强认知灵活性

2.1. Scaffold Student Memory: Case-based Reasoning

排挤学生记忆：基于案例的推理

The lessons that we understand the best are those in which we have been most involved and have invested the greatest amount of effort. Related cases can scaffold (or supplant) memory by providing representations of experiences that learners have not had. They cannot replace learners' involvement, but they can provide referents for comparison. When humans first encounter a situation or problem, they naturally first check their memories for similar cases that they may have solved previously (Polya, 1957). If they can recall a similar case, they try to map the previous experience and its lessons onto the current problem. If the goals or conditions match, they apply their previous case. By presenting related cases in learning environments, you are providing the learners with a set of experiences to compare to the current problem or issue.

学习者遇到新型案例时，往往会联想影射以前熟悉的案例。针对这种情况，建构学习环境应提供与当前问题相似的问题和观点，提供的问题应具有代表性并给以各种方式的相似点索引，以唤起学习者的记忆进行相关案例的推理，由已知感知未知。

Case-based reasoning argues that human knowledge is encoded as stories about experiences and events (Schank, 1990; Chapter 7). So, when people experience a problem or situation that they do not understand, they should be told stories about similar situations that function as lessons for the current problem. Learners retrieve from related cases advice on how to succeed, pitfalls that may cause failure, what worked or didn't work, and why it didn't work (Kolodner, 1993). They adapt the explanation to fit the current problem.

In order to provide a rich set of related cases that will help learners to solve the current one, it is necessary to collect a set of cases that are representative of the current one (those with similar contexts, solutions, or results), identify the lessons that each can teach, characterize the situations in which each case can teach its lesson, and develop an index and represent its features in a way that allows cases to be recalled (Kolodner, 1993). If constructing a constitution, provide examples of constitutions from other emerging democracies, along with descriptions of social and political consequences (e.g. newspaper or magazine clippings, video footage). In a case-based learning environment in transfusion medicine, we provided a set of related cases that could be accessed by medical students who were involved in solving new cases in transfusion medicine (Jonassen, Ambruso, & Olesen, 1992). Case reviews were indexed to each of the practice cases based on the similarities in symptomology, pathophysiology, and so on. Learners were provided the opportunity in every case to review related cases. Developing a story index, representing those stories, and providing access to them at appropriate times is difficult but very effective.

Another way of scaffolding (or supplanting) memory for novices is to provide worked examples of problems (described later).

2.2. Enhance Cognitive Flexibility

增强认知灵活性

Related cases also help to represent complexity in CLEs by providing multiple perspectives, themes, or interpretations on the problems or issues being examined by the learners. Instruction often filters out the complexity that exists in most applied knowledge domains, causing shallow understanding of domain knowledge to develop.

通过提供一个问题的多哥观点、论题、解释，在建构学习环境中相关案例体现了复杂性。许多应用学科的教学通常会滤掉复杂的部分，最终造成对整个领域知识的粗浅理解。

认知灵活性理论，作为建构学习环境中设计相关案例的一个重要模型，提供了知识内容的多种表征以期传送知识领域的内在复杂性。为增强认知灵活性，对当前案例提供体现多种观点的相关案例是尤为重要的。通过对比这些案例，学习者建构出他们自己的解释。

An important model for designing related cases in CLEs, cognitive flexibility theory, provides multiple representations of content in order to convey the complexity that is inherent in the knowledge domain (Jonassen, 1993; Spiro et al, 1987). Stress the conceptual interrelatedness of ideas and their interconnectedness by providing multiple interpretations of content. Use multiple, related cases to convey the multiple perspectives on most problems. To enhance cognitive flexibility, it is important that related cases provide a variety of viewpoints and perspectives on the case or project being solved. For instance, if resolving ethical dilemmas, provide divergent personal interpretations of the dilemma as well as interpretations of similar ethical conundrums, in order to convey thematic perspectives. By contrasting the cases, learners construct their own interpretations.

3. Information Resources

信息资源

In order to investigate problems, learners need information about the problem, in order to construct their mental models and formulate hypotheses that drive the manipulation of the problem space. So, when designing CLEs, you should determine what kinds of information the learner will need in order to understand the problem. Rich sources of information are an essential part of CLEs. CLEs should provide learner-selectable information just-in-time.。 CLEs assume that information makes sense only in the context of a problem or application. So, determine what information learners need to interpret the problem. Some of it is naturally included in the problem representation. Other relevant information banks and repositories should be linked to the environment. These may include text documents, graphics, sound resources, video, and animations that are appropriate for helping learners comprehend the problem and its principles.

建构学习环境需要及时提供学习者可选择的丰富信息，一些信息库应与该学习环境实现连接。对于WWW这一巨大的资源库，建构学习环境应滤出有用的相关信息。

The World Wide Web (WWW) is the default storage medium, as powerful new plug-ins enable users to access multimedia resources from the net. Too many learning environments, however, embed hypertext links to WWW sites based on the surface features of the site. Since learners do not possess sophisticated literacy skills for evaluating the quality of, and filtering, the information provided, information resources included in or linked to a CLE should be evaluated for their relevance and organized for ready access in ways that support the kind of thinking that you want the learners to do. Based on the activity structures that support the problem solution, information needed to perform each of the tasks should be linked to those activities. With learners who are new to CLEs, simply pointing to WWW resources may provide serious distractions to thinking necessary for solving the problem.

4. Cognitive (Knowledge-Construction) Tools

认知工具

If CLEs present complex, novel, and authentic tasks, you will need to support learners' performance of those tasks. To do that, you must identify the activity structures that are required to solve the problem. Which of the required skills are likely to be possessed by the learners? For those that are not, you should provide cognitive tools that scaffold the learners' abilities to perform those tasks. 如果建构学习环境的焦点是一个复杂的新型真实环境，则需要支持学习者完成这些任务，这就要求识别解决该问题所必须的行为结构。对于缺少预备知识的学习者，还要提供认知工具以补足学习者解决这些任务的能力。

Cognitive tools are generalizable computer tools that are intended to engage and facilitate specific kinds of cognitive processing (Kommers, Jonassen, & Mayes, 1992). They are intellectual devices that are used to visualize (represent), organize, automate, or supplant thinking skills. Some cognitive tools replace thinking, while others engage learners in generative processing of information that would not occur without the tool.

认知工具就是促进某特定认知过程的广义计算机工具(Kommers, Jonassen, & Mayes, 1992)。一些认知工具直接替代了思维，而另一些则是学习者实现信息加工所必不可少的工具。

认知工具实现了许多智能功能帮助学习者实现与建构学习环境的交互，帮助学习者更好地表述问题（如视件工具），更好地表述学习者所知道的知识以及正在学习的客体（静、动态认知工具），或者通过认知工具自动实现一些低层任务或代替做一些任务来减轻某些认知活动。最终，认知工具帮助学习者搜集了解决

问题所必需的重要信息。

Cognitive tools fulfill a number of intellectual functions in helping learners interact with CLEs. They may help the learners to better represent the problem or task they are performing (e.g. visualization tools). They may help the learners to represent what they know or what they are learning (static and dynamic knowledge modeling tools), or they may offload some of the cognitive activity by automating low-level tasks or supplanting some tasks (performance support). Finally, cognitive tools may help learners to gather important information needed to solve the problem. Each kind of cognitive tool engages or replaces different cognitive activity, so cognitive tools must be selected carefully to support the kind of processing that needs to be performed.

4.1. Problem/Task Representation Tools

问题/任表征工具

Learners' mental models of objects, systems, or other phenomena possess visual-spatial components (Jonassen & Henning, 1996). In order to understand a phenomenon, it is necessary for most humans to generate a mental image of it. Visualization tools help learners to construct those mental images and visualize activities. For example, graphical user interfaces visually represent files and applications to be manipulated.

为了理解一些现象，大部分人需要对次构建一个脑视图。

Numerous visualization tools provide reasoning-congruent representations that enable learners to reason about objects that behave and interact (Merrill, Reiser, Bekkalaar, & Hamid, 1992). Examples include the graphical proof tree representation in the Geometry Tutor (Anderson, Boyle, & Yost, 1986); the Weather Visualizer (colorizes climatological patterns); and the Climate Watcher (colorizes climatalogical variables) (Edelson et al, 1996). Programs such as Mathematica and MathLab are often used to visually represent mathematical relationships in problems so that learners can see the effects of any problem manipulation.

Visualization tools tend to be task- and domain-specific. There are no general-purpose visualization tools. Rather, these tools must closely mimic the nature of images required to understand the ideas. As a CLE designer, you should analyze the activity structures required to solve the problems and identify processes that need to be represented visually and how the learner needs to manipulate those images to test their models of the phenomena.

视件工具都是有针对性的，面向任务或面向知识领域，没有通用的视件工具。建构学习环境的设计者应做到分析问题解决所须的行为结构、明确需要可视表征的过程以及学习者在验证自己对该现象的所构模型时如何使用这些视件。

4.2. Static and Dynamic Knowledge Modeling Tools

静态动态知识建模工具

Jonassen (1996a)描述了使用不同的静态知识表征工具，诸如数据库、数据表单、语义网络、专家系统和超媒体结构，阐明知识域时的关键思维和知识表征活动。建模工具帮助学习者回答了“我知道什么”和“这个问题是什么意思”之类的问题。例如，数据库和语义网络帮助学习者澄清了整个知识域各个观点的语义关系。专家系统帮助学习者理清推导结果的过程中各个客体和因素之间的因果推理。作为建构学习环境的设计者，应该明确把握何时学习者需要整理自得所获的知识以及辅助学习者理解的最佳形式。

Jonassen (1996a) describes the critical thinking and knowledge representation activities involved in articulating knowledge domains using different static knowledge representation tools, such as databases, spreadsheets, semantic networks, expert systems, and hypermedia construction. As students study phenomena, it is important that they articulate their understanding of the phenomena. Modeling tools provide knowledge representation formalisms that constrain the ways learners think about, analyze, and organize phenomena, and they provide an environment for encoding their understanding of those phenomena. For example, creating a knowledge database or a semantic network requires learners to articulate the range of semantic relationships among the concepts that comprise the knowledge domain. Expert systems engage learners in articulating the causal reasoning between objects or factors that predict outcomes in a domain. Modeling tools help learners to answer "what do I know" and "what does it mean" questions. As a CLE designer, you must decide when learners need to articulate what they know and which formalism will best support their understanding.

Complex systems contain interactive and interdependent components. In order to represent the dynamic relationships in a system, learners can use dynamic modeling tools for building simulations of those systems and processes and for testing them. Programs like Stella use a simple set of building blocks to construct a map of a process. Learners supply equations that represent causal, contingent, and variable relationships among the variables identified on the map. Having modeled the system, Stella enables learners to test the model and observe the output of the system in graphs, tables, or animations. At the run level, students can change the variable values to test the effects of parts of a system on the others.

复杂系统的各个组件之间彼此依赖。为了表示一个系统中的这些动态关系，学习者使用动态建模工具来模拟、处理、测试这些系统。象Stella这样的程序使用一套简单的基础材料构建整个过程的图示。学习者通过测试这些模型，以图表动画的形式观察整个系统的输出，通过改变其中的部分变量来得出它们之间的关系和相互影响。

Building models of real-world phenomena is at the heart of scientific thinking and requires diverse mental activities such as planning, data collecting, accessing information, data visualizing, modeling, and reporting (Soloway, Krajcik, & Finkel, 1995). The process for developing the ability to model phenomena requires defining the model, using the model to understand some phenomena, creating a model by representing real-world phenomena and making connections among its parts, and finally analyzing the model for its ability to represent the world (Spitulnik, Studer, Finkel, Gustafson, & Soloway, 1995). They have developed a user-friendly dynamic modeling tool (Model It) which scaffolds the use of mathematics by providing a range of qualitative relationships that describe the quantitative relationships among the factors or by allowing them to enter a table of values that they have collected. Young learners create and then test models that represent real-world phenomena.

对现实世界中现象的建模是整个科学思维的核心，需要计划、数据搜集、访问信息、数据可视化、建模、报告等各项心智活动。

4.3. Performance Support Tools

绩效支持工具

在许多环境下，重复的算法性任务将浪费认知资源，而不能更好地执行更加密集智能的高层认知任务。因此，建构学习环境中应该自动实现这些低层任务。

In many environments, performing repetitive, algorithmic tasks can rob cognitive resources from more intensive, higher-order cognitive tasks that need to be performed. Therefore, CLEs should automate algorithmic tasks in order to offload the cognitive responsibility for their performance. For example, in business problem-solving environments, we have provided spreadsheet templates of problems for learners to test their hypotheses about levels of production, inventory, and sales. Most forms of testing in CLEs should be automated so that learners can simply call for test results. Generic tools such as calculators or database shells may be embedded to help learners organize the information they collect. Most CLEs provide notetaking facilities to offload memorization tasks. Identify in the activity structures those tasks with which learners are facile and may distract reasoning processes, and try to find a tool which supports that performance.

4. Information Gathering Tools

信息搜集工具

As stated before, information resources are important to understanding phenomena. Library research has shown that most learners are not skilled information seekers. The process of seeking information may distract learners from their primary goal of problem solving. 查找信息的过程将会分散学习者解决问题的主要精力，故在学习环境中嵌入搜索工具，诸如复杂搜索引擎和智能代理，将有助于学习。So, embedding search tools may facilitate learning. Sophisticated search engines (many with graphical interfaces) and intelligent agents are in common use for seeking out and filtering information sources on the WWW and selecting information that may be relevant to the user. Consider embedding information gathering tools like these in CLEs.

5. Conversation and Collaboration Tools

交谈和协作工具

Contemporary conceptions of technology-supported learning environments assume the use of a variety of computer-mediated communications to support collaboration among communities of learners (Scardamalia, Bereiter, & Lamon, 1994). Why? Learning most naturally occurs not in isolation but by teams of people working together to solve problems. CLEs should provide access to shared information and shared knowledge-building tools to help learners to collaboratively construct socially shared knowledge. Problems are solved when a group works toward developing a common conception of the problem, so their energies can be focused on solving it. Conversations may be supported by discourse communities, knowledge-building communities, and communities of learners.

建构学习环境应该提供共享信息和一些知识建模工具以帮助学习者实现共享知识的社会协作建构，所有协作学习者的经历均聚焦于一个问题的解决，必将推动整个知识的建构过程。

People who share common interests enjoy discussing their interests. In order to expand the community of discussants, people talk with each other through newsletters, magazines, and television shows. Recently, computer networks have evolved to support discourse communities through different forms of computer conferences (Listservs, electronic mail, bulletin boards, NetNews services, chats, MUDs (multi-user dimensions) and MOOs (MUDs objected oriented). These technologies support discourse on a wide range of topics.

Scardamalia and Bereiter (1996) argue that schools inhibit, rather than support, knowledge building by focusing on individual student abilities and learning. In knowledge building communities, the goal is to support students to "actively and strategically pursue learning as a goal" (Scardamalia, Bereiter, & Lamon, 1994, p. 201). To enable students to focus on knowledge construction as a primary goal, Computer-Supported Intentional Learning Environments (CSILEs) help students to produce knowledge databases so that their knowledge can "be objectified, represented in an overt form so that it could be evaluated, examined for gaps and inadequacies, added to, revised, and reformulated" (p. 201). CSILEs provide a medium for storing, organizing, and reformulating the ideas that are contributed by each of the members of the community. The knowledge base represents the synthesis of their thinking, something they own and of which they can be proud.

为了实现将知识建构作为学生的一个主要目标，计算机支持的意向学习环境（Computer-Supported Intentional Learning Environments）将帮助学生生成知识库，作为他们各项思维的综合，这样他们所掌握的知识则被对象化，公开的知识呈现形式将更易于评估、弥合差距与不足、增订、修改以及重组。CSILEs为每位学习者提供了一个存储、组织、重组观念的媒介。

CLEs can also foster and support communities of learners (COLs). Communities of learners are social organizations of learners who share knowledge, values, and goals (see e.g., Bielaczyc & Collins, Chapter 11). COLs emerge when students share knowledge about common learning interests. Newcomers adopt discourse structure, values, goals, and beliefs of community (Brown, 1994). COLs can be fostered by having the participants conduct research (reading, studying, viewing, consulting experts) and share information in the pursuit of a meaningful, consequential task (Brown & Campione, 1996). Many of these learning community environments support reflection on the knowledge constructed and the processes used to construct it by the learners. Scaffolded environments that support COLs include the Collaboratory Notebook (O'Neill & Gomez, 1994); CaMILE (Guzdial, Turns, Rappin, & Carlson, 1995) and the Knowledge Integration Environment (Bell, Davis, & Linn, 1995). Their common belief is that learning revolves around learners' conversations about what they are learning, not teacher interpretations.

建构学习环境也支持共同学习群（COLs）。这样的学习群环境包括协作笔记本（Collaboratory Notebook、O'Neill & Gomez, 1994); CaMILE (Guzdial, Turns, Rappin, & Carlson, 1995) and 知识集成环境（the Knowledge Integration Environment,Bell, Davis, & Linn, 1995)，系统的核心都是学习者的交谈，而不是教师的解释。

In order to support collaboration within a group of learners, who may be either co-located or at a distance, CLEs should provide for and encourage conversations about the problems and projects the students are working on. Students write notes to the teacher and to each other about questions, topics, or problems that arise. Textualizing discourse among students makes their ideas appear to be as important as each other's and the instructor's comments (Slatin, 1992). When learners collaborate, they share the same goal &emdash; to solve the problem or reach some scientific consensus about an issue.

CLEs should support collaboration within a group of participants, shared decision making about how to manipulate the environment, alternative interpretations of topics and problems, articulation of learners' ideas, and reflection on the processes they used. Collaboration on solving a problem requires shared decision making, which proceeds through consensus-building activities to socially shared construction of knowledge and understanding about the problem. Reflection through computer conferences also engenders meta-knowledge, the knowledge that participants have of the process in which the class is operating as well as the knowledge of themselves as participants in an evolving, ongoing conversation (Slatin, 1992).

建构学习环境应支持协作学习、关于环境操作的决策共识、交替的对问题解释、阐明学习者观点、学习过程的反馈。决策共识通过一致建构行为推动学习群对整个问题知识理解上的共同建构。

6. Social/Contextual Support

社会/情境支持

综观整个教学设计和教学技术的历史，往往由于项目的实现困难而不将其考虑在内。这是因为设计和技术研究人员没有充分囊括影响项目实现的环境和情境因素，没有虑及新技术实现的物质方面、组织方面以及文化方面的环境。

Throughout the history of instructional design and technology, projects have failed most often because of poor implementation. Why? Because the designers or technology innovators failed to accommodate environmental and contextual factors affecting implementation. Frequently they tried to implement their innovation without considering important physical, organizational, and cultural aspects of the environment into which the innovation was being implemented. For instance, many implementations of film and video failed because the physical environment couldn't be darkened sufficiently, adequate equipment wasn't available, or the content of the film or video was inimical or culturally insensitive to the audience. So the message was rejected by the learners.

In designing and implementing CLEs, accommodating contextual factors is important to successful implementation. It is also necessary to train the teachers and personnel who will be supporting the learning, and to train the students who will be learning from the environments. The CoVis project (Edelson et al, 1996) supports teachers by sponsoring workshops and conferences in which teachers can seek help from and establish a consensus with the researchers. Questions can be posed by teachers, which are answered by peer teachers or technical staff. Social and contextual support of teachers and users is essential to successful implementation of CLEs.

Supporting Learning in CLEs

支持建构学习环境下的学习

Table 1 lists learning activities that students perform in CLEs and instructional activities the CLE provides to support them. In most CLEs, learners need to explore, articulate what they know and have learned, speculate (conjecture, hypothesize, test), manipulate the environment in order to construct and test their theories and models, and reflect on what they did, why it worked or didn't, and what they have learned from the activities.

表1列出了建构学习环境下学生的学习活动以及支持学习活动的教学活动。在许多建构学习环境下，学习者需要探索学习，明确已有的知识，推测（猜测、假设、测试），操纵这个学习环境以建构和测试自己的理论和模型，仔细考虑他们所做的事情、工作原理、从学习活动中获得的知识。

学习活动：探索、阐明、思考；

教学活动：建模、教练、脚手架；

Table 1.Learning and instructional activities in CLEs.

Learning Activities	Instructional Activities
Exploration Articulation Reflection	Modeling Coaching Scaffolding

Exploring attributes of the problem includes investigating related cases for similarities, and perusing information resources to find evidence to support solution of the problem or completion of the project that focuses the CLE. The most important outcomes of exploration are goal-setting and managing the pursuit of those goals (Collins, 1991). What are the cognitive entailments of exploration?

探索问题的性质包括调查相关案例的相似性，查找信息资源来寻找建构学习环境的焦点稟问题解决和完成项目稟的证据。探索中最重要的成果是目标集和管理达到目标的进程。什么是探索中认知所必需的？

The cognitive activities engaged while exploring CLEs include speculating and conjecturing about effects, manipulating the environment, observing and gathering evidence, and drawing conclusions about those effects. Most of these activities require reflection-in-action (Schon, 1982). Skilled practitioners often articulate their thoughts while performing, that is, they reflect-in-action.

探索建构学习环境的认知活动包括关于效果的考虑和猜测、操纵整个学习环境、 观察和搜集证据、得出有关那些效果的结论。许多学习活动要求进行行为反思，也就是在学习的过程中就能够清楚地表达自己的想法。

CLEs also require articulating and reflecting on their learning performance. Reflecting-on-action&emdash;standing outside yourself and analyzing your performance&emdash;is also essential to learning. Requiring learners to articulate what they are doing in the environment and the reasons for their actions and to explain the strategies they use supports knowledge construction and metacognition. Collins and Brown (1988) recommend that learners imitate the performance that is modeled for them, and that the teacher replays their learners' performances (using videotape, audit trails, think alouds, etc.) for engaging learners in reflection-on-action.

建构学习环境要求学习者能够清楚的表达自己的学习过程并对此进行反思。

These learning activities indicate the goals for providing instructional supports in CLEs, such as modeling, coaching, and scaffolding (illustrated in Figure 1).

这些学习活动正是建构学习环境中提供教学支持的原因所在，例如建模、教练、脚手架。

A. Modeling

建模是建构学习环境下最常使用的教学策略，包括两种类型：显式绩效的行为建模和隐式认知过程的认知建模。建构学习环境的行为建模主要考虑如何执行行为结构中的各项行为。认知建模阐明在活动中学习者应使用的推理。

Modeling is the most commonly used instructional strategy in CLEs. Two types of modeling exist: behavioral modeling of the overt performance and cognitive modeling of the covert cognitive processes. Behavioral modeling in CLEs demonstrates how to perform the activities identified in the activity structure. Cognitive modeling articulates the reasoning (reflection-in-action) that learners should use while engaged in the activities.

Model performance. Carefully demonstrate each of the activities involved in a performance by a skilled (but not an expert) performer. When learners need help in a CLE, they might press a "Show Me" or a "How Do I Do This?" button. Modeling provides learners with an example of the desired performance. It is important to point out each of the discrete actions and decisions involved in the performance, so that the learner is not required to infer missing steps. A widely recognized method for modeling problem solving is worked examples.

模型的功能详尽囊括了各项离散的学习行为。当学习者需要帮助时，只需点按帮助按钮。对建模问题的一个充分的认识是工作例子。工作例子包括问题如何解决的一个描述，促进了整个问题框架的发展和基于该问题的各类问题的认知，这使得学习者的注意力从解决问题转向到问题陈述的配置及其相关的移动上。学习者将整个推理阐释清楚的过程本身就会提高工作例子的质量。

Worked examples include a description of how problems are solved by an experienced problem solver (Sweller & Cooper, 1985). Worked examples enhance the development of problem schemas and the recognition of different types of problems based on them. Using worked examples redirects the learner's attention away from the problem solution and toward problem-state configurations and their associated moves. Worked examples should be augmented by articulation of the reasoning (reflection-in-action) by the performer.

Articulate reasoning. As an experienced performer models problem-solving or project skills, s/he should also articulate the reasoning and decision making involved in each step of the process&emdash;that is, modeling the covert as well as the overt performance. For example, record the performer thinking aloud while performing. Analyze the protocol in order to provide cues to the learners about important actions and processes, perhaps even elaborating on, or providing alternative representations of, those activities. You might also record the performer conducting a post mortem analysis or abstracted replays, where you discuss the performer's actions and decisions.

In solving ill-structured problems that characterize most CLEs, learners need to know how to develop arguments to support their solutions to the problem. In these cases, performers should overtly model the kinds of argumentation necessary to solve the problem. You might also consider providing reasoning-congruent visual representations (described before) generated by the skilled performer. These visual models of the objects of expert reasoning may provide rich alternative representations to help learners perceive the structure of reasoning. You might also have performers use some of the cognitive tools to represent their understanding of, or reasoning through, the problem. The purpose in all of these is to make the covert overt, so that it can be analyzed and understood, so that learners know why they should perform, as well as how to perform.

在解决建构学习环境中常见的非良构问题使，学习者应该知道如何发展自己的论点使其支持问题的最终解决。在这种情况下，执行者需要明确对解决问题的必要论点进行建模，也可以由熟练的执行者提供推理一致性的可视化表征，这些以专家推理为目标的可视模型对于学习者理解整个推理结构大有裨益。所有这些工作的目的就是将隐含的东西显示化以便于分析理解，使学习者知其然且知其所以然。

B. Coaching

教练

Modeling strategies focus on how expert performers function. The assumption of most instruction is that, in order to learn, learners will attempt to perform like the model, first through crude imitation, advancing through articulating and habituating performance, to the creation of skilled, original performances. At each of these stages, learners' performances will likely improve with coaching. The role of coach is complex and inexact. A good coach motivates learners, analyzes their performances, provides feedback and advice on the performances and how to learn about how to perform, and provokes reflection on and articulation of what was learned.

建模策略的焦点是专业执行者使用的每一步。许多教学的前提假设是学习者需要按照模型进行学习，首先通过大致的模仿，然后通过表述和习惯这些功能而实现进一步提高，直至组出熟练的执行。在每个阶段，学习者都可以通过教练的方法进一步提高。教练的角色是复杂和不确定的。一个好的教练能够调动学习者的动机，分析他们的水平，提供反馈和学习方法，激励学习者对所学知识进行阐释和反思。

Coaching may be solicited by the learner. Students seeking help might press a "How am I Doing?" button. Or coaching may be unsolicited, when the coach observes the performance and provides encouragement, diagnosis, directions, and feedback. Coaching naturally and necessarily involves responses that are situated in the learner's task performance (Laffey, Tupper, Musser, & Wedman, 1997). You can include the following kinds of coaching in CLEs.

学习者也可以寻求教练，通过点按“现在怎么办”按钮。有时教练也是主动提供的，以进行激励、诊断、定位和反馈。建构学习环境下，教练实现以下功能：

Provide motivational prompts. A good coach relates the importance of the learning task to the learner. In case the learners are not immediately engaged by the problem, then the CLE coach needs to provide learners a good reason for becoming engaged. Once started, the coach should boost the learners' confidence levels, especially during the early stages of the problem or project. Motivational prompts can usually be faded quickly once learners become engaged by the problem. It may be necessary to provide additional, intermittent prompts during the performance of particularly difficult tasks.

提供动机刺激。好的教练会把学习任务的重要性以及理由摆在学习者面前。一旦学习开始进行，教练要提高学生的自信度，尤其是在整个过程的初期。对于较难的任务，在整个过程中在恰当的时期应不断有动机激励。

Monitor and regulate the learner's performance. The most important role of the coach is to monitor, analyze, and regulate the learners' development of important skills. Coaching may:

监控管理学习者行为：提供暗示和帮助，提醒任务执行中被忽视的部分。

?Provide hints and helps, such as directing learners to particular aspects of the tasks or reminding learners of parts of the task they may have overlooked.

建议合适的思维模式，如图解、推理、归纳观点、类比、故事化、生成问题、总结成果或得出含义。

?Prompt appropriate kinds of thinking, such as suggestions to generate images, make inferences, generalize another idea, use an analogy, make up a story, generate questions, summarize results, or draw an implication.

?Prompt the use of collaborative activities.

提示进行协作学习

?Prompt consideration of related cases or particular information resources that may help learners interpret or understand ideas.

提示考虑相关案例和特定信息资源以帮助学习者理解问题。

?Prompt the use of specific cognitive tools that may assist articulation and understanding of underlying concepts or their interrelationships.

提示使用特定认知工具，揭示隐藏的观念和相互之间的关系。

?Provide feedback that not only informs the learners about the effectiveness and accuracy of their performance, but also analyzes their actions and thinking.

提供反馈，确认学习者行为的有效性和正确性，并分析学习者的行为和思路。

Provoke reflection. A good coach becomes the conscience of the learner. So, a good coach provokes learners to reflect on (monitor and analyze) their performance. Engaging the monitoring of comprehension and the selection of appropriate cognitive strategies can be implemented in CLEs by inserting provoking questions that:

提供思考。一个好的教练将促进学习者对他们的行为进行反思。监控学习者的理解和选择合适的认知策略，通过下列几个提问刺激实现：

?ask the learners to reflect on what they have done,

要求学习者反思自己的学习过程

?ask the learners to reflect on what assumptions they made,

要求学习者反思自己学习过程之前的假设

?ask the learners to reflect on what strategies they used,

要求学习者反思自己使用的学习策略

?ask the learners to explain why they made a particular response or tool an action,

要求学习者解释为何对一个行为作出这样的响应和选择这样的工具

?ask learners to confirm an intended response,

要求学习者确定自己想做的反应

?ask learners to state how certain they are in a response,

要求学习者确定自己在一个反应中有多大把握

?require learners to argue with the coach,

要求学习者同教练进行争论

?provide puzzles that learners need to solve which will lead to appropriate performance.

提出相关概念的论题

Perturb learners' models. The mental models that naive learners build to represent problems are often flawed. They often misattribute components of the problem or incorrectly connect them, so they are trying to solve the wrong kind of problem. So it is necessary to perturb the learner's model. When learners see that their models do not adequately explain the environment they are trying to manipulate, they adjust or adapt the model to explain the discrepancies.

打乱学习者的模型。初学者的脑建模一般是不完善的，经常错误理解了某些成分的属性和他们之间的关系，因此这样解决的问题也是有偏颇的。所以打乱重建学习者的模型是十分必要的。当学习者发现自己的模型无法很好地解释其所在的环境中时，就会不断地调整这个模型来消除之间的差距。

通过嵌入激励性的问题可以实现对学习者理解方面的扰乱。比如这样的问题：你想到…了吗？如果…会怎么样？你的模型能够解释…吗？同样，也可以诱发学习者对自己的学习行为进行反思：为什么你这样？你期望什么样的结果？如果你那样做情况将会怎样？更为简单的方法是直接让学习者明确阐释当前的问题状态以及作出某种反应的原因。当作出响应的同时，教练也要求学生再次确认是否就作出这样的决定，以让学习者对自己响应的把握乃至该研究客体的深入程度做再度反思。但这种做法最好在关键的问题上应用，因为学习者不可能在任何问题上都保持很好的精力。另一种扰乱学习者模型的方法是在学习者对一个问题作出某种响应时，学习环境将提出与之相异的观点。

Perturbing learners' understanding can be accomplished by embedding provoking questions (Have you thought about ...?, What will happen if ...?, Does your model explain ...?). It is also useful to require learners to reflect on actions they have taken (Why did you ...?, What results did you expect ...?, What would have happened if ...?). A simpler approach is to ask learners to confirm or clarify what did happen (Why did that reaction occur ...?). Along with eliciting responses, the coach should ascertain the learner's response certainty. That is, when a learner makes a response (keys a response into the computer) a simple probe (On a scale of 1 to 10, how sure are you of that response?) will cause the learner to reflect on how s/he knows about the subject. This tactic will likely not work for every response due to learner fatigue, so reserve it for the important interactions. Another approach to perturbing learner models is to provide dissonant views or interpretations in response to student actions or interpretations.

Most of the coaching processes, especially the monitoring and regulation of learner performance, require some form of intelligence in the CLE system in order to judge the performance. That normally entails some form of expert model of the performance and thinking to be used as the benchmark for analyzing and comparing the student's performance, thinking, and resulting mental model.

许多教练进程，尤其是监控管理学习者绩效的那一部分，要求在建构学习环境中假如智能部分以期对学习者的行为表现、思维模式、脑建模作出判断、分析和对比。

C. Scaffolding

脚手架

Modeling is focused on the expert's performance. Coaching is focused on the learner's performance.

Scaffolding is a more systemic approach to supporting the learner, focusing on the task, the environment, the teacher, and the learner. Scaffolding provides temporary frameworks to support learning and student performance beyond the learners' capacities.

建模是针对专家的行为进行展开的，；教练是针对学习者的行为所展开的，而脚手架在支持学习者方面则显得更为系统化，因为它是针对任务、环境和教师的，它为学习者临时搭筑了一个学习超出自己能力知识的阶梯支架。

当承认和儿童共同完成一个任务时，脚手架的概念就是指成人提供的任何一种对认知行为的支持(Wood & Middleton, 1975)。 Wood, Bruner, 和Ross (1976)将解决问题时的脚手架描述为激励儿童的兴趣、简化任务、鼓励儿童和显示正确行为。Resnick指出保持记录和其他许多工具都可以作为教学的脚手架，Lehrer (1993)指出将计算机工具和交替的评估作为脚手架。从这些观点我们可以看出，关于脚手架的概念描述远没有建模和教练描述的清楚和那么有确定性。

The concept of scaffolding represents any kind of support for cognitive activity that is provided by an adult when the child and adult are performing the task together (Wood & Middleton, 1975). Wood, Bruner, and Ross (1976) describe scaffolding during problem solving as recruiting the child's interest, simplifying the task, motivating the child, and demonstrating the correct performance. Resnick (1988) proposes that record keeping and other tools can serve as instructional scaffolds, especially representational devices commonly found in computer microworlds. Lehrer (1993) also suggests scaffolding with computer tools, as well as scaffolding through alternative assessments. It is obvious from these descriptions that the concept of scaffolding is fuzzy and indistinct from modeling and coaching.

For purposes of CLEs, I believe that scaffolding represents some manipulation of the task itself by the system. When scaffolding performance, the system performs part of the task for the student, supplants the student's ability to perform some part of the task by changing the nature of the task or imposing the use of cognitive tools that help the learner perform, or adjusts the nature or difficulty of the task. Whereas coaching focuses on an individual task performance, scaffolding focuses on the inherent nature of the task being performed. A learner's request for scaffolding might take the form of a "Help Me Do This?" button.

教练的方式主要集中于个人的任务绩效上，而脚手架则主要考虑任务本身的内在性质，故也对应着“帮助我做这件事”这样的按钮。

Learners experiencing difficulties in performing a task possess insufficient prior knowledge or readiness to perform. This suggests three separate approaches to scaffolding of learning: adjust the difficulty of the task to accommodate the learner, restructure the task to supplant a lack of prior knowledge, or provide alternative assessments. Designing scaffolds requires explication of the activity structure required to complete a job (using activity theory or cognitive task analysis, as described before). From the list of tasks or activities, identify those which are not currently possessed by the learners or for which the learners are not ready (defining the learner's zone of proximal development).

学习者在完成任务过程中感到的困难主要缘于对高层知识的理解和准备不充分，脚手架提供了三种方式：调整任务的难度与学习者相适应、重构任务屏蔽高层知识理解的不足、采用另一种评价标准。脚手架的设计要求使用行为理论和认知任务分析的方法对完成整个任务所须的行为结构详尽分析，指出在所须行为的列表中，哪些是学习者已掌握的，那些是学习者还不会的。

Adjust task difficulty. Scaffolding may provide an easier task. Start the learners with the tasks they know how to perform, and gradually add task difficulty until they are unable to perform alone. This will be their zone of proximal development. This form of task regulation is an example of black-box scaffolding (Hmelo & Guzdial, 1996), that which facilitates student performance but which will not be faded out while learners are using the environment. This is the kind of scaffolding that learners cannot see; the adult supporter is invisible.

调整任务难度。脚手架应该首先提供一个较为简单的任务，然后逐步增加难度知道自身无法独立完成这个任务，这种脚手架是黑盒子脚手架的例子，在学习环境中促进整个学习的同时并学习者并没有感到磕畔。这是学习者感觉不到的一种脚手架。00000000rs' performance is to redesign the task in a way that supports learning&emdash;that is, supplanting task performance (Salomon, 1979). Task performance may also be supplanted by suggesting or imposing the use of cognitive tools to help learners represent or manipulate the problem. These forms of scaffolding are examples of glass-box scaffolding (Hmelo & Guzdial, 1996) because they are faded after a number of cases. Otherwise they become intellectual crutches. Learners need to be helped to perform that which they cannot do alone. Having performed desired skills, they must learn to perform without the scaffolds that support their performance.

重构一个任务移植知识。任务可以使用认知工具协助解决，这种脚手架是玻璃盒脚手架，因为在几个案例之后，学习者就会感到磕畔，需要帮助工具才能完成任务。在完成这种学习任务之后，学习者应该做到无须脚手架也能完成这个学习任务。

Provide alternative assessments. Learning is, to a large degree, assessment-driven. Learners develop fairly sophisticated strategies for identifying the expected performance and studying accordingly. More often than not, that performance is reproductive, so learners develop strategies for identifying what the teacher will believe is important and memorizing that. Test pools and notetaking services scaffold this kind of learning. However, when learners apply these reproductive strategies in problem-oriented CLEs, they often fail. Learners must be aware of the complex nature of the learning task and understand what the task means, so that they metacognitively adjust their attention, effort, and thinking strategies to accommodate the task. In CLEs, it is important that the project or problem requirements are clearly communicated, so that learners understand what will be required of them. This may be done through worked examples of sample problems or sample questions, as well as understanding the nature of the problem. The problem representation and decomposition process cannot begin until learners understand what the solution will be like (Jonassen, 1997).

提供不同评价。在很大程度上，学习是评价驱动的。学习者往往采用相当复杂的策略来判断什么样的绩效和学习是自己所期望的，而通常这种绩效是可以复制的。故学习者采用另外一种策略去考虑什么样的东西是老师所认为重要的并将这些重点加以牢记。测试池和记事本支持这种类型的学习。然而，一旦学习者将这种复制性的策略应用到面向问题的建构学习环境中去，往往并不奏效。学习者必须做到对整个学习任务复杂性质和基本含义的了解，以便宏认知地调节自己的注意力、思维模式以适应与当前的任务。在建构学习环境中，一定要清楚的理解问题或项目的需求，以便学习者知道完成该次任务之前自己应该具备的先决条件，这可以通过样例问答来实现。只有在学习者对问题的解决方案有一个大概理解之后，才开始表述问题和分解任务过程。

Summary

This chapter has cursorily described a model for designing CLEs. It has conceptually described the components of a CLE and the strategies for supporting learners' performances in them. Because of page limitations, I was unable to articulate the philosophical assumptions behind CLEs, impediments to learning from CLEs, how to evaluate CLEs, and alternative approaches to using technology to support constructive learning. Those topics have been and will be addressed in other publications. It is important to note that this model is intended to provide guidelines for designing learning environments (not instruction) to support constructive learning. Constructive learning emphasizes personal meaning making and so intentionally seeks to relate new ideas to experiences and prior learning. Constructive learning therefore engages conceptual and strategic thinking, rather than reproductive learning. CLEs are not appropriate for all or even most learning outcomes. If you want to design learning environments to engage learners in personal and/or collaborative knowledge construction and problem solving outcomes, then consider designing CLEs.建构学习强调个人意义建构，所以着重将新概念与已有经验知识的相关，其侧重的是观念和策略上的思考，而不是复制式的学习。

Note

In order to conform to the structure of this book, this model for designing constructivist learning environments is described conceptually in an objectivist way. That is not my preference. In my classes, students define or accept a problem first and learn how to design CLEs in the context of that problem. However, any competent objectivist instruction (including this chapter) is obligated to provide examples. Page limitations prevent this, as well as a full elaboration of the model and its theoretical foundations. So CLE prototypes and environments can be examined elsewhere (http://www.ed.psu.edu/~jonassen/cle/).

References

Anderson, J.R., Boyle, C.F., & Yost, G. (1986). The geometry tutor. Journal of Mathematical Behavior, 5, 5-

19.

Barrows, H.S. (1985). How to design a problem-based curriculum for the pre-clinical years. New York: Springer.

Barrows, H.S., & Tamblyn, R.M. (1980). Problem-based learning: An approach to medical education. New York: Springer.

Bell, P., Davis, E.A., & Linn, M.C. (1995). The knowledge integration environment: Theory and design. In J.L. Schnase & E.L. Cunnius (Eds.), Proceedings of CSCL ' 95: The first international conference on computer support for collaborative learning (pp. 157-160). Mahwah, NJ: Lawrence Erlbaum Associates.

Brown, A.L. (1994). The advancement of learning. Educational Researcher, 23 (8), 4-12.

Brown, A.L, & Campione, (1996).

Bruner, J. (1990). Acts of meaning. Cambridge, MA: Harvard University Press.

Cognition and Technology Group at Vanderbilt (1992). Anchored instruction in science and mathematics: Theoretical bases, developmental projects, and initial research findings. In. R.A. Duschl, & R.J. Hamilton (Eds.), Philosophy of science, cognitive psychology, and educational theory and practice (pp. 244-273). New York: SUNY Pres.

Cooper, G., & Sweller, J. (1987). The effects of schema acquisition and rule automation of mathematical problem-solving transfer. Journal of Educational Psychology, 79, 347-362.

Duffy, T. M.. & Jonassen, D. (Eds.), (1992).Constructivism and the technology of instruction: A conversation. Hillsdale NJ: Lawrence Erlbaum Associates.

Edelson, D. C., Pea, R. D., & Gomez, L. (1996). Constructivism in the collaboratory. In B. G. Wilson (Ed.), Constructivist learning environments: Case studies in instructional design (pp. 151&endash;164). Englewood Cliffs NJ: Educational Technology Publications.

Guzdial, M., Turns, J., Rappin, N., & Carlson, D. (1995). Collaborative support for learning in complex domains. In J.L. Schnase & E.L. Cunnius (Eds.), Proceedings of CSCL ' 95: The first international conference on computer support for collaborative learning (pp. 157-160). Mahwah, NJ: Lawrence Erlbaum Associates.

Hall, E.P., Gott, S.P, & Pokorny, R.A.(1994). A procedural guide to cognitive task analysis: The PARI methodology (AL/HR-TR-1995-0108). Brooks AF Base, TX: Armsrong Laboratory.

Hmelo, C.E. & Guzdial, M. (1996). Of black and glass boxes: Scaffolding for doing and learning. In the Proceedings of the Second International Conference on the Learning Sciences (pp. 128-133). Charlottesville, VA: Association for the Advancement of Computers in Education.

Honebein, P., Duffy, T.M., & Fishman, B. (1993). Constructivism and the design of learning environments: Context and authentic activities for learning. In T.M. Duffy, J.Lowyck, & D. Jonassen (Eds.), Designing environments for constructivist learning. Heidelberg: Springer-Verlag.

Jonassen, D.H. (1991). Objectivism vs. constructivism: Do we need a new philosophical paradigm? Educational Technology: Research and Development, 39,

Jonassen, D.H. (1993). Cognitive flexibility theory and its implications for designing CBI. In S. Dijkstra (Ed.), Instructional models in computer based learning environments. Heidelberg, FRG: Springer-Verlag.

Jonassen, D.H. (1995a). Supporting communities of learners with technology: A vision for integrating technology with learning in schools. Educational Technology, 35(4), 60-63.

Jonassen, D.H. (1995b). An instructional design model for designing constructivist learning environments. In H. Maurer (Ed.), Proceedings of the World Conference on Educational Media. Charlottesville, VA: AACE.

Jonassen, D.H. (1996a). Computers in the classroom: Mindtools for critical thinking. Columbus, OH: Prentice-Hall.

Jonassen, D.H. (1996b). Scaffolding diagnostic reasoning in case-based learning environments. Journal of Computing in Higher Education, 8 (1), 48-68.

Jonassen, D.H. (1997). Instructional design model for well-structured and ill-structured problem-solving learning outcomes. Educational Technology: Research and Development 45 (1).

Jonassen, D.H., Ambruso, D.R., & Olesen, J. (1992). Designing a hypertext on transfusion medicine using cognitive flexibility theory. Journal of Educational Hypermedia and Multimedia, 1(3), 309-322.

Jonassen, D.H., Campbell, J.P., & Davidson, M.E. (1994). Learning with media: Restructuring the debate. Educational Technology: Research and Development, 42(2), 31-39.

Jonassen, D. H. & Henning, P.H. (1996, July). Mental models: Knowledge in the head and knowledge in the world. In Proceedings of the 2nd International Conference on the Learning Sciences. Evanston, IL, Northwestern University.

Jonassen, D.H., Peck, K., & Wilson, B.G. (in press). Learning WITH Technology: A constructivist perspective. Columbus, OH: Merrill/Prentice-Hall.

Jonassen, D.H., & Rohrer-Murphy, L. (1998, February). Activity theory as a framework for designing task analyses for constructivist learning environments. Paper presented at the annual conference of the Association for Educational Communications and Technology, St. Louis, MO.

Kolodner, J. (1993). Case-based reasoning. San Mateo, CA: Morgan Kaufmann.

Kommers, P., Jonassen, D.H., & Mayes, T. (1992). Cognitive tools for learning. Heidelberg, FRG: Springer-Verlag

Krajcik, J.S., Blumenfeld, P.C., Marx, R.W., & Soloway, E. (1994). A collaborative model for helping middle grade science teachers learn project-based instruction. The Elementary School Journal, 94 (5), 483-497.

Laffey, J., Tupper, T., Musser, D., & Wedman, J. (1997). A computer-mediated support system for project-based learning.

Lave, J. & Wenger, E. (1991). Situated learning: Legitimate peripheral participation. New York: Cambridge University Press.

Lehrer, R.. (1993). Authors of knowledge: Patterns of hypermedia design. In S.P. LaJoie & S.J. Derry (Eds.), Computers as cognitive tools. Hillsdale, NJ: Lawrence Erlbaum.

Leont'ev, A.N. (1979). The problem of activity in psychology. In J.V. Wertsch (Ed.), The concept of activity in Soviet psychology (pp. 37-71). Armonk, NY: M.E. Sharpe.

Lindeman, B. Kent, T., Kinzie, M., Larsen, V., Ashmore, L., & Becker, F. (1995). Exploring cases online with virtual environments. In Schnase & Cunnius (Eds.), Proceedings of the First International Conference on Computer-Supported Collaborative Learning. Mahwah, NJ: Lawrence Associates.

Merrill, D.C., Reiser, B.J., Bookelaar, R., Hamid, A. (1992). Making processes visible: Scaffolding learning with reasoning-congruent representations. In C. Frasson, C. Gauthier, & G.I. McCall (Eds.), Intelligent tutoring systems: Proceedings of the Second International Conference, ITS '92 (pp. 103-110)(Lecture Notes in Computer Science, No. 608). Berlin: Springer-Verlag.

Perkins, D. (1995). Phenomenaria. Educational Technology,

Polya, M. (1957). How to solve it (2nd Ed.). New York: Doubleday.

Resnick, L.B. (1988).

Salomon, G. (1979). The interaction of media, cognition, and learning. San Francisco: Josey-Bass.

Savery, J. & Duffy, T.M. (1996). Problem based learning: An instructional model and its constructivist framework. In B.G. Wilson (Ed.), Designing constructivist learning environments. Englewood Cliffs, NJ: Educational Technology Publications.

Scardamalia, & Bereiter (1996). Adaptation and understanding: A case for new cultures of schooling. In S. Vosniadou, E. De Corte, R. Glaser, & H. Mandl (Eds.), International perspectives on the design of technology-supported learning environments (149&endash;163). Hillsdale NJ: Erlbaum.

Scardamalia, Bereiter, & Lamon (1994). The CSILE Project: Trying to bring the classroom into World 3. In K. McGilly (Ed.), Classroom lessons: Integrating cognitive theory and classroom practice (pp. 201&endash;228). Cambridge MA: MIT Press.

Schank, R.C. (1990). Tell me a story: Narrative and intelligence. Evanston, IL: Northwestern University Press.

Schank, R.C., Kass, A., & Riesbeck, C.K. (1994). Inside case-based explanation. Hillsdale, NJ: Lawrence Erlbaum Associates.

Schon, D.A. (1982). The reflective practitioner" How professionals think in action. New York: Basic Books.

Slatin, J.M. (1992). Is there a class in this text? Creating knowledge in the electronic classroom. In E. Barett (Ed.), Sociomedia: Multimedia, hypermedia, and the social construction of knowledge. Cambridge, MS: MIT Press.

Soloway, E., Krajcik, J., & Finkel, E.A. (1995, April). The ScienceWare project: Supporting science modeling and inquiry via computational media & technology. Paper presented at the annual meeting of the America Educational Research Association, San Franciso, CA.

Spiro, R.J., Vispoel, W., Schmitz, J., Samarapungavan, A., & Boerger, A. (1987). Knowledge acquisition for application: Cognitive flexibility and transfer in complex content domains. In B.C. Britton (Ed.), Executive control processes. Hillsdale, NJ: Lawrence Erlbaum Associates.

Spitulnik, J., Studer, S, Finkel., Gustafson, E., Laczko, J., & Soloway, E. (1995). The RiverMUD design rationale: Scaffolding for scientific inquiry through modeling, discourse, and decision making in community based issues. In J.L. Schnase & E.L. Cunnius (Eds.), Proceedings of CSCL ' 95: The first international conference on computer support for collaborative learning. Mahwah, NJ: Lawrence Erlbaum Associates.

Sweller, J. & Cooper, G. (1985) The use of worked examples as a substitute for problem solving in learning algebra. Cognition and Instruction, 2, 59-89.

Tessmer, M., & Richey, R.C. (1997). The role of context in learning and instructional design. Educational Technology: Research and Development, 45 (3).

Whitehead, A.N (1929). The aims of education and other essays. New York: Macmillan.

Williams, S. (1992). Putting case-based instruction into context: Examples from legal and medical education. Journal of the Learning Sciences, 2 (4), 367-427.

Wood, D.J., Bruner, J.S., & Ross, G. (1976). The role of tutoring in problem solving. Journal of Child Psychology and Psychiatry, 17, 89-100.

Wood, & Middleton, (1975). A study of assisted problem solving. British Journal of Psychology, 66(2), 181-191.

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