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Strategy Instruction versus Direct Instruction in the Education of Young Adults with Intellectual Disabilities

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ABSTRACT

In the Netherlands, students with intellectual disabilities (ID) attend practical education (PE). Teachers generally use demonstration as a form of direct instruction (DI) and students have difficulty working independently. Strategy instruction (SI) is a question-answer-based method that stimulates students' autonomy by getting them to verbalize task strategies. A small scale teaching experiment involving a total of 33 students (aged 14 to 15 in four classes at two schools) was conducted. Classes were randomly assigned to SI or DI. Students who received SI had higher quality post-test assignments and were able to verbalize them better than students in the DI group.

INTRODUCTION

In the Netherlands, practical education (PE) students are adolescents with intellectual disabilities (The American Psychiatric Association, 2013, distinguishes two main characteristics of this group of students: IQ score below 75 and deficits in skills needed to live in an independent and responsible manner). The main goal of PE is to teach students to handle everyday situations independently and prepare them for manual work. The students function best at a social and vocational level in small PE classes. Most of them can learn to function independently and they adjust well, but it takes significant time and effort. PE in the Netherlands is similar to special vocational training or career and technical education in the United States and Great Britain (Wonacott, 2001; Levesque, et al., 2008).

During their study of PE schools, Blik, Harskamp & Kuiper (2012) found that teachers often use an approach in whole-class instruction that can be described as direct instruction (DI). Teachers start a lesson by activating the prior knowledge of their students and by demonstrating how a new task is performed. Sometimes they devote a few minutes to Guided Practice. The students then work on their tasks individually and the teacher evaluates (grades) the results at the end of the lesson. Blik et al. (2012) noticed that this method works well for simple tasks with few steps. But as the tasks got more complex, students often found it difficult to remember the different steps they had to make. They needed a lot of individual help and guidance from the teacher in order to carry out their task correctly.

DI, in the form of demonstrating a task with little interaction with the students, is quite common in PE. Teachers are convinced that their students can replicate their example of how a task is performed but believe that students are not able to reason and talk about the steps that need to be taken (the task strategy). Because students are not asked to think ahead, most students lack insight into the steps needed to carry out tasks on their own.

An alternative way of teaching students with intellectual disabilities is strategy instruction (SI) (Swanson, 2001; Alexander, 2006). SI is a highly interactive teaching method that prepares students for an assignment by showing them a task and asking them to explain the steps needed to complete it. The teacher provides feedback on their answers and tries to develop the students' understanding of how (strategy) a task is done.

This research project aims to find out whether these two instruction models produce a different effect when it comes to performing complicated tasks involving several steps. PE students are prepared for manual work and many male students prefer technical training. Effective teaching is important if students are to learn how to make different types of products. Our research uses products made in a metalworking class.

Our literature search did not produce any studies on the effects of DI or SI in the technical domain. We searched for publications in research journals and handbooks between 2000 and 2013 in ERIC, Academic Search Full Text Elite (EBSCO), and Dissertation Abstracts using the following search terms: special needs students, intellectual disability, direct instruction, strategy instruction, experiments, and effect studies. We selected recent studies (after 2000) in other domains to show the effects that the two instruction models are expected to have on students with intellectual disabilities.

DIRECT INSTRUCTION (DI)

In the DI model, the teacher directs the learning process. The teacher teaches by demonstrating the learning task in small steps, guiding students through the steps during initial practice and making sure students can successfully carry out the task on their own. In an influential essay, Rosenshine and Stevens (1986) called this "direct instruction."
Our literature search produced only a few studies on the effect of DI on students with intellectual disabilities. A study by Hughes et al. (2002) shows evidence that DI improved the practical and social communication skills of intellectually disabled students. Ryder, Burton and Silberg (2006) indicated that DI taught by specially trained teachers improved the students' reading skills and their ability to perform tasks autonomously. Jackson (2010) showed the effect of DI on the language capabilities of students with ID. Jackson's research puts forward that instruction with worked examples and explicit explanation effectively expands the students' language capabilities.

STRATEGY INSTRUCTION (SI)

SI consists of teaching in the form of questions and answers. In class, the teacher and the students choose a strategy to solve a category of tasks and then map the strategy to a step-by-step plan (Alexander, 2006; Graham & Bellert, 2004). During discussions, the teacher asks the students to present a sequence of steps, helps them and shows how the steps can be taken. The purpose is to encourage students to think ahead about the steps to accomplish a task. Students then start Individual Work and the teacher helps by referring to the step-by-step plan they discussed. The products made by the students and their learning process are reviewed at the end of the task.

Our literature search produced research by Klingner, Vaughn, & Boardman (2007) that shows that students with comprehensive reading disabilities are able to effectively apply a strategy when it is chosen together with their teacher. Consequently, they were more capable of performing assignments autonomously and reflecting on their own actions. Montague (2008) and Montague & Dietz (2009) compared SI with DI in a study on word problem solving for students with intellectual disabilities. They concluded that both the students' autonomous execution of word problems during the program and their performance in a post-test improved more through SI than DI. The research also shows that letting students verbalize solution strategies before they solve a problem is an important aspect of SI. Verbalizing solution strategies helps students structure their work on an assignment (see also Roy & Chi, 2005; Larkin, 2002; Larkin & Ellis, 2004; Rosenshine, 1997 for the effect of students verbalizing task strategies in different domains). SI seems to help students effectively apply their knowledge to new tasks. SI and verbalization challenge students with intellectual disabilities to form an internal representation of a strategy more than DI does. This could be because SI engages students more actively in the thought process of how a task can be performed. However, SI is only successful in small groups in which the teacher makes all of the students answer questions and lets them put forward suggestions (Englert & Mariage, 2003; Hegarty, 2005).

As indicated above, several studies have shown that SI enhances students' understanding of how to carry out an assignment more than DI does. Most of these studies were conducted using complex tasks, such as learning to solve word problems or learning reading comprehension. But Adams & Carnine (2006), Kroesbergen (2002), and Swanson & Deshler (2003) have shown that both DI and SI could be effective instruction models in teaching students with intellectual disabilities. The research they refer to is often in the field of skills teaching, such as reading, spelling, or mathematics. Still, SI may be more effective when it comes to accomplishing tasks that call for students to apply their knowledge and understand the steps needed to complete a task. Both models can be taught in the stages of a lesson (Blik et al., 2012; Hunter, 1994; Rosenshine & Stevens, 1986). A lesson consists of different stages that can be followed by both instruction models, namely Introduction, Instruction, Guided Practice, Individual Work, and Evaluation. The main differences between the models are in the stages of Instruction and Guided Practice. Here, the SI model is less teacher centered and directed more at student initiative, thinking and planning.

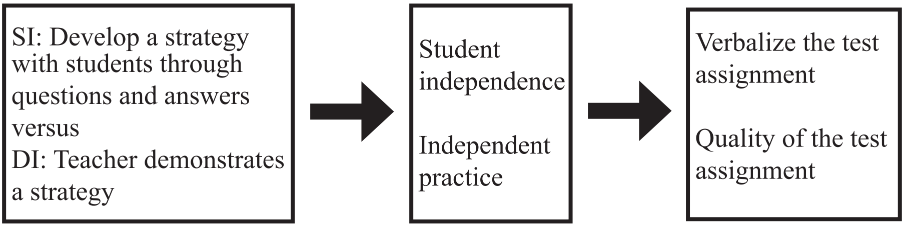
THE PRESENT STUDY

Students with intellectual disabilities struggle with strategic performance because of their very low problem-solving capacities (Kroesbergen, 2002; Reid & Lienemann, 2006; Melzer, 2007). As a result, PE teachers let students copy examples of how to make a new product but do not let them think about and discuss the steps required to make a product (Blik et al., 2012). SI is based on the teacher and the students discussing the strategy to make a product. From our literature search, it can be expected that PE students are capable of taking in SI. Figure 1 shows the main difference between the two instruction models and the possible additional effects SI could have on student autonomy and task accomplishment.

Based on our literature search and our expectations of the effects that SI and DI could have on complex tasks, we have postulated three hypotheses:

1. SI will result in more student autonomy during Individual Work than DI.
2. SI will result in a higher quality product in a post-test compared with DI.
3. SI will result in better student verbalization of the steps to make a product compared with DI.

Figure 1. *Research Model*



METHOD

RESEARCH DESIGN

Two teachers from two PE schools took part in the experiment. The teachers were selected because of their well-structured lessons, their teaching experience, and their interest in learning to teach in two different ways. We decided to test the effectiveness of SI versus DI on a small scale in order to secure the correct implementation of the two instruction models. That is why teachers received pre-flight training and were observed during their lessons.

Table 1 sets out the research design. The teachers were trained and practiced the correct use of the two instruction models in trial lessons before the experiment started. Two researchers observed the lessons and gave feedback until the models were applied correctly.

The experiment was then carried out. Both teachers instructed one class in their school using DI and another using SI. None of the students had taken part in the trial lessons and were randomly assigned to a DI or an SI class. The teachers taught each instruction model in four lessons of 100 minutes. In each lesson, the students had to make a different metal product (result of a task). All of the lessons were observed by the same two researchers who had monitored the correct and consistent use of the two instruction models during the trial lessons.

STUDENT SAMPLE

Thirty-three students in grade 8 (13-14 years old) participated in the study. There were 17 students in the SI condition (4 female, 13 male) and 16 in the DI condition (3 female, 13 male). At both schools, one group (8 or 9 students) was taught in the DI condition and the other group in the SI condition. There was no difference in gender composition and general intelligence between the groups. The mean IQ score for the SI group was 71.5 (*SD* = 5.8) and for the DI group 71.7 (*SD* = 8.0).

Table 1
Research Design

Stage	Contents
Training and trial lessons	Inform teachers about the differences between teaching a SI and DI lesson. Teachers and researchers develop four product construction tasks, including the step-by-step plans for the students. Teachers are coached during trial lessons, which focus on the correct use of the instruction models. Collect background information on students including IQ scores.
Pre-test	Students take the pre-test and verbalize it.
Intervention	Lessons 1 to 4 Strategy instruction: Group 1 in school A and group 2 in school B Lessons 1 to 4 Direct instruction: Group 2 in school A and group 1 in school B Researcher observes teachers' use of the DI and SI models, the question-answer interaction, and the autonomy of the students.
Post-test	Students take the post-test and verbalize it.

Table 2
The Two Instruction Models: A Different Approach in Each Stage of Teaching a Lesson

Stages	Direct Instruction	Strategy Instruction
Orientation (1 aspect)	1. The teacher explains what will be made in the lesson and shows a finished product.	1. The teacher shows a finished product and asks the students what they are going to make and if they already know how to make it.
Instruction (3 aspects)	1. The teacher demonstrates how the product is made using a construction drawing (see Figure 2).	1. The teacher introduces the product and a step-by-step plan (Figure 3). The teacher asks the students to tell him how to carry out the steps and lets the students verbalize.
	2. The teacher demonstrates how the product is assembled.	2. The teacher asks the students to explain the sequence of the steps.
	3. The teacher asks if the students understand.	3. The teacher repeats the process and asks the students to verbalize the steps.
Guided practice (2 aspects)	1. One or more students demonstrate how the product is made.	1. The teacher asks if the steps can be carried out into a different sequence. A final step-by-step plan is agreed with the students.
	2. The teacher corrects where necessary.	2. One or more students use the step-by-step plan to show the agreed work sequence. The teacher asks the students questions.
Individual work (2 aspects)	1. The teacher gives feedback: requested and unrequested by the students.	1. The teacher walks around the classroom and monitors the students.
	2. The teacher corrects where necessary.	2. The teacher helps the students by referring to the step-by-step plan and by asking questions.
Closing (2 aspects)	1. The teacher and the students review the students' products.	1. The teacher and the students review the processs and the students' products.
	2. The teacher evaluates what went right and what did not, and grades the product.	2. The students are asked how they made the product and how they would grade their work. The teacher assigns grades after the discussion.

THE INTERVENTION

The intervention consisted of two distinct models of teaching PE students how to make metal products. Table 2 describes the two instruction models (research conditions) for five stages of teaching a lesson. In both conditions, the students performed the same four metalworking tasks. Figures 2 and 3 are examples of the first task in the two conditions.

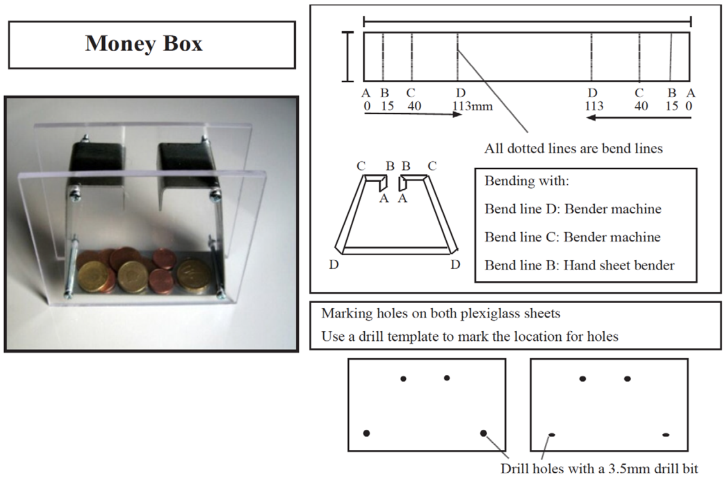
Figure 2 shows the construction drawing used in DI. The teacher demonstrates the steps needed to arrive at the final product while pointing at the drawing. The students in DI are given a card with the construction drawing that helps them observe and replicate what the teacher is demonstrating. Students can also use the card as a cheat sheet in the Guided Practice and Individual Work stages.

In SI, students are given a card with a step-by-step plan to make the product. The teacher shows the final product and the card with the steps (Figure 3). He asks the students how they would take these steps and the sequence that is most practical for them. The teacher lets the students tell him how to make the product. The card helps students verbalize the sequence of work and the processes involved.

OBSERVATIONS

Fidelity of implementation of the two instruction models. Table 2 shows that DI and SI both have five stages of teaching: Introduction, Instruction, Guided Practice, Individual Work, and Closing. The table shows that a total of 10 different aspects

Figure 2. *Construction Drawing in DI*



of teaching are carried out in each stage. The data in Table 2 were used to create an observation checklist for these aspects. Each 100-minute lesson was divided into 20 observation periods of five minutes. In the first four minutes of each observation period, the researcher determined which stage of teaching the teacher was in. The aspects of that stage were marked "1" if the aspect was not carried out during the observation period, "2" if the aspect was partially carried out, and "3" if the aspect was fully carried out by the teacher.

Question-answer patterns. An additional check on the fidelity of implementation was the frequency of question-answer patterns between teacher and students. In SI, each student is supposed to take an active part in the question-answer method the teacher applies. In DI, the teacher demonstrates the task and the students observe the teacher. Students are asked only a few questions during a lesson.

In the four-minute observation period, the observer also kept track of the question-answer patterns between teacher and students in both research conditions. For each student, the observer counted how often the student answered a task-related question asked by the teacher. The question could be directed at the group or at an individual

Figure 3. *Construction Drawing in SI*

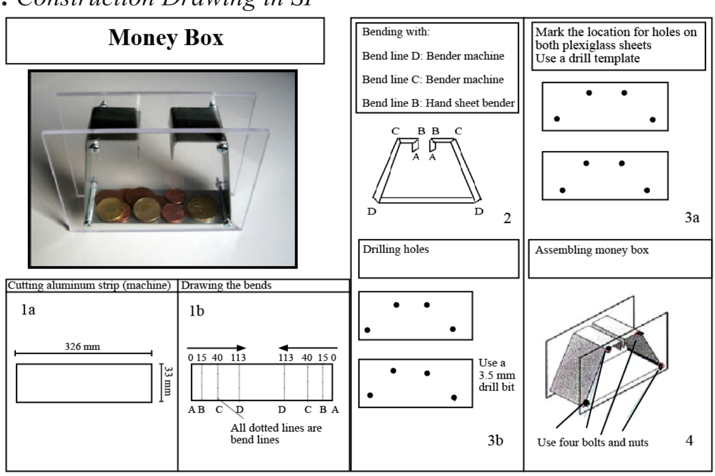
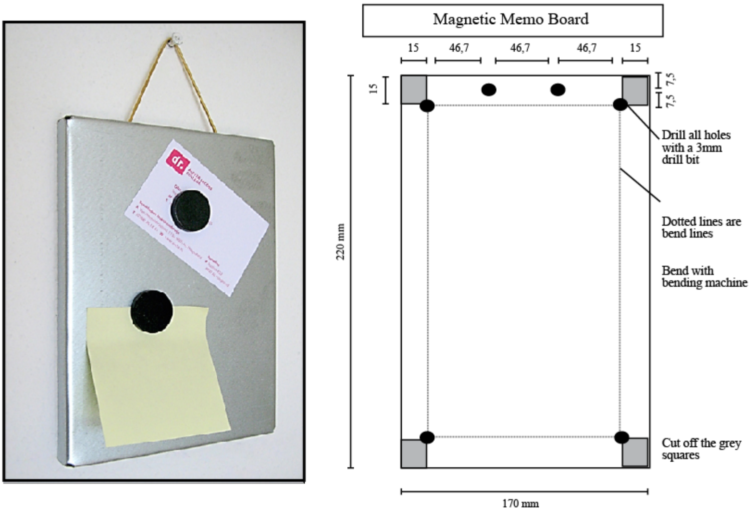


Figure 4. *Pre-test: Magnetic Memo Board*



member. The number of times a student answered a question asked by the teacher was calculated.

Student autonomy. In the fifth minute of an observation period, the students who were inactive (not working on the task, not listening to instructions, waiting for another student at a machine, waiting for the teacher for help, social talk, etc.) were given a score. In the Individual Work stage students who were not actively at work or with assistance from the teacher (who showed them how to make a part, took over, or asked questions), were given a score. Thus, a measure for the inactivity and dependency of students could be established. From this score the proportion of periods that students were active and autonomously at work during the 20 observation periods of a lesson was calculated. After four lessons, the mean percentage of active and autonomous time was calculated for each student in order to determine the student's autonomy.

All lessons were observed by two researchers. All lessons were filmed. After watching the video footage, the observations were reviewed and graded. The inter-observer reliability between the two observers regarding the scores that were given for each lesson in the observation checklist, the mean question-answer frequency, and the active learning time were high and varied between Kappa .82 and Kappa .87.

Figure 5. *Post-test: Binder Made of Metal*

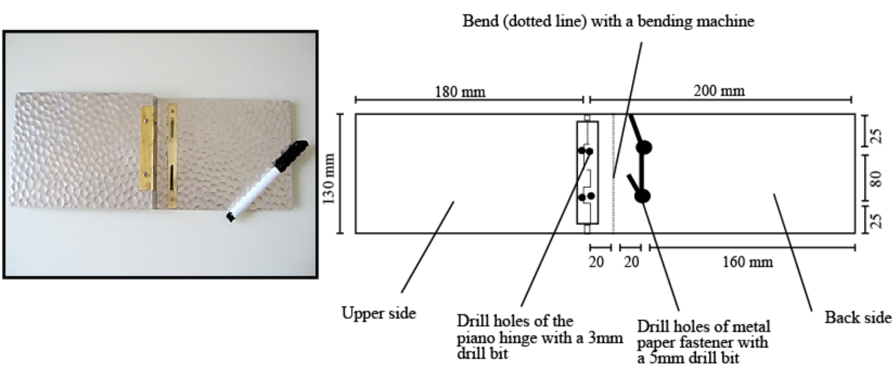


Table 3
Grading the Verbalization of Students on Pre- and Post-Test Assignments

Pre-test	Tasks
Binder ***Max. score: 6 points***	1. Draw bend lines and holes 2. Drill four holes in the corners 3. Drill two holes on top 4. Cut the corners 5. Bend sides 90 degrees and fasten iron wire
Post-test	**Tasks**
Magnetic memo board ***Max. score: 5 points***	1. Draw bend lines and holes 2. Drill two holes for paper fastener 3. Drill four holes for piano hinge 4. Bend bottom with angle bending machine 5. Fasten the hinge with rivets 6. Fasten paper fastener and finish the work piece

PRE- AND POST-TEST

The students' ability to make a product by themselves using a construction drawing was measured by means of a pre- and post-test. Each student carried out the test assignment. The pre-test assignment was somewhat simpler than the post-test assignment. The two test assignments are shown in Figures 4 and 5. The figures show a worksheet with a picture of the product and a construction (drawing) with a few instructions. As there were no further instructions, the students needed to come up with a step-by-step sequence themselves.

The students were observed closely by a researcher. In the pre-test, students had to follow five steps to finish the product, while the post-test consisted of six steps (Table 3). The students were filmed during the test. After each test, the quality of the students' task performance was graded by a researcher based on a checklist (Table 4). Students received a score of 0 – 3 depending on the steps they completed and the relative quality (finishing) of the product (see Table 4). If students asked and received help with their assignment, their unfinished product before help was graded.

Verbalization. The students' verbalization of the assignment was measured after the test. Students were invited to tell the researcher how they had worked on the assignment and which steps they had taken. A maximum score of 5 was given for the pre-test if the student could verbalize the steps correctly. The maximum score for the post-test was 6 because of the 6 different steps (as shown in Table 3).

The videotaped products of the students were scored by two researchers. The inter-observer reliability between the two observers for the quality scores and the verbalization scores on the pre- and post-test was calculated. We found Kappa .79 to Kappa .81. This indicates a good inter-rater reliability for the two tests on both aspects.

DATA ANALYSIS

The design of this study implies that two teachers with two classes were nested in the experimental factor: condition SI and condition DI. Each teacher taught SI with one

Table 4
Grading the Quality of the Assignments

Quality of the assignment	Pre- and post-test grade scale
None of the subjects were carried out correctly	0
Insufficient -- Assignment was not assembled correctly; steps were ignored or were carried out incorrectly	1
Sufficient -- Assignment was assembled correctly by student did not work neatly and/or the product was not finished correctly.	2
Good -- All steps were carried out correctly and the product nicely finished	3

group of students and DI with another. The number of teachers was too small to allow for multilevel analysis (Snijders & Bosker, 2012). Although we trained both teacher thoroughly in the use of the two instruction models there could still be a difference between the teachers in implementation of the models (conditions) and in their students' outcome. This is why we used "Teacher" as a factor in a two-way analysis of variance with "Condition" as the other factor. For all analyses, we first checked whether there was an interaction effect of "Condition" x "Teacher" on the dependent variable. If there was no interaction effect, the possible main effect of "Teacher" was tested. If there was an effect this would be reported. If there was no interaction effect or main effect of Teacher then this was not reported because we tried to control the effect of the teachers through preflight training and close observation of the lessons. The significance level was p > .05 and two-sided testing was applied. Even if there were no interaction or main effect of "Teacher," we showed the mean scores of the two teachers within each condition in order to allow observation of the size of the difference between the teachers.

If there were no "Teacher" effects, a t-test was performed for the effect of "Condition" on the implementation variables, namely the implementation score in the observation list and the frequency of question-answer patterns. An analysis of covariance was used (with the pre-test assignment as covariate) for the effect of "Condition" on students' autonomy (students mean scores of active and autonomous time in four lessons), quality of post-test assignment and verbalization of the assignment.

RESULTS

IMPLEMENTATION OF THE INSTRUCTION MODELS

To determine whether the teachers implemented the two instruction models properly, the researchers observed the lessons using a standard observation checklist with time sampling (see the 5 lesson stages and 10 teaching aspects in Table 2). During the observation of the four lessons, the researchers checked the stage(s) the teacher used and graded aspects in these stages on a scale of 1 to 3.

Direct instruction. Both teachers implemented the stages Orientation, Instruction, and Individual Work very well. The other two stages were not implemented on such a high level in all lessons. For the Guided Practice stage, teachers in two lessons thought

Table 5

Implementation of Instruction Models and Averages by Teaching Aspect (SD)

Stages	Teaching aspect	Direct instruction		Strategy instruction	
		Teacher A	Teacher B	Teacher A	Teacher B
Orientation	1	2.5 (*0.58*)	2.5 (*0.58*)	2.5 (*0.58*)	2.5 (*0.58*)
Instruction (3 aspects)	1	3.0 (*0.00*)	2.8 (*0.50*)	3.0 (*0.00*)	2.8 (*0.50*)
	2	2.5 (*1.00*)	2.8 (*0.50*)	2.5 (*1.00*)	2.8 (*0.50*)
	3	2.8 (*0.50*)	2.8 (*0.50*)	2.8 (0.50)	2.8 (*0.50*)
Guided practice (2 aspects)	1	2.3 (*0.96*)	2.3 (*0.96*)	2.3 (*0.96*)	2.3 (*0.96*)
	2	2.3 (*0.96*)	2.3 (*0.96*)	2.3 (*0.96*)	2.3 (*0.96*)
Individual work (2 aspects)	1	3.0 (*0.00*)	2.8 (*0.50*)	3.0 (*0.00*)	2.8 (*0.50*)
	2	2.5 (*1.00*)	2.8 (*0.50*)	2.5 (*1.00*)	2.8 (*0.50*)
Evaluation (2 aspects)	1	3.0 (*0.00*)	2.5 (*1.00*)	3.0 (*0.00*)	2.5 (*1.00*)
	2	3.0 (*0.00*)	2.5 (*1.00*)	3.0 (*0.00*)	2.5 (*1.00*)

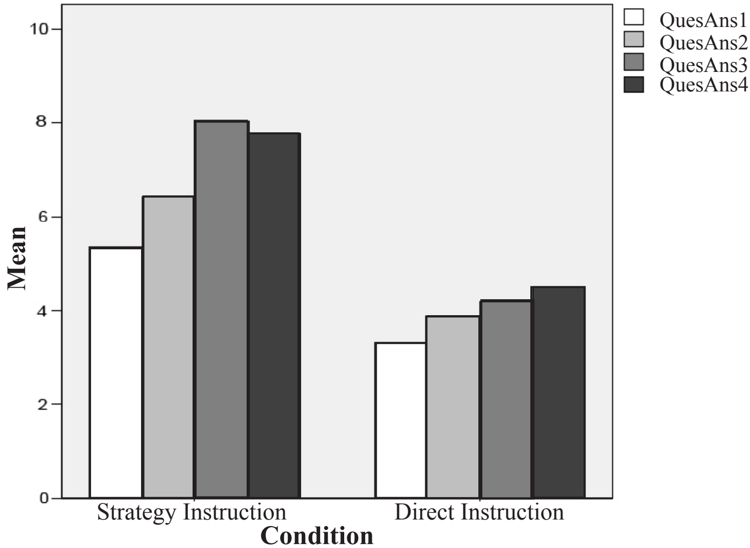
Figure 6. *Sample of the Instruction Stage in DI and SI*

Making a Money Box	
Direct Instruction	**Strategy Instruction**
Teacher: "We are going to make a money box. If you have a look at this construction drawing, you'll see that this money box is divided into three parts.....One part of metal and two parts of plexiglass." Teacher: "If we want to make this money box, we need to use the following hand tools, which are shown on the construction drawing: pencil, ruler, saw, hand bender....." (Teacher picks up or shows the tools one by one). Teacher: Look at the construction drawing to note the correct sizes of the aluminum strip: length 326 mm and width 33 mm. Teacher: "I will first show you how to draw the aluminum part.......First, I draw the bend lines. Note on which side I'm starting." Teacher: "We connect the parts with bolts and nuts. Watch how I do it. First, I put.........and then....." Teacher to one of the students: "Can you show us how to assemble the parts?" Student: Demonstrates the assembling of the three parts.	Teacher: "Please have a look at the step-by-step plan. Can anyone tell me what we are going to make?" Student 1 answers: "A piggy bank"; Student 2 answers: "A money box"; etc. Teacher: "What would you do with a money box?" Student: "I could save my allowance in it." Student: "You can also use it as a gift box!" Teacher: "Take a good look at the step-by-step plan. Try to find out what hand tools and machines you need to make this money box." Students pick up and name the tools one by one. Teacher: "Have a look at the step-by-step plan. What are the dimensions of the components and how do you draw the parts? Let's start with the aluminum strip. ....How wide is it?" The students answer the questions while the teacher draws....... Teacher: "Do you know how to saw the plexiglass and metal parts?" The teacher shows how to saw one part. The teacher has already made the other part. Teacher: "How do we connect the aluminum and plexiglass parts?" Student 1: "With screws." Student 2: "No. With four nuts and bolts." Teacher asks student 3: "Who is right?" Student 3 hesitates..... "I think we have to put the bolts through the plastic and screw the nuts into the bolts." Teacher: "Exactly!" Teacher: "Who can show the others how to do this?" A student demonstrates while another student reads the instructions step by step.

that getting individual students to repeat the instructions took too much time. Instead, the teachers repeated the construction of a product by showing the steps in the construction plan. Furthermore, the Evaluation stage was not fully implemented because in two lessons Teacher A had limited time to end the lesson properly.

Strategy instruction. Both teachers implemented the five stages very well, with the exception of Guided Practice. In two lessons, the teachers found that this stage was already included in the Instruction stage. The interactive instruction of the task and the verbalization of the steps by the students had shown that the students understood the

Figure 7. *The Average Number of Question-Answer Patterns in SI and DI*



steps in the process. The teachers let individual students repeat and verbalize the steps again before starting Individual Work.

Conclusion. Both teachers used the two instruction models as designed during most lessons. In one or two lessons, the Guided Practice stage was shortened to save time.

QUESTION-ANSWER PATTERNS

To illustrate the differences between the Instruction stage in SI and DI, an example of an assignment is shown in Figure 6. The researchers kept track of the question-answer patterns between teacher and students during the 20 four-minute observation periods. For each student, the researchers kept track of how often a student answered a task-related question asked by the teacher in order to calculate the number of times a student answered a question asked by the teacher.

Figure 7 shows the average number of question-answer patterns in SI and DI for the four lessons (QuesAns1 – QuesAns4). The figure shows an increase in the number of question-answer patterns for the second two lessons compared with the first two. This is especially the case in SI, where the difference seems to be greater than in DI. Table 6 displays the averages and standard deviations for the four lessons.

As we expected, Table 6 shows that teachers gave their students more questions to answer in SI than in DI. Students were taught in groups of 8 to 9 participants (see Research design). In SI, students answered 6.9 task-related questions on average during

Table 6
Mean Number of Questions Answered by Individual Students during Four Lessons

Condition	N	Mean number of question-answer patterns by lesson	Standard deviation (SD)
Strategy instruction	17	6.9	2.9
Teacher A	10	6.7	2.9
Teacher B	7	7.1	3.0
Direct instruction	16	4.0	1.7
Teacher A	9	4.1	2.0
Teacher B	7	3.8	1.5

Table 7
Percentage of Active Learning Time During Four Lessons

Condition	N	Mean percentage of active and independent engagement by student	Standard deviation (SD)
Strategy instruction	17	.90	.03
Teacher A	10	.91	.03
Teacher B	7	.88	.02
Direct instruction	16	.78	.10
Teacher A	9	.75	.12
Teacher B	7	.82	.04

a lesson. In DI, students answered 4 such questions. The difference was analyzed with a t-test for independent samples (t = 3.48; p = .002) and showed a substantial effect size (Cohen's d = 1.04). The result confirmed that teaching according to the SI model was more interactive than teaching according to the DI model.

Further analysis was done to find out if teachers had more interaction with students who scored higher in the pre-test assignment. Although teachers were asked during the training to divide their questions more or less equally over the students, it is also important to help weaker students. In the SI group, the product moment correlations between the number of teacher questions and the pre-test scores of students was r = -.59, and r = -.53 in the DI group. This indicates that teachers had more question- answer interactions with weaker students. However, the correlations are not strong enough to suggest that the teachers only interacted with weaker students. The above results show that teachers asked more questions in the SI group and that, just as in the DI group, more questions were directed at weaker students than at stronger students.

STUDENT AUTONOMY DURING CLASSES

The students' autonomy was observed during the lessons and was calculated by counting how much time students were actively engaged during teaching and worked actively and independently on their task. An overview is provided in Table 7.

The students in SI seemed to be more actively involved and independent (86% of the observed lesson time) than the students in DI (76% of the observed lesson time). The difference between the two instruction models has statistical significance (t = 3.38; p =.002). (Cohen's d = 1.24). It can be concluded that students in the SI group were more actively and independently involved in their tasks and by that showed more autonomy than the students in the DI group.

STUDENT TEST RESULTS

Quality of the assignments. The students' pre- and post-test products were graded on a scale of 0 - 3 (totally insufficient - very well finished in all details). The pre-test assignment (magnetic board) was less complex than the post-test assignment (binder). Table 8 shows the average scores for both instruction groups.

It can be concluded that the students did relatively well on both assignments. In the pre-test, the average quality of the assignments in the DI group (2.1) is somewhat higher than in the SI group (1.7), while in the post-test it is the other way round. The difference in the pre-test is small (Cohen's d = - 0.39) and not significant (t = -1.13; p = .27) but was nevertheless taken into account when testing the effect of SI against DI in the post-test. An analysis of covariance (using the pre-test assignment as covariate) was used. First, there was a check for a possible interaction effect of condition and pre-test on the post-test. But this effect was not evident [F (1.29 = .34; p = .56]. Next, the main effect of condition was analyzed. The results showed that students in the SI group had significantly higher post-test scores than students in the DI group [F (1.30) = 6.4; p = 0.02]. Their assignment was of better quality (Cohen's d = 0.57, a medium-sized effect).

Table 8
Average Pre- and Post-Test Quality Scores (SD)

	DI		SI	
	Pre-test	**Post-test**	**Pre-test**	**Post-test**
Average score	2.1 (1.02)	1.8 (0.93)	1.7 (1.10)	2.2 (0.90)
Teacher A	2.1 (1.05)	1.7 (0.95)	1.9 (0.99)	2.1 (0.88)
Teacher B	2.1 (1.07)	1.9 (0.90)	1.4 (1.27)	2.5 (0.98)

VERBALIZING

The pre-test (magnetic board) and post-test (binder) assignments were completed within 50 minutes. After the assignment, each student had to try to verbalize the steps and sequence them correctly. Table 9 shows the average number of steps the students verbalized correctly.

In comparison with the pre-test, the post-test contained one additional step that had to be verbalized in order to obtain the maximum score (see Table 3). In the pre-test, there was hardly any difference between the students of the two conditions. In the post-test, students in the DI group correctly verbalized on average 4.6 of the 6 steps. Most of these students could verbalize at least two steps. Students in the SI group had an average score of 5.5. Almost all of these students could verbalize at least four steps.

It was decided to take the pre-test assignment scores into account when comparing the mean post-test scores of the two groups. An analysis of covariance was used with the pre-test as covariate. There was no interaction effect of condition x pre-test on the post-test verbalization [F (1.29 = .7; p = .40]. The next step consisted of analyzing the main effect of Condition. It showed that there was a significant difference between students in the DI and SI groups in favor of the last group [F (1.30) = 4.9; p = 0.04]. There is an intermediate effect (Cohen's d = 0.45). Students who were taught with SI verbalized more steps in the post-test task correctly than students taught with DI.

DISCUSSION AND CONCLUSIONS

This study was an effort to find a way to improve the instruction of young adults in practical education (PE) with limited cognitive abilities. In PE, most teachers use a form of direct instruction (DI). They show how a task is carried out and students replicate the example. Then students go to work individually and the teacher walks around and helps students. When tasks get complex and have many process steps, students find it hard to remember what to do and in which sequence. Students taught with DI are not taught to think ahead.

The aim of this study was to explore if a different way of teaching could increase the autonomy of students and improve the execution quality of complex tasks. SI fits this purpose. In SI, students receive interactive instruction on the steps to complete a task. They have to think ahead and verbalize the steps required to complete a task (task strategy).

Table 9
Average Scores for Verbalizing in the Pre- and Post-Test

	DI		SI	
	Pre-test	**Post-test**	**Pre-test**	**Post-test**
Verbalizing (N = 33)	3.0 (1.71)	4.6 (2.16)	2.7 (1.84)	5.5 (1.50)
Teacher A	2.4 (1.59)	4.7 (2.65)	2.3 (1.33)	5.4 (1.89)
Teacher B	3.7 (1.70)	4.6 (1.51)	3.1 (2.41)	5.6 (0.78)

We decided to test the effectiveness of SI in PE on a small scale and compare it with DI. Two teachers were trained beforehand in the correct way of teaching both instruction models in metalworking classes. In the ensuing experiment, both teachers taught two groups of students, each with a different instruction model, for four lessons. The implementation of the different instruction models was observed by two researchers during all lessons. The teachers implemented the DI and SI models according to plan, with a few adaptations. As expected, the students in the SI condition engaged in more question-answer patterns with their teachers than students in the DI condition. They discussed the steps needed to complete a task with their teacher before starting an assignment. Students in the DI condition were given examples of how a task should be processed.

The first research question was about the autonomy of students during their Individual Work. Throughout the four lessons of this intervention, the students in the SI condition worked more actively and had less help. There is a clear difference in autonomy between the groups of students. In the SI condition, on average 86% of the students worked actively and autonomously. In the DI condition, this was 76%. Our research shows that the teachers using the SI model were especially successful at getting students to work autonomously.

The second research question was about the quality of the students' post-test assignment. The students received a worksheet with a drawing of the product and some written instructions. Students in the SI condition finished the post-test at a higher level of performance. We expect that this is a result of their new verbalization and planning skills.

The answer to the third research question, which consisted of finding out whether there was evidence of higher verbalization skill in students in the SI condition, supports this. After the post-test, students were asked to indicate the sequence in which they had performed the task and how they had proceeded. Students in the SI condition were indeed better at reflecting on their task. There was an intermediate effect on the SI condition compared with the DI condition.

This study can be seen as a first support of the hypothesis that SI can effectively improve the planning and working abilities of PE students. However, there are some restrictions to the research outcome. First, teachers were intensively trained and their implementation of the lessons was closely monitored by researchers. For the sake of this experiment, teachers were willing to assign students randomly to two groups and were willing to follow lesson plans prepared by the researchers. They taught the classes in different ways. This is not a normal classroom setting. It remains to be investigated whether teachers can or will follow the instruction models and lesson plans as closely without a researcher in their classroom.

Second, the sample we used was small. But this did not threaten the power of our statistical tests because we expected the SI and DI condition to differ substantially and no large sample was needed. As for the generalizability of the outcome in terms of the selection of students in our sample, we are confident that our students are representative of the PE student population because entrance to this school is subject to strict terms (general intelligence between 55 and 75, three years behind in cognitive skills compared with their peers in regular education, no behavioral disorder). For this reason, the student population does not differ very much between PE schools. In fact, the mean IQ scores of the students in our sample (71.8) are close to the mean score of a sample of all students in Dutch PE ($M = 73$; Blik and Naayer, 2012).

Third, the number of SI lessons was limited (four lessons of 100 minutes). We expect that more extensive instruction in an experimental setting will increase the effect of SI and increase students' ability to think ahead independently before starting a new task.

RECOMMENDATIONS

We assume that the effect of SI is especially due to the question-answer teaching approach and the use of a step-by-step plan to let students explain how a task can be performed. This enables students to learn to think ahead when they have to perform a task. We recommend further research to test this assumption.

First, we recommend measuring one's thinking about one's action - the core of SI - using think-aloud research, for example, with test assignments that are repeated over time. This will provide more insight into the development of thinking ahead during a series of lessons (Reid & Lienemann, 2006). If SI is found to improve the development of students' thinking more than DI, the hypothesis that better thinking ahead will lead to a more independent processing of tasks and a higher quality of the outcome will be supported. This study points in that direction.

A second recommendation for further study is to find out whether SI also works on a larger scale. In a quasi-experiment, teachers can be trained to use either the SI or the DI model in their (metalworking) classes. If teachers are trained and are guided by a consultant in their practice they will implement a model sufficiently and it is interesting to observe what the results will be (Joyce and Showers, 2002). From meta-analysis we know that the effect of an instructional innovation is usually higher if researchers monitor its implementation than if the teachers are left to their own devices (Kuhn and Dean, 2004). That is why research on implementation is needed to study the effect of training and consultation in SI for teachers in practical education.

A last recommendation is the possibility of applying SI in other areas besides the technical domain of metalworking or woodworking. PE has practical domains such as cleaning, cooking, and gardening. The research could focus on the differences in the effect of SI compared with DI between girls and boys. Mostly boys participated in our research, which was carried out in a metalworking setting. It would be interesting to see if boys perform differently in SI during typical boy subjects and if SI is also effective for them in more traditional girl subjects, such as cooking and housekeeping (see Montague & Dietz, 2009, for gender differences in SI). ■

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