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Principles of instruction

by Barak Rosenshine

EDUCATIONAL PRACTICES SERIES–21

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Series Preface

This booklet is about the most effective methods of teaching. It has been prepared for inclusion in the Educational Practices Series developed by the International Academy of Education and distributed by the International Bureau of Education and the Academy. As part of its mission, the Academy provides timely syntheses of research on educational topics of international importance. This booklet is the twenty-first in the series on educational practices that generally improve learning.

The booklet author Barak Rosenshine was educated in the schools of Chicago. He received a B.A. and M.A. from the University of Chicago and then taught United States History in the Chicago Public Schools Later, he earned and a Ph.D. from Stanford University. He has long been on the faculty of the University of Illinois at Urbana-Champaign, which is well known for attracting graduate students from economically developing countries. Many of these students studied with Professor Rosenshine. Rosenshine's work on teaching has been honored by the American Educational Research Association and the American Federation of Teachers.

The officers of the International Academy of Education are aware that this booklet is based on research carried out primarily in economically advanced countries. The booklet, however, focuses on aspects of language learning and instruction that are universal. The practices presented here are likely to be generally applicable throughout the world. Indeed, they might be especially useful in countries that are currently less developed economically. Even so, the principles should be assessed with reference to local conditions, and adapted accordingly. In any educational setting or cultural context, suggestions or guidelines for practice require sensitive and sensible application, and continuing evaluation.

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Table of contents

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Introduction

This pamphlet presents ten research-based principles of instruction, and suggestions for classroom practice. These principles come from three sources: (a) research on how our brain acquires and uses new information; (b) research on the classroom practices of those teachers whose students show the highest gains; and (c) findings from studies that taught learning strategies to students.

The first source of these suggestions is research in cognitive science. This research focuses on how our brains acquire and use information. This cognitive research also provides suggestions on how we might overcome the limitations of our working memory when learning new material. These suggestions appear in these ten principles.

A second source of the instructional ideas in this pamphlet comes from observing the classroom practices of master teachers. Master teachers are those teachers whose classrooms made the highest gains on achievement tests. These teachers were observed as they taught, and the investigators coded how they presented new material, how and whether they checked for student understanding, the types of support they provided to their students and a number of other instructional activities. The activities that were used by the most-successful teachers are incorporated into these ten principles.

A third source of suggestions for classroom practice came from the research of cognitive scientists who developed and tested cognitive supports and scaffolds that helped students learn complex tasks. Instructional procedures, such as thinking aloud, providing students with scaffolds and providing students with models, came from this research and these procedures are also described in these ten principles.

Each of these three sources has suggestions for classroom practice that are included in this pamphlet. An interesting finding is that there is no conflict at all between the instructional suggestions that come from each of these three sources. In other words, these three sources supplement and complement each other. And the fact that the instructional ideas from three different sources supplement and complement each other gives us faith in the validity of these findings.

The following is a list of some of the instructional procedures that have come from these three sources. These ideas will be described and discussed in this pamphlet:

- Begin a lesson with a short review of previous learning.
- Present new material in small steps with student practice after each step.
- Limit the amount of material students receive at one time.
- Give clear and detailed instructions and explanations.
- Ask a large number of questions and check for understanding.
- Provide a high level of active practice for all students.
- Guide students as they begin to practice.
- Think aloud and model steps.
- Provide models of worked-out problems.
- Ask students to explain what they had learned.
- Check the responses of all students.
- Provide systematic feedback and corrections.
- Use more time to provide explanations.
- Provide many examples.
- Re-teach material when necessary.
- Prepare students for independent practice.
- Monitor students when they begin independent practice.

1. Daily review

Daily review can strengthen previous learning and can lead to fluent recall.

Research findings

Daily review is an important component of instruction. Review can help us to strengthen the connections of the material we have learned. The review of previous learning can help us to recall words, concepts and procedures effortlessly and automatically when we need this material to solve problems or to understand new material. The development of expertise requires thousands of hours of practice and daily review is one component of this practice.

Daily review was part of a successful experiment in elementary-school mathematics. Teachers in the experiment were taught to spend eight minutes every day on review. Teachers used this time to check the homework, go over problems where there were errors, and practise the concepts and skills that needed to be practised until they became automatic. As a result, students in these classrooms had higher achievement scores than did students in other classrooms.

Daily practice of vocabulary can lead to seeing the words as a unit, to seeing the whole word automatically rather than as individual letters. When students see words as a unit, they have more space available in their working memory, and this space can now be used for comprehension. Mathematical problem-solving is also improved when the basic skills (addition, multiplication, etc.) are overlearned and become automatic, thus freeing memory capacity.

In the classroom

The most effective teachers in the studies of classroom instruction understood the importance of practice and they would begin their lessons with a five- to eight-minute review of previously covered material. Some teachers would review vocabulary, or formulae, or events or previously learned concepts. These teachers provided additional practice on facts and skills that were needed for recall to become automatic.

Teacher activities might also include reviewing the concepts and skills that were necessary to do the homework, having students correct each others' papers, asking about points over which the students had difficulty or made errors, and reviewing or providing additional practice on facts and skills that need overlearning. These reviews ensured that the

students had a firm grasp of the skills and concepts that would be needed for the day's lesson.

Effective teachers also reviewed the knowledge and concepts that are relevant for that day's lesson. It is important for a teacher to help students recall the concepts and vocabulary that will be relevant for the day's lesson, because our working memory is small. If we do not review previous learning, then we will have to make a special effort to recall old material while we are learning new material, and this process will make it difficult for students to learn the new material.

Daily review is particularly important for teaching material that will be used in subsequent learning. Examples include reading sight words (i.e. any word that is known by a reader automatically), grammar, math facts, math computation, math factoring and chemical equations.

When planning for review, teachers might want to consider which words, math facts, procedures and concepts need to become automatic, and which words, vocabulary or ideas need to be reviewed before the lesson begins.

In addition, teachers might consider doing the following during their daily review:

- Correction of homework;
- Review of the concepts and skills that were practised as part of the homework;
- Asking students about points where they had difficulties or made errors;
- Review of material where errors were made;
- Review of material that needs overlearning (i.e. newly acquired skills should be practised well beyond the point of initial mastery, leading to automaticity).

Suggested readings: Miller, 1956; LaBerge & Samuels, 1974.

2. Present new material using small steps

Only present small amounts of new material at any time, and then assist students as they practise this material.

Research findings

Our working memory, the place where we process information, is small. It can only handle a few bits of information at once—too much information swamps our working memory. Presenting too much material at once may confuse students because their short-term memory will be unable to process it.

Therefore, the more effective teachers do not overwhelm their students by presenting too much new material at once. Rather, these teachers only present small amounts of new material at any time, and then assist the students as they practise this material. Only after the students have mastered the first step do teachers proceed to the next step.

The procedure of first teaching in small steps and then guiding student practice represents an appropriate way of dealing with the limitation of our working memory.

In the classroom

The more-successful teachers did not overwhelm their students by presenting too much new material at once. Rather, they only presented small amounts of new material at one time, and they taught in such a way that each point was mastered before the next point was introduced. They checked their students' understanding on each point and re-taught material when necessary.

Some successful teachers taught by giving a series of short presentations using many examples. The examples provided concrete learning and elaboration that were useful for processing new material.

Teaching in small steps requires time and the more-effective teachers spent more time presenting new material and guiding student practice than did the less-effective teachers. In a study of mathematics instruction,

the most-effective mathematics teachers spent about twenty-three minutes of a forty-minute period in lecture, demonstration, questioning and working examples. In contrast, the least-effective teachers only spent eleven minutes presenting new material. The more-effective teachers used this extra time to provide additional explanations, give many examples, check for student understanding and provide sufficient instruction so that the students could learn to work independently and not have difficulty. In one study, the least-effective teachers only asked nine questions in a forty-minute period. Compared to the successful teachers, the less-effective teachers gave much shorter presentations and explanations and then they would pass out worksheets and tell students to solve the problems. Under these conditions, the success rate for their students was lower than the success rate that the more-successful teachers obtained in their classrooms. The less-successful teachers were then observed going from student to student and having to explain the material again.

When students were taught a strategy for summarizing a paragraph, the teacher taught the strategy using small steps. First, the teacher modelled and thought aloud as he/she identified the topic of a paragraph. Then, he/she led practice on identifying the topic of new paragraphs. Then, he/she taught students to identify the main idea of a paragraph. The teacher modelled this step and then supervised the students as they practised both finding the topic and locating the main idea. Following this, the teacher taught the students to identify the supporting details in a paragraph. The teacher modelled and thought aloud, and then the students practised. Finally, the students practised carrying out all three steps of this strategy. Thus, the strategy of summarizing a paragraph was divided into smaller steps, and there was modelling and practice at each step.

Suggested readings: Evertson et al., 1980; Brophy & Good, 1990.

3. Ask questions

Questions help students practise new information and connect new material to their prior learning.

Research findings

Students need to practise new material. The teacher's questions and student discussion are a major way of providing this necessary practice. The most successful teachers in these studies spent more than half the class time lecturing, demonstrating and asking questions.

Questions allow a teacher to determine how well the material has been learned and whether there is a need for additional instruction. The most-effective teachers also ask students to explain the process they used to answer the question, to explain how the answer was found. Less-successful teachers ask fewer questions and almost no process questions.

In the classroom

Good and Grouws (1979) conducted an experimental study where the teachers were taught to follow the presentation of new material with a high frequency of questions. Teachers were taught to increase the number of questions and process questions they asked during this guided practice. The teachers in the experimental group increased the number of factual and process questions they asked and the students of teachers in these classes achieved higher scores on the post-test in mathematics than did students of teachers in the control groups.

Imaginative teachers have found ways to involve all students in answering questions. Examples include having each student:

1. Tell the answer to a neighbour.
2. Summarize the main idea in one or two sentences, writing the summary on a piece of paper and sharing this with a neighbour, or repeating the procedures to a neighbour.
3. Write the answer on a card that he or she then holds up.
4. Raise their hand if they know the answer (thereby allowing the teacher to check the entire class).
5. Raise their hand if they agree with the answer that someone else has given.

The purpose of all these procedures (cards, raising hands, writing answers) was to provide active participation for the students and also to allow the teacher to see how many students were correct and confident. The teacher may then re-teach some material when it was considered necessary. An alternative was for students to write their answers and then trade papers with each other.

Other teachers used choral responses to provide sufficient practice when teaching new vocabulary or lists of items. This made the practice seem more like a game. To be effective, however, all students needed to start together, on a signal. When students did not start together, then only the faster students answered.

In addition to asking questions, the more-effective teachers facilitated their students' rehearsal by providing explanations, by giving more examples and by supervising students as they practised the new material.

King (1994) developed a series of stems for questions (see below) that teachers might ask when teaching literature, social science content and science content to their students. Teachers would develop questions based on these stems. Sometimes students would also develop questions from these stems and ask questions of each other.

EXAMPLES OF STEMS FOR QUESTIONS

How are _____ and _____ alike?

What is the main idea of _____?

What are the strengths and weakness of _____?

In what way is _____ related to _____?

Compare _____ and _____ with regard to _____.

What do you think causes _____?

How does _____ tie in with what we have learned before?

Which one is the best _____ and why?

What are some possible solutions for the problem of _____?

Do you agree or disagree with this statement: _____?

What do you still not understand about _____?

Suggested readings: Good & Grouws, 1979; King, 1994.

4. Provide models

Providing students with models and worked examples can help students learn to solve problems faster.

Research findings

Students need cognitive support to help them learn to solve problems. Modelling and the teacher thinking aloud as he/she demonstrates how to solve a problem are examples of cognitive support.

Worked-out examples are another form of modelling that has been developed by researchers in Australia. Worked-out examples allow students to focus on the specific steps that can solve the problems and thus reduce the cognitive load on their working memory. Modelling and worked examples are used successfully to help students learn to solve problems in mathematics, science, writing and reading comprehension.

In the classroom

Many of the skills that are taught in classrooms can be conveyed by providing prompts, modelling the use of the prompt by the teacher, and then guiding students as they develop independence. When teaching reading comprehension, for example, teachers provided students with prompts that the students could use to ask themselves questions about a short passage. The first step is to give the students prompts that they can use to begin a question. Students were given words such as "who", "where", "why" and "how" to help them begin a question. Then everyone read a passage and the teacher modelled how to use these words to ask a question. Many examples were given.

Then, during guided practice, the teacher helped the students practise asking questions by helping them select a prompt and develop a question that begins with that prompt. The students practised this step many times with lots of support from the teacher.

Then the students read new passages and practised asking questions on their own, with support from the teacher when needed. Finally, students are given short passages followed by questions and the teacher expressed an opinion about the quality of the students' questions.

This same procedure—providing a prompt, modelling, guiding practice and supervising independent practice—can be used for many

tasks. When teaching students to write an essay, for example, first the teacher modelled how to write each paragraph, then the students and teacher worked together on two or more new essays and, finally, students worked on their own with supervision from the teacher.

"Worked-out examples" is another form of modelling that has been used to help students learn how to solve problems in mathematics and science. A worked-out example is a step-by-step demonstration of how to perform a task or how to solve a problem. The presentation of worked-out examples begins with the teacher modelling and explaining the steps than can be taken to solve a specific problem. The teacher also identifies and explains the underlying principle for these steps.

Usually students are then given a series of problems to complete at their desks as independent practice (sometimes called "seatwork"). But, in the research carried out in Australia, students were given a mixture of regular problems and worked-out examples. Worked-out examples were problems where all the steps were completed for the students. So, during independent practice, students first studied a worked-out example; then they worked-out a regular problem; and then they studied a worked-out example and worked on another problem. In this way, students could use the worked-out examples that showed them how to focus on the essential parts of the problem.

Of course, not all students studied the worked-out examples. To correct this problem, the Australian researchers also presented partially-completed problems where only some of the problem was worked out and students had to complete the missing steps. When partially-completed problems are presented, students are required to pay more attention to the worked-out example.

Suggested readings: Sweller, 1994; Rosenshine, Chapman & Meister, 1996; Schoenfeld, 1985.

5. Guide student practice

Successful teachers spent more time guiding the students' practice of new material.

Research findings

It is not enough simply to present students with new material, because the material will be forgotten unless there is sufficient rehearsal. An important finding from the information-processing research is that students need to spend additional time rephrasing, elaborating and summarizing the new material in order to store this material in their long-term memory. When there has been sufficient rehearsal, the students are able to retrieve this material easily and, thus, are able to make use of this material to foster new learning and to aid in problem-solving. But when the rehearsal time is too short, students are less able to store or remember or use the material. As we know, it is relatively easy to place something in a filing cabinet, but it can be very difficult to recall where exactly we filed it. Rehearsal helps us remember where we filed it.

A teacher can help this rehearsal process by asking questions, because good questions require the students to process and rehearse the material. Rehearsal is also enhanced when students are asked to summarize the main points, and when they are supervised as they practice new steps in a skill. The quality of storage will be weak if students only skim the material and do not engage in "depth of processing". It is also important that all students process the new material and receive feedback.

In the classroom

In one study the more-successful teachers of mathematics spent more time presenting new material and guiding practice. The more-successful teachers used this extra time to provide additional explanations, to give many examples, to check for student understanding and to provide sufficient instruction so that the students could learn to work independently without difficulty. In contrast, the less-successful teachers gave much shorter presentations and explanations and then they passed out worksheets and told students to work on the problems. Under these conditions, the students made too many errors and had to be re-taught the lesson.

The most-successful teachers presented only small amounts of material at a time. After this short presentation, these teachers then guided student practice. This guidance often consisted of the teacher working the first problems at the blackboard and explaining the reason for each step. This instruction served as a model for the students. This guidance also included asking students to come to the blackboard to work out problems and to discuss their procedures. Through this process, the students seated in the classroom saw additional models.

Although most teachers provided some guided practice, the most-successful teachers spent more time in guided practice, more time asking questions, more time checking for understanding, more time correcting errors and more time having students work out problems with teacher guidance.

Teachers who spent more time in guided practice and had higher success rates also had students who were more engaged during individual work at their desks. This finding suggests that, when teachers provided sufficient instruction during guided practice, the students were better prepared for the independent practice (e.g. seatwork and homework activities) but when the guided practice was too short the students were not prepared for the seatwork and they made more errors during independent practice.

Suggested readings: Evertson et al., 1980; Kirschner, Sweller & Clark, 2006.

6. Check for student understanding

Checking for student understanding at each point can help students learn the material with fewer errors.

Research findings

The more-effective teachers frequently check to see if all the students are learning the new material. This check provides some of the processing that is needed in order to move new learning into the long-term memory. This check also lets teachers know if students are developing misconceptions.

In the classroom

Effective teachers also stopped to check for student understanding. They checked for understanding by asking questions, by asking students to summarize the presentation up to that point or to repeat directions or procedures, or asked students whether they agreed or disagreed with other students' answers. This checking has two purposes: (a) answering the questions might cause the students to elaborate upon the material they learned and augment connections to other learning in their long-term-memory; and (b) checking for understanding can also tell the teacher when parts of the material need to be re-taught.

In contrast, the less-effective teachers simply asked "Are there any questions?" and, if there were no questions, they assumed that the students had learned the material and proceeded to pass worksheets for students to do the work on their own.

Another way to check for understanding is to ask students to think aloud as they worked to solve mathematical problems, to plan an essay or identify the main idea in a paragraph. Another check is to ask students to explain or defend their position to others. Having to explain a position may help students to integrate and elaborate their knowledge in new ways.

Another reason for the importance of teaching in small steps, guiding practice, checking for understanding and obtaining a high success rate comes from the fact that we construct and reconstruct knowledge. We cannot simply repeat what we hear word for word. Rather, we connect our understanding of the new information to

our existing concepts or "schema", and we then construct a mental summary: "the gist" of what we have heard. However, when left on their own, many students make errors in the process of constructing this mental summary. These errors occur, particularly, when the information is new and the student does not have adequate or well-formed background knowledge. These constructions are not errors so much as attempts by the students to be logical in an area where their background knowledge is weak. These errors are so common that there is a literature on the development and correction of student misconceptions in science. Providing guided practice after teaching small amounts of new material, and checking for student understanding, can help limit the development of misconceptions.

Suggested readings: Fisher & Frey, 2007; Dunkin, 1978.

7. Obtain a high success rate

It is important for students to achieve a high success rate during classroom instruction.

Research findings

In two of the major studies on the impact of teacher, the investigators found that students in classrooms of the more-effective teachers had a higher success rate as judged by the quality of their oral responses and their individual work. In a study of fourth-grade mathematics, it was found that 82% of students' answers were correct in the classrooms of the most-successful teachers, but the least-successful teachers had a success rate of only 73%. A high success rate during guided practice also leads to a higher success rate when students are working on problems on their own.

The research also suggests that the optimal success rate for student achievement appears to be about 80%. A success rate of 80% shows that students were learning the material, and it also shows that the students were challenged.

In the classroom

The most-effective teachers obtained this success level by "teaching in small steps", that is, by combining short presentations with supervised student practice, and by giving sufficient practice on each part before proceeding to the next step. These teachers frequently checked for understanding and required responses from all students.

It is important that students achieve a high success rate during instruction and on their practice activities. Practice, we are told, makes perfect, but practice can be a disaster if students are practising errors! If the practice does not have a high success level, there is a chance that students are practising and learning errors and once errors have been learned they are very difficult to overcome.

When we learn new material we construct a "gist" of this material in our long-term memory. However, many students make errors in the process of constructing this mental summary. These errors can occur when the information is new and the student did not have adequate or well-formed background knowledge. These constructions were not errors so much as attempts by the students to be logical in an area where their background knowledge was weak. But students were more

likely to develop misconceptions if too much material was presented at once, and if teachers did not check for student understanding. Providing guided practice after teaching small amounts of new material, and checking for student understanding, can help limit the development of misconceptions.

I once observed a class where the teacher was going from desk to desk during independent practice and suddenly realized that the students were having difficulty. She stopped the work and told the students not to do these problems for homework and she would re-teach this material the next day. She stopped the work because she did not want the students to practice errors.

Unless all students have mastered the first set of lessons there was a danger that the slower students would fall further behind when the next set of lessons was taught. So there is a need for a high success rate for all students. "Mastery learning" is a form of instruction where lessons are organized into short units and all students are required to master one set of lessons before they proceed to the second set. In mastery learning, tutoring by other students or by teachers was provided to help students master each unit.

Variations of this approach, particularly the tutoring, might be useful in other classroom settings.

Suggested readings: Anderson & Burns, 1987; Frederiksen, 1984.

8. Provide scaffolds for difficult tasks

The teacher provides students with temporary supports and scaffolds to assist them when they learn difficult tasks.

Research findings

Investigators have successfully provided students with scaffolds, or instructional supports, to help them learn difficult tasks. A scaffold is a temporary support that is used to assist a learner. These scaffolds are gradually withdrawn as learners become more competent, although students may continue to rely on scaffolds when they encounter particularly difficult problems. Providing scaffolds is a form of guided practice.

Scaffolds include modelling of the steps by the teacher, or thinking aloud by the teacher as he or she solves the problem. Scaffolds may also be tools, such as cue cards or checklists, that complete part of the task for the students, or a model of the completed task against which students can compare their own work.

The processes of helping students solve difficult problems by modelling and providing scaffolds has been called "cognitive apprenticeship". Students are learning strategies during this apprenticeship that will enable them to become competent readers, writers and problem-solvers. They are aided by a master who models, coaches, provides supports and scaffolds the students as they become independent.

In the classroom

One form of scaffolding is to give students prompts for steps they might use. Prompts such as "who" and "why" and "how" have helped students learn to ask questions while they read. Teaching students to ask questions has been shown to help students' reading comprehension.

Berkowitz (1986) developed a prompt to help students organize material.

1. Draw a central box and write the title of the article in it.
2. Skim the article to find four to six main ideas.

3. Write each main idea in a box below the central box.
4. Find and write two to four important details to list under each main idea.

Another form of scaffolding is thinking aloud by the teacher. For example, teachers might think aloud as they try to summarize a paragraph. They would show the thought processes they go through as they determine the topic of the paragraph and then use the topic to generate a summary sentence. A teacher might think aloud while solving a scientific equation or writing an essay, while providing labels for their processes. Thinking aloud by the teacher provides novice learners with a way to observe "expert thinking" that is usually hidden from the student. Teachers can also study their students' thought processes by asking them to think aloud during their problem-solving processes.

One characteristic of experienced teachers is their ability to anticipate students' errors and warn them about possible errors that some of them are likely to make. For example, a teacher might have students read a passage and then show the class a poorly written topic sentence and ask students to correct this topic sentence. In teaching division or subtraction, students might be shown the places where students frequently made errors and then these errors were discussed.

In some of the studies, students were given a checklist to evaluate their work. One checklist item was: "Have I found the most important information that tells me more about the main idea" or "Does every sentence start with a capital letter". The teacher then modelled use of the checklist.

In some studies, students were provided with expert models to which they could compare their work. For example, when students were taught to generate questions, they could compare their questions with those generated by the teacher. Similarly, when learning to write summaries, students could compare their summaries on a passage with those generated by an expert.

Suggested readings: Pressley et al., 1995; Rosenshine & Meister, 1992.

9. Independent practice

Provide for successful independent practice.

Research findings

In a typical teacher-led classroom, guided practice is followed by independent practice—by students working alone and practising the new material. This independent practice is necessary because a good deal of practice (overlearning) is needed in order to become fluent and automatic in a skill. When material is overlearned it can be recalled automatically, and doesn't take up any space in our working memory. When students become automatic in an area, they can then devote more of their attention to comprehension and application.

Independent practice provides students with the additional review and elaboration they need to become fluent in a skill. This need for fluency applies to facts, concepts and discriminations that must be used in subsequent learning. Fluency is also needed in operations, such as dividing decimals, conjugating a regular verb in a foreign language or completing and balancing a chemical equation.

In the classroom

The more-successful teachers provided for extensive and successful practice, both in the classroom and after class. Independent practice should involve the same material as the guided practice. If guided practice dealt with identifying types of sentences, then independent practice should deal with the same topic or, perhaps, with creating individual compound and complex sentences. It would be inappropriate if this guided practice contained an independent practice assignment that asked students do activities such as: "Write a paragraph using two compound and two complex sentences", because the students have not been adequately prepared for such an activity.

Students need to be prepared for their independent practice. Sometimes, it may be appropriate for a teacher to practice some of the seatwork problems with the entire class before they begin independent practice.

Students were more engaged when their teacher circulated around the room and monitored and supervised their seatwork. The optimal time for these contacts was thirty seconds or less. Classrooms where

the teachers had to stop at students' desks and provide a great deal of explanation during seatwork were also classrooms where students were making errors. These errors occurred because the guided practice was not sufficient for students to engage productively in independent practice. This finding suggests the importance of adequately preparing students before they begin their independent practice.

Students helping students

Some investigators (Slavin, 1996) have developed procedures, such as co-operative learning, during which students help each other as they study. Research shows that all students tend to achieve more in these settings than do students in regular settings. Presumably, some of the advantage comes from having to explain the material to someone else and/or having someone else (other than the teacher) explain the material to the student. Co-operative learning offers an opportunity for students to get feedback from their peers about correct as well as incorrect responses, which promotes both engagement and learning. These co-operative/competitive settings are also valuable for helping slower students in a class by providing extra instruction for them in this setting.

Suggested readings: Rosenshine, 2009; Slavin, 1996.

10. Weekly and monthly review

Students need to be involved in extensive practice in order to develop well-connected and automatic knowledge.

Research findings

Students need extensive and broad reading, and extensive practice in order to develop well-connected networks of ideas (schemas) in their long-term memories. When the knowledge on a particular topic is large and well-connected, it becomes easier to learn new information and prior knowledge is more readily available for use. The more one rehearses and reviews information, the stronger these interconnections become. It is also easier to solve new problems when one has a rich, well-connected body of knowledge and strong ties between the connections. One of the goals of education is to help students develop extensive and available background knowledge.

Knowledge that is organized into patterns only occupies a few bits in our limited working memory. So having larger and better connected patterns frees up space in our working memory. This available space can be used for reflecting on new information and for problem-solving. This development of well-connected patterns (also called "unitization" and "chunking") and the freeing of space in the working memory is one of the hallmarks of an expert in a field.

Thus, the research on cognitive processing supports the need for a teacher to assist students by providing for extensive reading of a variety of materials, frequent review, and discussion and application activities. The research on cognitive processing suggests that classroom activities, such as extensive reading of a variety of materials, discussion and frequent review, help students increase the number of pieces of information in their long-term memory and organize this information into patterns and chunks.

The more one rehearses and reviews information, the stronger the interconnections between the materials become. Review also helps students develop their new knowledge into patterns, and helps them acquire the ability to recall past learning automatically.

The best way to become an expert is through practice—thousands of hours of practice. The more the practice, the better the performance.

In the classroom

Some of the successful programmes in elementary schools provided for frequent review. In one successful experimental, study teachers were asked to review the previous week's work every Monday and the previous month's work every fourth Monday. These reviews and tests provided the additional practice that students needed to become skilled, successful performers who could apply their knowledge and skills to new areas.

Many successful programmes provided for extensive review. One way of achieving this goal is to review the previous week's work every Monday and the previous month's work every fourth Monday. Some teachers also gave tests after these reviews. It was also found that even at the secondary level classes that had weekly quizzes scored better on final exams than did classes that had only one or two quizzes during the term. These reviews and tests provide the additional practice that the students need to become skilled, successful performers who can apply their knowledge and skills in new areas.

Teachers face a difficult problem when they are faced with the need to cover a lot of material, but without sufficient review. But the research states (and we know from personal experience) that material that is not adequately practised and reviewed is easily forgotten.

Suggested readings: Good & Grouws, 1979; Kulik & Kulik, 1979.

Conclusion

The ten principles in this pamphlet come from three different sources: (a) research on how the mind acquires and uses information; (b) the instructional procedures that are used by the most successful teachers; and (c) the procedures that were invented by researchers to help students learn difficult tasks. The research from each of these three sources has implications for classroom instruction, and these implications are described in each of these ten principles.

Even though these principles come from three different sources, the instructional procedures that are taken from one source do not conflict with the instructional procedures that are taken from another source. Instead, the ideas from each of the sources overlap and add to each other. This overlap gives us faith that we are developing a valid and research-based understanding of the art of teaching.

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