

On the Design of a Learning Environment

Gaurav Bhatnagar

NIIT Ltd, R&D Centre, Centre for Research in Cognitive Systems (CRCS),
Synergy Building, IIT Campus, New Delhi 110 016, India
gauravb@niit.com

Constructivism is a theory of how people learn, sharply in contrast with the earlier behavioral theories that advocated "direct instruction," "behavior modification," and "explicit teaching" as a means to designing training programs. We survey the theory of constructivism, and show how managers and others can evaluate training programs with reference to constructivist principles. We also indicate the pedagogical motivations for using some of the technologies involved in Technology Based Training and Performance Support Systems. Technology Based Training and Performance Support Systems form an integral part of defining effective Knowledge Management strategies.

1 Introduction

Pedagogy is the study of how children learn. A related area is *andragogy* which studies how adults learn. There are many theories on how people learn, such as Behaviorism, Cognitivism, Social Constructivism, Connectionism, Post-modernism¹. These theories are based on philosophies of the mind, and in some cases, on ideas from neuroscience or computer science. In this paper, we introduce various pedagogical principles, and explain the application of technology from a pedagogical viewpoint. These considerations go in the design of various training programs. It is therefore important for all those involved in buying, selling, managing, or developing such training programs to understand these ideas.

This work arose within the context of NIIT, a US\$ 206 million IT solutions company, with a market capitalization of more than US \$2 billion (January 2000 figures). NIIT's revenues are evenly divided between its software services and education and training businesses. In particular, this work arose within the context of NIIT's Education and Training business, which caters to about 175,000 students in its Instructor Led Training (ILT) programs conducted in about a thousand NIIT centers worldwide. A large number of these centers are in India, and are owned by business partners of NIIT who operate these centers as 'franchise' centers. The design of the learning centers as well as the instructional materi-

als are standardized, in an attempt to maintain the quality of the services offered. This learning environment is continuously evaluated for two issues: First, whether the curriculum offered is up-to-date; and secondly, whether the learning environment is in tune with pedagogical theories. This paper is motivated by the second issue: Evaluating the Learning Environment.

Moreover, this evaluation has to be done by many people in the system: Creators of the learning methodology, designers of the "standard learning centres", instructional designers, managers of the training programs, the sales people, and even the customers. Thus, here, we have made an attempt to explain various pedagogical principles by appealing to common, everyday examples familiar to us from our own educational experience.

We have chosen three of the theories amongst those listed above namely, Behaviorism, Cognitivism, and Constructivism, since they are the most influential in the field of instructional design. In the subsequent section, we give the reader a flavor of how learning happens, according to each of these three theories. In particular, we have focused on the theories of constructivism—which have gained wide acceptance since the mid-eighties—that seem to explain best the complex phenomenon we call learning.

How does one judge a training solution? There is no easy answer. What we have done here is to list five simple

questions that we can ask about any training solution. These questions help understand and judge any learning environment, and are based on theories of cognitivism and constructivism. They refer to the learning environment, which includes the learner, experts facilitating the learning, peers, learning materials (whether textual or technology based), other resources available and even the physical environment. The questions are as follows:

- How much does the learner have to interact with the information during the training?
- Is the interaction between the learner and peers encouraged?
- Are the activities the learner is expected to do, situated in the context of where the learner will have to apply the knowledge?
- Is there an opportunity to observe an expert doing the job?
- Does the training program give the learner an opportunity for self-learning?

The appendix summarizes our discussion, and may serve as a quick guide to the strengths of various training modalities such as Instructor Led Training (ILT), Computer Based Training (CBT), and Web Based Training (WBT), in addressing these questions. Technology Based Training (TBT) is usually considered to be a mix of these. In addition the use of videos in broadcasting learning materials (used along with ILT or in distance education), and Performance Support Systems are also included under these broad headings. Technology Based Training and Performance Support Systems are an integral part of Knowledge Management Strategies. In addition, we also indicate some examples of systems in the workplace that address these questions.

The paper is organized as follows: In section 2, we briefly indicate how learning happens according to the three theories of learning mentioned above. In sections 3-7, we consider each of the five questions listed above, mention their theoretical underpinnings, and also show which technologies are inspired by the pedagogical principles involved. Finally, we indicate some future directions of this study.

2 Behaviorism, Cognitivism, and Constructivism

Of the many theories mentioned above, we consider three main theories that are most influential where it

comes to instructional design, namely, Behaviorism, Cognitivism, and Constructivism. Their main ideas may be described as follows:

Behaviorism—Mental processes of the learner cannot be observed, and are thus discounted. Focus is on behaviors expected of a learner, and “conditioning” the learner to demonstrate those behaviors on appropriate occasions. The main proponents were Pavlov, Watson, and Skinner.

Cognitivism—The learner’s mind is essential in the learning process. The mind makes “schemas” or “mental models”, and the change/reformulation of these schemas in response to experiences lead to learning. The main proponents were Piaget and Chomsky (The word *Cognition* means understanding).

Constructivism—The learner’s mind is necessary, but the environment (social and physical) also plays a very important role in cognition. Individuals construct their own personal representation of knowledge, based on their experiences. The role of collaboration is emphasized in learning. Learning happens within real contexts (situated learning). The principal ideas were given by Vygotsky and Bakhtin and have been extended by a host of researchers in recent years. Recently, researchers have come to believe that cognition resides not only in our mind, but also in the environment.

There is another important theory to keep in mind when considering adult learners, namely the theory of androgogy, given by Knowles². According to Knowles the experience of the learner is the central issue as far as adult learners go. Here, experience is defined as the interaction between the learner and his/her environment. In addition, motivation plays a very important part in the effectiveness of learning for an adult.

One example of behaviorist teaching is the way multiplication tables were taught in primary school, by making us memorize them by repeating them loudly. There are other situations where behaviorist teaching materials are used. For example:

- In getting started with a software package the learner needs to know the steps for doing a common task, such as saving a file. The same applies for many common tasks within any IT training curriculum.
- When assembling a do-it-yourself kit, it is helpful to know the procedure very clearly in steps.

These come along in a manual accompanying the kit.

- Recipes are often written as a procedure to follow with a list of ingredients listed first.

These same things may be expanded upon in other ways as well. For example the cognitivist's approach would be:

- The procedure to be taught (such as saving a file) appears in different software. An icon that looks like a disk needs to be pressed to save a file, or an option has to be chosen from the File Menu. The learner has to understand what "files" are in a computer system, and that files are saved on a disk (floppy disk or hard-disk). The icon represents a "floppy disk" and stands for saving a file. Also, "Save As..." in the file menu leads to a similar but different operation. Now, it is hoped that there is a model in the learners' minds that makes them hunt for the save icon when they have to save the file (or look under the file menu for the save option).
- Some pictures and diagrams with arrows give the assembler of the kit a holistic model of the end product, as well as the procedure to assemble the object. This helps in understanding the instructions. For really complicated tasks, a video may be helpful.
- Pictures of the dish are made in the recipe book. A TV series on cooking starts with a cook making simple dishes, describing the procedure, the ingredients, the smells in the kitchen, and shows the final product when served. It begins by showing how to make simple dishes, and progresses to more complicated recipes over time.

Finally, according to the constructivist approach, the same learning might happen as follows:

- The worker gets a computer for the first time and is supposed to do a particular job, such as typing a letter. A friend or a colleague shows the person how to get started, and many things naturally follow (such as saving a file). Soon, a really important document—not saved on disk—is lost because of a sudden power failure. While wondering what can be done, sympathetic colleagues tell stories about the first

time they lost their really important documents. The local guru says he knows something about recovering the last-saved file, so maybe all the changes are not lost. The worker watches and tries to make sense of the guru's actions while the guru recovers the file.

- A person goes and buys a kit to make a computer desk. It has several nice features, but is more complicated than it appeared. The assembly of the complicated kit is going fine, but the instruction booklet is not very clear. The person messes around with all the components, trying to make them fit, and trying to make sense of the instructions. Talks to friends about particular problems, and remembers what Dad used to do while making the airplane kits. Finally, solves all the problems, and is able to patch together the desk.
- Whenever there is a big party at home, everyone gets together in the kitchen to help. Complicated and special dishes are made. We sit together and help in small ways, in laying out the spread, or fetching things from the shop. We taste all the dishes, and get chased out by mom. Somehow, while following the recipes on the Internet, I just wing it, and let the sights and smells decide how to interpret the recipe.

In deciding a training program for individuals, we have to be aware of these three ways of learning that we have indicated. It is clear that while the third situation is more complete, it may not always be practical. But ideas from these scenarios may add a little something to the training program. In the rest of the paper, we explain some of the technical terms associated with these theories and list some simple questions that we can ask to gauge the effectiveness of any training program. In each section, we also indicate the technologies that are inspired by the pedagogical principles in question. All these pedagogical principles are desirable; it is, however, not necessary that every principle should be followed in every situation.

3 Interacting with Information

Question 1—How Much Does The Learner Have To Interact With The Information During The Training?

This is perhaps the key issue in designing and developing training materials. Try to remember the course in

school where you felt you learnt a lot. Is it the one course where you had to work really hard, whether it was in doing problems, writing programs or whatever? Many of our best academic memories involve instructors who really challenged us to think and grapple with ideas and information.

Many different ideas come under the general umbrella of making students interact with information. For example, some of the ways of making the learner interact with the information are:

- Make the learners solve problems that are complex enough to make them read the material and think about it.
- Make learners perform challenging tasks that require a synthesis of what is taught.
- Engage their attention by making interesting course materials.
- Make students research and write about topics.
- Make students answer tough questions, so they have to grapple with the material to find an answer.
- Ask trick questions, so that a careful reading of the written material is required.
- Present ideas in a different manner, using multimedia presentations or videos.
- Write interesting textual material, with appropriate illustrations.
- Assign challenging homework.

Question 1 is motivated from the theory of cognitivism and constructivism.

Students may already have a “mental model” for understanding or organizing ideas and facts. It does not seem possible to take what understanding students have already in structuring the learning material. While this can be done for a small number of students, it does not seem possible to do in a large-scale manner. Nevertheless, it is important for developers and teachers/facilitators to be aware that students bring a certain understanding into the classroom, and the training or education to move them towards making better mental models. The learners can start by making small and simple models of what is being learnt, that are related to models they may already have, and they can progress to more complex models with time.

In the constructivist framework, since individuals construct their own personal knowledge based on their experiences, it is desirable that they get to do things that help them gain experience with what they are learning. Active participation in learning encourages the learning. Constructivists believe that individuals make their own representations of knowledge, and not necessarily the schemas (or mental models), defined by the cognitivists. So the above comments apply here too.

In addition, there is the concept of exposing a learner to “Multiple Approaches” to ideas and concepts³. This is a good idea because there is rarely one way to do things. For example, after we have typed a complete paragraph in a Word Document, we can save the file by pressing the CTRL and s keys at the same time. This is more efficient than lifting the hand and bringing it to the icon in the toolbar, and then clicking. However, if we have just inserted a picture using the mouse, then using the mouse again is more efficient. By making students do many tasks and solve problems, they will naturally solve problems in different ways, and stumble upon multiple approaches on their own.

Instructional design methodologies, such as ‘Learning by Doing’ and ‘Problem Based Learning’, encourage students to interact with knowledge.

There is also a lesson for the choice of the media used as an instructional aid. Interactive multimedia is better than mass media (such as videos, TV and radio), since the learner has an opportunity to interact with the information presented by the multimedia learning materials. Further, the learner is able to actively hunt for information with this media.

However, as we have seen in section 2, using interesting videos may absorb the attention of the learner, and lead to effective learning too.

Finally, there are some cases where too much interaction with information could be counterproductive. For example:

- The learner does not have enough time to do the required activities.
- The learner is learning how to do a very specific—procedural—task.
- The learner brings a lot of experience to the training, and simple explanations, organized in a logi-

cal fashion, may instantly relate to the learner's previous knowledge.

4 Collaboration

Question 2—Is The Interaction Between The Learner and Peers Encouraged?

Like many pedagogic principles, this one seems to be obvious. How many of us had to take training to use a personal computer, to use e-mail or the internet? And how many managed it with the help of just slightly more knowledgeable friends and colleagues? This is what carried many IT users over the initial hump!

Once again, interaction between peers can be encouraged in many different ways. Some ways of encouraging interaction with peers are:

- Require learners to participate in group-projects.
- Group discussions in classrooms.
- The use of discussion forums (e-mail/web-page based), chat rooms, newsgroups for specific topics.
- The use of labs where many learners do similar activities at the same time, with the freedom to walk around and observe or interact with peers.

The constructivists stress social aspects of learning. They believe that learning is collaborative^{4,5} with “meaning negotiated from multiple perspectives”⁶. By collaborating and discussing with others, we get exposed to multiple perspectives to the same concepts. This helps us choose our own way of thinking about things.

There is another aspect that seems to be relevant to interaction with peers. Vygotsky⁷ has suggested that instruction be aimed towards the “Zone of Proximal Development”. The Zone of Proximal Development is the difference between what a learner can do with help and what he or she can do without guidance. Very often, colleagues at work are intuitively able to provide an answer that is at the right level for us to understand. On the other hand, these colleagues too understand better what they have been able to explain, making the learning “collaborative”. Instructors and mentors are often able to do this too.

5 Situated Learning

Question 3—Are The Activities The Learner Is Expected To Do, Situated In The Context of Where The Learner Will Have To Apply The Knowledge?

“I learnt more in one year of work than in four years at school.” Ever wonder why this remark is so common? Given that a common refrain amongst students that university teaching is very “theoretical”, how is it that they are able to apply knowledge from various domains at work? There are very few specialized jobs that require us to apply all that we have learnt at school. A quote from Wilson *et al*¹ says it all:

“Given the reality that in-school experience oversimplifies the application of knowledge, how do adults become collaborative workers, motivated professionals and competent problem solvers? Collin, Brown and Newman (1989) assert that it is likely on-the-job and out-in-the-world apprenticeships that result in experience. It's what people have done for years to adopt the behavior and beliefs of their peers”

In short, these authors believe in “situated learning”^{8,9}.

The idea that learning is situated in real contexts is not difficult to understand. Learning involves forming our individual interpretations of knowledge. And this seems to happen more often at work than at school. What makes work more ‘real-life’ than school? Actually, in many cases we re-interpret what we have learnt or read in the context of what we are doing. And we get the feeling that this interpretation is more real.

For example, suppose a programmer (proficient in C++) has to do a project in Java. The programmer is forced to learn Java prior to working on the project, and brings experience of C++ to the learning situation. The programmer will naturally try to compare every concept of Java with what exists in C++. The dull, otherwise meaningless, phrases pointing out features of Java will take meaning in the context of the previous knowledge of the programmer. If the student is able to interpret most of the learning material in this manner, s/he will come out of the training program satisfied with the course. Later, however, the programmer may have to return to the Java books to refer to specific ideas needed for the real-life project. The programmer may then realize that the Java course did not teach all the right things needed for doing the project. After the project the programmer might feel that the real learning happened on the job!

So, should the problems that the student have to do in a training program always be as real-life as possible?

Not necessarily. This is because 'real-life problems', when contrived, are often too simple. They may also be too boring. And one of the principles of androgogy is that adult learners must be highly motivated to learn². Moreover, ideas from one field when applied in another field often lead to very creative thoughts. In general, there should be a mix of abstract concepts and their applications in various contexts as part of the material used for a training program.

In many cases, training support (during and post-training) provides an opportunity for contextual learning. Systems such as Performance Support Systems (or Electronic Performance Support Systems (EPSS)) are tools designed to provide help and learning, as and when required at work. Some common examples of performance support systems are:

- Library facilities.
- Manuals for reference while working.
- Process or workflow documents.
- Systems to give help.
- Internet sites with FAQs.
- Internal web-sites giving information on company policies.

E-mail, chat groups and discussion forums also help in this direction. We have also noted that peers and mentors often always provide contextual help.

6 Cognitive Apprenticeship

Question 4—Is There An Opportunity to Observe An Expert Doing The Job?

In many countries (including India) you can find traders and artisans whose families have been in the same profession for centuries. Artisans who have grown up watching their family weave intricate patterns make the best carpets. Hindustani classical musicians still learn directly from their *gurus*, practicing and living as part of the musician's family for many years before they are allowed to strike off on their own. However, since society came up with the idea of schools and universities, this kind of learning has vanished from mainstream education—except possibly in the Ph.D. programs, where a student is still guided by an advisor in the manner indicated above.

Though this seems to be different from our usual schooling, this kind of learning environment is very much present at our work places. Collins *et al*¹⁰. have pointed

out that learners in the real world learn very efficiently from the process of "Cognitive Apprenticeship". The idea of Cognitive Apprenticeship is that the learner observes the expert going about the task and imbibes the culture, methods and values of the subject. This is one of the reasons why some children find it easy to follow their parents' professions: they have imbibed the culture and values of the profession by observing and interacting with their parents.

This question is relevant even to the cognitivist approach to learning. They believe that experts have a different mental model than a novice, and a novice's mental model can become closer to the expert model by observing an expert going about the job.

Cognitive Apprenticeship is a complicated phenomenon, impossible to pin-down completely. However, we can recognize many everyday situations that contribute to the cognitive apprenticeship of learners:

- In classrooms, students watch instructors go about doing things.
- Animated graphics are used in multimedia systems to give learners an overview of the task at hand, and also show an expert's method of performing tasks.
- Experts answer questions in class/discussion forums/newsgroups.
- A more experienced person mentors colleagues in business settings.
- Videos show experts performing tasks.
- Interviews of experts published in newspapers or shown on TV.
- Conferences and seminars involve interaction with experts, and an opportunity to find out how they think and act.

We must remember that the above situations are merely some of the ways in which cognitive apprenticeship happens.

7 Meta-cognitive Skills

Question 5—Does The Training Program Give the Learner An Opportunity for Self-learning?

This may sound contradictory, since most training solutions make sure that they give materials that are to the

point and simply written, so as not to waste the time of the learners. However, if the student is required to look up the Internet—or refer to technical manuals—then the student should be able to use these facilities away from the training environment. In other words the student will learn some *meta-cognitive* skills—more abstract skills that help in learning.

The word meta-cognition means ‘cognition about cognition’. It is well established that *learning to learn* is a desirable skill in everyone, especially in the context of IT, where changes happen at rapid-fire pace. In addition, many people have studied heuristics for problem solving, and general rules of thumb that apply in various situations. Some of these ideas can be imbibed by observing experts approach problems in any field. Many can only be won after a lot of hard practice, e.g., programming a large system using an object oriented approach. Further, with the information explosion on the internet, it is becoming difficult to judge the authenticity of the information one finds, nor is it easy to find information relevant to the issue at hand.

Many constructivists now insist that cognition resides not only ‘solo’ in an individual’s mind, but is also distributed within the environment. For example, let us return to our saving-the-file example. After the disaster of losing the file, and the relief of getting the computer guru recover part of the work, the worker may forget the exact process of how to recover the file, but does know that the guru knows how it can be done. So when this happens again, the worker tries to find the guru, and this time pays a little more attention to what the guru is doing. Other day-to-day examples of distributed cognition—that we all use, but pay little attention to—are things like labels on files, standardized computer-user-interfaces, letters on the keyboard¹¹.

Some common ideas that appear in instructional programs, which encourage learners to develop the wide variety of these skills, are:

- Term papers or essays on subjects.
- Projects that involve surfing on the web to collate information.
- Explicit hints/tips given to students on how to approach problems in general.
- Discussing the processes of learning within training programs.
- Including topics such as design into the curriculum.

- Ensuring that students have to look up multiple sources of information in order to do their assignments.
- Training on how to use the EPSS systems installed within the organization.
- Participating in group problem solving, where students can observe peers’ thought-process
- Explicit discussions of the problem solving process with peers or experts.

The organization As a Learning Environment

We have briefly mentioned the concept of ‘distributed cognition’, that cognition resides not only solo within an individual, but is distributed within a group, and in the environment. Many people¹² have considered the social entity as a learner, and have talked about learning by teams or even organizations. We have not considered these in this paper, but it seems that an individual’s learning forms an integral part of an organization’s learning¹³. Thus, training programs designed to increase the competency of employees are an integral part of effective Knowledge Management.

To summarize, all we have done in this paper is to list some questions that may be asked to judge a learning environment, especially in the context of a training program. The training program may or may not involve technological tools. Our questions are motivated by pedagogical theories.

Further, if we consider the workplace as a learning environment, then many of the questions given above are relevant to judging whether the workplace supports learning by individuals (or groups of individuals). Some of these ideas are included in the Appendix that follows. However, we have not considered the impact of pedagogical theories on Knowledge Management in a comprehensive manner. We hope to do that some time in the future.

Acknowledgement

I thank Renu Gupta for explaining to me most of the ideas that appear below. Her two articles^{14,15} on IT training are very informative and useful.

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About the author

Dr Gaurav Bhatnagar after completing his PhD in Mathematics from the Ohio State University in 1995, Gaurav stayed at Ohio State for a year, teaching mathematics to undergraduates. He visited the Indian Statistical Institute for a year and then joined the R&D Centre of NIIT Ltd., which is part of the Center for Research in Cognitive Systems. He has authored or co-authored five research papers in the area of Special Functions and Combinatorics, and co-edited a book on Multimedia. Currently, he is interested in the fields of Cognitive Design, Education, Algorithms, and Combinatorics.

Appendix A

This table relates some questions we ask to judge a training program with elements of the training in ILT, CBT and WBT. We have also given examples of systems or policies in the workplace, that can contribute to making the work environment a learning environment

Question	Related terms	ILT	CBT	WBT	The workplace as learning environment
1 How much does the learner have to interact with the information during the training?	Mental models Multiple approaches	Home-work Problem-Solving Videos Facilitator can adjust levels of instruction to suit particular group Facilitator can motivate learners	Interactive Multimedia makes learning interesting Standardized instruction Anytime, anywhere learning	Many alternatives available on Internet Material available on most recent developments Anytime, anywhere learning	Challenging work Regular change in work functions
2 Is the interaction between the learner and peers encouraged?	Collaborative learning Multiple perspectives	Group discussions Brainstorming		Chat rooms Discussion forums Newsgroups E-mail	Team projects Social functions and mixers Virtual teams Group projects
3 Are the activities the learner is expected to do in the context of where the learner will apply the knowledge?	Situated learning	Real-life problems required Projects similar to where application happens Tutoring while problem solving	Learn when required Simulated multimedia environments Virtual Reality	Can find advice from best people in the world Learn when required	Practical training Performance support Systems (Electronic or otherwise)
4 Is there an opportunity to observe an expert doing the job?	Cognitive apprenticeship	Instructor as facilitator Overviews of tasks can be given by expert Expert demonstrates problem solving	Demonstrations by Animation Expert solutions	Demonstrations Email support by experts Discussion forums Newsgroups	Mentoring at work Watching colleagues work. Product/Project reviews by management
5 Does the training program give the learner an opportunity for self-learning?	Meta-cognitive skills Distributed cognition	Term paper assignments Discussion of multiple problem solving approaches among peers Explicit teaching of tools to learn Expert demonstrates how to think	Self-learning increases meta-cognitive skills	Opportunity for self-learning by surfing the web Chat rooms, discussion forums, newsgroups FAQs	Training on using EPSS/other systems Data ware-houses and Data mining systems. 'Knowledge-bases'