Developing an instrument for identifying a person's ability to solve problems
Results of a pilot study

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SUMMARY
Increasing people's ability to solve complex problems is more and more often being seen as an integral part of vocational education. While there have been numerous empirically-based approaches to the didactic structuring of teaching and learning arrangements by which students' ability to solve problems can be increased, knowledge of how to evaluate a person's ability to solve problems is far more limited. There is a lack of testing instruments that are inexpensive to implement and evaluate and take account of the features of ill-defined problems as they occur in professional practice. This article describes, with reference to a pilot study, the further development of a method of measuring a person's ability to solve problems (AIT according to Sembill) which is reliable but too expensive to evaluate in practice. The new MAPS instrument (Measurement and Assessment of Problem Solving) is more structured in terms of both performance and evaluation. The results of the pilot study indicate a high level of reliability and validity of the new instrument, these results having to be confirmed in a follow-up study, the design of which is also presented in this article.

Problem

Young people in vocational education and those entering the job market nowadays face a rapidly changing, increasingly complex world. This restructuring in the business world ([1]) (cf. Buttler, 1992; Schunck, 1993, Dohmen, 1999; Reetz, 1999; Achtenhagen, 2000; Picot, 2000; Kessler, 2003), often referred to simply as 'megatrends', also leads to a change in requirements for business staff (white collar jobs). In particular, the question is raised as to the extent to which knowledge acquired during education is retained over time and whether other, higher cognitive abilities are not also crucial when it comes to carrying out the work and tackling problems in one's professional life. A person's ability to solve problems is discussed as being a key skill and may be defined as a knowledge of how to deal adequately with complex, not fully understood and ever-changing realities (cf. Sembill, 1992a; Bransford; Stein, 1993; Sembill, 1995; Wuttke, 1999; Wolf, 2003).

Increasing a person's ability to solve problems should therefore already form an integral part of one's professional training: '*Learning to solve problems is the most important skill that students can learn in any setting. In professional contexts, people are paid to solve problems, not to complete exams.*' (Jonassen, 2004, XXI). However, traditional teaching in vocational colleges has hitherto failed to promote this in any systematic way. This is particularly evident when students are supposed to apply acquired knowledge in problem situations but are unable to do so ([2]). Failures to apply knowledge are attributable not least to the teaching practice still prevailing in many (vocational) schools. For the most part (over 70% of teaching time), the teacher presents facts and details. There is barely any time left to look at the application of knowledge and any particular increasing of a person's ability to solve problems (Hage; Bischoff; Dichanz; Eubel; Oehlschläger; Schwittmann, 1985, Dichanz; Schwittmann, 1986; Bohl, 2000; Pätzold; Klusmeyer; Wingels; Lang, 2003). Although teachers generally identify a person's ability to solve problems as being a skill that is crucial to success in the workplace, they do almost nothing to help their students acquire this skill. There are three possible reasons for this:

Teachers think that rudiments and basic skills have to be taught first before they can move on to more demanding subjects like problem-solving. As there are plenty of rudiments to teach in any subject and, furthermore, increasing a person's ability to solve problems takes time, they tend to put it off from one year to the next.

([1]) Internationalisation of markets, globalisation of the use of resources, introduction of new technologies, breakdown of traditional values, development into a service society, demand for highly qualified staff.

([2]) The problem is far from new. Back in 1929, Whitehead referred in this respect to the problem of inert knowledge. Inert knowledge is knowledge that can be repeated by people if they are explicitly asked for it, but cannot be used and applied spontaneously in situations where problems have to be solved.

Most teachers are unsure how learning environments can be structured in order to increase a person's ability to solve complex problems (lack of known methods).

While a person's ability to solve problems is established as a learning objective in curricula, it is unclear how it can be evaluated. Standardised tests in schools and as part of one's vocational training focus on the reproduction of facts, not on a person's ability to solve ill-defined problems. As learning processes are largely influenced by the tests that follow, teachers and students still focus on acquiring and reproducing factual knowledge.

In the light of these deficiencies, our research concentrates on the key areas of the structuring and implementation of learning environments to increase a person's ability to solve problems, and measurement of the acquired ability to solve problems. The following comments focus on the problems of measurement from the point of view of the structuring and implementation of learning environments (cf. Sembill, 1992a, Wuttke, 1999, Schumacher, 2002, Wolf, 2003 and Seifried, 2004).

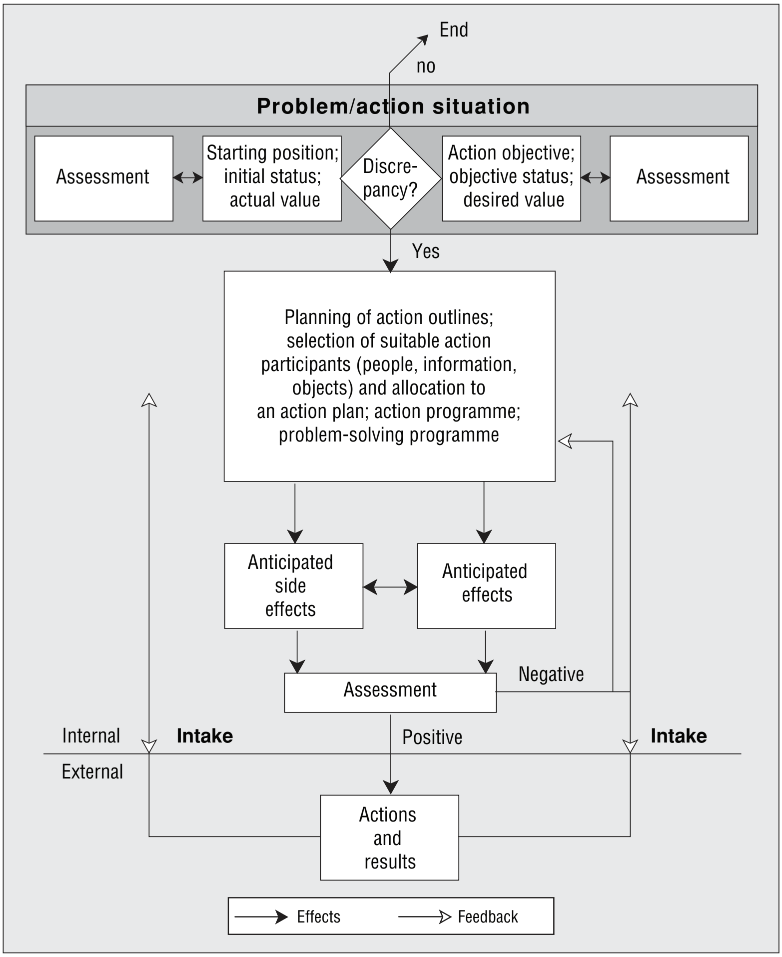
Learning environments for increasing a person's ability to solve problems

There are various approaches defining the 'ideal typical' steps to be taken in order to solve a problem and therefore giving clues as to how learning environments should be structured to increase a person's ability to solve problems. Bransford and Stein (1993) propose, for example, the IDEAL framework (Identify, Define, Explore, Anticipate and Act, Look and Learn). In the German-speaking sphere, Sembill (1992a) has developed a comparable framework model that he describes as an analytical ideal type of planned actions (see Fig. 1).

The characteristic components of complex problem-solving processes contained therein are identified in problem-solving research and cognitive psychology (cf. Dörner, 1976, Dörner, 1983, Sembill, 1992a, Dörner, 1999). They form the basis for structuring complex learning environments in which students:

(1) Identify the problem by:
 (1.1) Analysing and assessing a given situation;
 (1.2) Setting objectives;
 (1.3) Identifying possible discrepancies between the initial situation and the desired objectives;
(2) Use their existing knowledge;
(3) Gather the necessary information;
(4) Propose solutions (action or problem-solving programme);
(5) Analyse side effects in relation to the desired effects;
(6) Implement proposed solutions;
(7) Check and evaluate the result of the solution to the problem and
(8) Improve future problem-solving processes.

Figure 1. The Analytical Ideal Type (AIT) of planned Action (Sembill, 1992a; Sembill; Wolf; Wuttke; Schumacher, 2002) ([3]).



Most of these elements are also found in what are referred to as constructivistically-based learning environments like *anchored instruction* (CTGV, 1992), *intentional learning* (Bereiter & Scardemelia, 1989) and *learning with cognitive tools* (Kommers; Jonassen; Mayes, 1992).

The self-organised learning developed in our research group is based on the basic principle described above and therefore enables a person's ability to solve complex problems to be increased (cf. Sembill, 1992a; Wuttke, 1999; Sembill; Wolf, 2000). Self-organised learning can be described

([3]) This plan is an elaborated form of the TOTE unit (Test-Operate-Test-Exit; Miller; Galanter; Pribram, 1960), which is regarded as the unit on which problem-solving processes are based.

in terms of four main characteristics (cf. Sembill; Wolf; Wuttke; Schumacher, 2002; Wolf, 2003):

- Central to self-organised learning are the problem-solving activities of students. The problems to be tackled are complex and are generally solved in a project-based and group-oriented environment.
- The planning, implementation and assessment of learning processes is – as far as possible – left to the students (4). Self-organised learning also has to cover the definition of and reflection on objectives and the assessment of and reflection on a person's own actions and his solutions to the problem (cf., in this respect, the 'ideal typical' steps for solving a problem shown in Fig. 1).
- In self-organised learning, each person naturally also does his own learning. However, in addition, *learning for others* (sharing work when tackling problems and presenting results) and *with others* are central elements in the design of self-organised learning. It is also assumed here that arguments within groups and with the teacher and the expression of people's own ideas promote reflection and analysis and help the generation of knowledge and the ability to solve problems (cf. Wuttke, 2005).
- When solving complex, realistic problems, there is always the risk that mistakes will be made and first attempts will fail. However, it also means that people can learn from their mistakes, reach an understanding independently and build up skills (cf. Spychiger; Gut; Rohrbach; Oser, 1999; Oser; Spychiger; Mahler; Reber, 2002; Spychiger, 2003).

Self-organised learning has already been introduced and evaluated in five vocational colleges. In two of the studies, a virtual business was also created as an 'anchor' to help in problem-solving (a furniture company with imaginary data such as price lists, catalogues, calculations, lists of materials, delivery dates, etc.). Within the framework of the respective teaching units, problems relating to established curriculum subjects had to be solved. For example, students were put in the shoes of a furniture manufacturer when dealing with the subject of 'Materials business'. This manufacturer, at the request of a travel agent, has to submit a tender for the furnishing of an entire new branch to be opened in a student district. Computer equipment – apart from sector-specific software – also has to be provided. While tackling this problem (over the course of about 20 hours of teaching), students have to solve a large number of subsidiary problems. For example, decisions have to be made as to whether a new line of furniture will be purchased or made by the company itself or whether a just-in-time delivery is less or more expensive than keeping the furniture in stock.

A summary of the main findings of the studies so far shows that, when following a course of self-organised learning and in comparison with conventionally taught lessons, students:

(4) This all of course takes place within the framework of prescribed curricular requirements.

- *are able to master the subject matter just as well* as students who are taught it by teachers. In tests based on learning objectives, they come off just as well as those in the control group despite poorer initial qualifications in some cases;
- show a far *greater ability to solve problems* after completing the respective teaching unit. This applies both to problems specific to the subject and to problems from other spheres of the lives of young people not covered in the subject;
- show a greater degree of self-motivation required for analysis-oriented learning (intrinsic motivation and interest);
- broaden their range of learning strategies and apply learning strategies more appropriately;
- get fully involved in their respective learning groups and classes and feel that they are being taken seriously ([5]).

If the first finding were now to be looked at in isolation – 'self-organised learning achieves the same level of knowledge as conventional teaching' – one would have to wonder whether the undoubtedly higher cost of self-organised learning is actually worth it. However, as explained above, the aim is not just to enable students to repeat factual knowledge, it is also to give them the ability to solve problems as is required when meeting the challenges of the workplace. But in order to be able to comment on whether a person's ability to solve problems has actually increased, and in order to be able to include this skill in the measurement of performance, a person's ability to solve problems has to be made measurable.

Measuring a person's ability to solve complex problems

In psychological research and research into learning and teaching, information provided by students themselves are generally gathered by means of questionnaires in order to measure their ability to solve problems (e.g. Stäudel's Skills Questionnaire, 1987 or Dirksmeier's Diagnostic Inventory of Problem-Solving DIP, 1991). However, this does not tell us how well students are actually able to solve problems in their professional environment ([6]). In our work we therefore concentrate on measuring actual performance in problem-solving. Students are given complex and realistic written problems to be solved by giving written answers. For this purpose, Sembill (1992a,, 1992b) developed a system to enable the quality of written solutions to problems be assessed. It includes both quantitative and qualitative criteria and

([5]) Detailed descriptions and discussions of the findings are given, for example, in Wuttke, 1999; Wolf, 2003; Santjer-Schnabel, 2002, Sembill, 2004, Seifried, 2004; Schumacher, 2002).

([6]) A strongly subject-oriented 'Test of ability to solve sector-specific problems' is described by Hussy; Seeling (2004a, 2004b).

Figure 2. Example of an ill-defined problem

Please imagine you are faced with the following situation:

You are Head of the Personnel Department at a furniture factory (Justus-Liebig-Büromöbelwerke, JLB) in Gießen, South Hesse. The company has just been taken over by the Swedish HAVARTI Group.

The Personnel Manager Mrs Olsen wants Mrs Mertens – an office worker in the Personnel Department's payroll office – to be trained in PowerPoint so that she can produce transparencies for Mrs Olsen's advertising presentations. Mrs Mertens refuses because it is not part of her job description. 'I already have my hands full with the wages accounting', she explains.

Mrs Olsen is annoyed and consults you in your capacity as her manager. 'I think job descriptions are a waste of time. What good do they do anyway? They only make staff inflexible. And it takes ages to produce these descriptions. The business we are in is constantly changing and the requirements of our staff change at the same time'. Mrs Olsen asks you to send out a memo stating that job descriptions are no longer binding.

Please imagine you are the Manager and try to resolve the dispute. Think of the possible consequences of doing away with binding job descriptions.

Please describe how you weigh up the arguments for and against various solutions and which solution you go for. Remember to give your reasons.

You have 30 minutes.

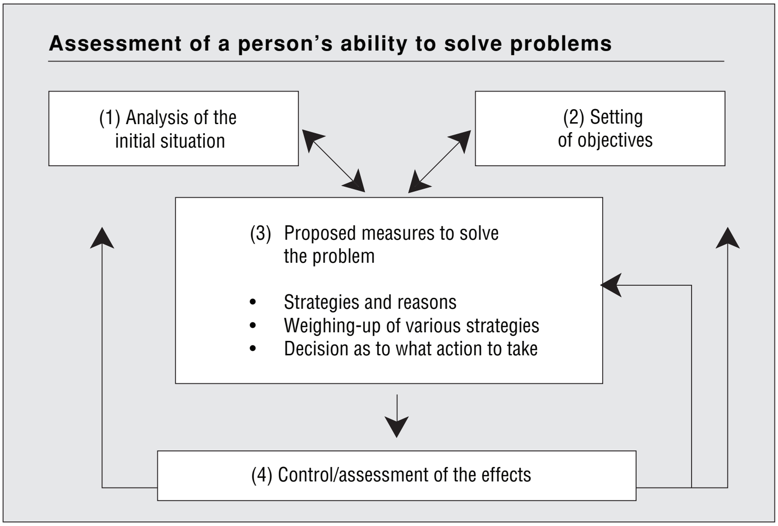
contains the ideal steps in a problem-solving process (see Fig. 1; cf. also Dörner, 1976; Dörner; Kreuzig; Reither; Stäudel, 1983):

- Analysis of the initial situation
- Setting of objectives
- Developing problem-solving strategies or measures
- Controls to check the appropriateness of the solution to the problem (taking account of main and side effects).

Students are given descriptions of problems (see, for example, Fig. 2) and are supposed to provide written solutions to them.

The written solutions to these sorts of problems are assessed in a first step according to quantitative criteria. Analysis is carried out here as to whether the students have carried out all problem-solving steps appropriately (for the system, see Fig. 3).

Figure 3. Overview of the evaluation categories for assessing problem-solving ability



Below is a brief overview of how the evaluation is carried out. Detailed instructions for codes used are given by Sembill (1992b) and Wuttke (1999).

(1) Coding for the category 'Analysis of the initial situation' (actual situation):

AS1: Number of facts having a bearing on the problem. This category provides information on the student's ability to obtain relevant information (from texts).

AS2: Comments, opinions and assessment of these facts (critical analysis of available information);

AS3: Number of people/groups specified in the problem having different interests (who is relevant to the initial situation, who has to be taken into account).

Coding example:

Example of a student's solution	AS1	AS2	AS3
Mrs Mertens is an office worker in the payroll office, so she possibly knows nothing about advertising.	1	1	1
I think it is a good idea to ignore the job description.		1	
I think Mrs Mertens is right to refuse to produce the transparencies.		1	(1)

(2) Coding for the category ‘Setting objectives’(desired situation)
DS1: Number of objectives specified;
DS2: Production of a hierarchy of objectives (importance, sequence, priorities).

Coding example:

Example of a student’s solution	DS1	DS 2
If Mrs Olsen needs help, she should persuade her manager to employ an assistant for her.	1	
At the moment, it is probably more important to do the work than to waste time in a power struggle.	2	1

(3) Coding for the category ‘Measures’
M1: Number of measures proposed;
M2: Giving reasons for the measures;
M3: Weighing up the measures (likelihood of success, main effects and side effects);
M4: Decision on measures to be taken.

Coding example:

Example of a student’s solution (7)	M1	M2	M3	M4
You should first talk about their differences.	1			
They should share the work and do the transparencies together.	1			
If they do it together, both can manage their work.		1		
It is better to reach a compromise than to impose rules (this is directed at Mrs Mertens, who is relying on her job description and refusing to produce the transparencies).	2		1	
I think it would be best if there were job descriptions but the managers also asked employees to be flexible.				1

(4) Coding for the category of ‘Controls’
C1: Facts in the solution are referred back to the initial situation;
C2: Description of the consequences of the solution for the initial situation;
C3: Facts in the solution are referred to the desired situation;
C4: Description of the consequences of the solution for the desired situation;
C5: Facts in the solution are referred to the measures;
C6: Description of the consequences of the measures.

(7) In the evaluation, it is striking that almost all participants specify measures but hardly ever give reasons.

Coding example:

Example of a student's solution	C1	C2	C3	C4	C5	C6
I would explain to Mrs Olsen that it would be complete chaos if there were no compulsory job descriptions.	1	1				
It might be useful to mention in future job advertisements that employees have to be flexible and cooperative, even if they are asked to carry out tasks that do not precisely come under their job description.			1			
Employees would then be unlikely to insist on doing only what comes under their job description.				1		
If he could persuade the two women to cooperate and do the work together, it would be much better for the workplace atmosphere.					1	1

The categories can then be added together to give an overall score, the 'Analytical Ideal Type'. A high score indicates a highly developed ability to solve problems.

In the next step, the quality of the problem-solving is analysed by expert rating. The categories to be taken into account here are:

- Use of declarative and procedural knowledge (giving reasons and alternatives, logical comprehensibility and prospect of success of the problem-solving);
- Complexity of the problem-solving and the reasons given (quality of the theoretical model);
- Formulation of original objectives and ideas (e.g. moral considerations).

In previous studies, this evaluation system has given results that were consistent both with the assessments of teachers and with our own assessments and observations in the classroom (cf. e.g. Wuttke, 1999; Wolf, 2003; Seifried, 2004). The problem is the large amount of time required to evaluate written problem-solving, making the instrument unsuitable for use in schools. As there are a number of evaluation steps to go through, several lessons have to be set aside for each solution. Furthermore, the results are hugely dependent on how motivated and prepared students are to write down what they think. Account also has to be taken of the fact that, because the questions are very open, students will not mention certain aspects that they do in fact know.

As a result, the instrument is currently being developed to produce a more practical instrument for measuring a person's ability to solve problems (MAPS – Measurement and Assessment of Problem Solving Skills). This instrument cuts down the time spent on evaluation and should be less dependent on the student's motivation and ability to put thoughts into writing. MAPS comprises a combined analysis of quantitative and qualitative aspects of problem-solving. Unlike the original AIT method, students are also given specif-

ic questions along with the problem (cf. Fig. 4). These should structure and help in the solutions and answers and prompt answers relating to all aspects, even for students who are not so motivated and/or are unable to put their answers in writing. Together with an evaluation sheet, the questions can help teachers ascertain the students' ability to solve problems.

Figure 4. Problem together with specific questions

Problem for the students
Please imagine you are faced with the following situation: … the problem already described in Fig. 2 is inserted here **Questions:** *Initial situation:* • Please describe the situation in your own words. • What information is missing? Who would you ask for it, who could help you? Where would you look for additional information? • Please describe the assumptions you are making with respect to missing information (when tackling this problem, you can work on the basis of assumptions because you currently have no access to additional information). *Objectives:* • Which objectives would be conceivable in relation to the situation described above? • Which would you try to achieve and why? *Measures:* • What measures could help you to achieve the objectives? • Please say why you think these measures are appropriate. • Are some measures better than others? Please take account not only of the objectives you are trying to achieve, but also of possible (undesired) side effects. • Decide which measure(s) is/are most appropriate. *(Theoretical) control:* • How do your solutions alter the initial situation? • How successful is your solution given the objective you are trying to achieve? • How promising is/are your measure(s)?

The students' answers are evaluated using the following assessment system:

Figure 5. Evaluation sheet for solutions to problems

MAPS assessment sheet	
Analysis of the initial situation	
Student gives a comprehensive description of the situation.	Yes (in own words) – to a certain extent – no
The student's description covers the main points.	Completely – to a certain extent – not at all
Student indicates missing/required information.	Entirely sufficiently – not much – none
Student formulates ideas as to where/from whom missing information can be found.	Many – some – none
Student formulates assumptions on missing information.	Many – some – none
The student's assumptions are reasonable.	All – some – none
Definition of objectives	
Student formulates objectives.	Many – some – none
The objectives are reasonable.	All – some – none
Student formulates objectives for all those involved in the problem.	For all – only for some – for none
Student chooses one or more objectives.	Several objectives – one objective – no objectives
Student says why s/he chose the objective(s).	Yes, explicitly – yes, implicitly – no
The choice of objective(s) is well-founded.	Yes – to a certain extent – no reasons or poor reasons
Measures and action plans	
Student proposes various strategies/action plans.	Yes – only a few – none
Student explains why s/he thinks these measures are reasonable.	Yes – partly – no
Student weighs up various measures against one another.	Yes – partly – no
Student takes account of possible (undesired) side effects.	Yes – partly – no
Student decides which measure(s) is/are reasonable.	Yes – no
Control	
Student analyses whether and how measures might alter the initial situation.	Yes – to a certain extent – no
Student analyses whether the measure(s) is/are successful in achieving the desired objective(s).	Yes – to a certain extent – no
Student analyses whether the measure(s) is/are reasonable.	Yes – to a certain extent – no

For each answer, marks are awarded according to the level shown (from 0 to 2). In this way, performance in the individual sections and an overall score for a person's ability to solve problems can be ascertained. The evaluation table is in principle suitable for all subject areas (8), but subject experts are required to carry out the evaluation in order to enable assessment of the students' performance.

MAPS evaluation: First findings from a pilot study

Method

For MAPS evaluation, a first pilot study with students has been carried out so far; the second test is to start in schools in autumn 2005. In the pilot study, nine students whose main course was business education (9) were looked at and given two similar problems. Both related in terms of their subject to previously attended business education seminars. One problem was open (like the one in Fig. 2), the second problem was, as shown in Fig. 4, supplemented by specific questions. The first problem was assessed by two encoders according to the AIT system, the second – also by two encoders – according to the MAPS evaluation system. The results of this study should provide starting points when it comes to answering the following research questions (10).

How reliable are the measurements of the two AIT and MAPS instruments? The interrater reliability (Cohen's Kappa) is used check this.

The results relating to a person's ability to solve problems achieved so far using the AIT system are satisfactory insofar as they confirm theoretically expected findings. For example, there is, in accordance with the theory, a positive correlation between analysis and a person's ability to solve problems. Such findings indicate that, using the AIT system, a valid instru-

(8) The two instruments (AIT and MAPS) have so far only been trialled in German vocational colleges and universities. However, as they are independent of any subject, they could also be used for measurement purposes in other European and non-European educational estabishments. The only requireement is a subject expert to assess the quality of the solutions.

(9) The participants in the sample are therefore future teachers at vocational colleges in Germany. The sample is unrepresentative for numerous reasons. To begin with, it is too small to enable the findings to be generalised. Furthermore, MAPS is being developed for use in vocational colleges, in other words for a target group which is a) younger and b) usually less well educated than the sample in the pilot study. For these reasons, other studies of the population for which the instrument is designed are required. Design considerations in this respect are presented in the course of the paper.

(10) As already mentioned, the sample of 9 participants is extremely small and the findings are certainly unrepresentative. As a result, the follow-up study will be carried out on a much broader basis.

ment for measuring a person's ability to solve problems could exist ([11]). It should now be examined whether MAPS also measures a person's ability to solve problems. To do this, the relationship between the two measures of a person's ability to solve problems (measured by the AIT system and measured by the MAPS system) is determined. Ranking correlations are calculated with respect to the subdivisions of a person's ability to solve problems (actual situation, objectives, measures and control) and with respect to the overall score (AIT).

Findings of the pilot study

When calculating the interrater reliability, findings were as expected. As both the tackling of the problem and the evaluation are more structured and prescribed with MAPS, the measures of the participants' ability to solve problems correlate much more often than with AIT evaluation. The interrater reliability within the framework of the AIT evaluation can only be assessed as being satisfactory (Cohen's Kappa = 0.66). Correlation within the framework of the MAPS evaluation, on the other hand, is very acceptable with a Kappa of 0.89.

The ranking correlations between the two measuring instruments indicate that both instruments at least measure similar constructs (Fig. 6).

The correlation coefficients generally indicate a medium to high correlation between the two instruments. The statistical validation (significance) that is not available in all cases is presumably attributable to the small sample. Nevertheless, the findings can be regarded as being an indication that the instruments measure similar things.

Figure 6. Ranking correlations between AIT and MAPS findings in unrepresentative testing (N = 9)

	AIT and MAPS correlations
Actual situation	.543 (p = .065)
Objectives	.377 (p = .159)
Measures/strategies	.820** (p = .003)
Control	.789** (p = .006)
Overall score for a person's ability to solve problems	.807** (p = .004)

([11]) In order actually to establish whether the 'ability to solve problems' construct is being validly ascertained, an external criterion would have to be applied. This has been difficult hitherto because, to our knowledge, there have never been any proven, valid instruments that actually measure a person's ability to solve problems. Although there are a number of questionnaires on the subject, to use these as an external criterion is problematical in that information provided by students themselves and measurements of skills do not necessarily have to be connected.

Consequences for teacher training and for subsequent investigations

International comparative studies like PISA have shown that German students are often insufficiently capable of applying their knowledge and solving complex problems. With respect to a person's ability to solve problems ([12]) ascertained within the framework of research into interdisciplinary skills in the PISA 2003 study, it was revealed that although German students were above the OECD average, they were significantly behind the international leaders (Korea, Finland and Japan). Moreover, 14.1 per cent of young people in Germany have to be classified below the first skill level as far as problem-solving is concerned (cf. OECD, 2004).

As mentioned at the beginning, the relevant literature contains plenty of methodical advice on the design of problem-based teaching and learning arrangements that might address this deficiency. However, the problem remains that teachers are often still very attached to conventional teaching methods and hence make insufficient use of the opportunities to increase a person's ability to solve problems. To improve the situation, greater use of more innovative methods is required in teacher training and further education events for teachers who are already established.

However, this does not overcome the problem that, at present, there are no instruments for measuring a person's ability to solve problems available that are suitable for use in vocational colleges. As most of what is learnt is that which is tested at the end of the year – and is at present still predominantly factual knowledge – this lack of available test instruments and measurement methods may have a negative impact on the design and implementation of teaching and learning processes.

MAPS is a first step towards closing this gap by developing a practical instrument. Findings so far provide starting points enabling development of a reliable and possibly also valid instrument for measuring a person's ability to solve problems. As the previous study was carried out in a university environment, though the instrument was designed for use at vocational colleges, the next study will be carried out at a vocational college. It should first be examined here whether students and teachers can work with this instrument, in particular whether the MAPS rating categories are appropriate. Secondly, it should be checked again with a larger sample how reliably MAPS measures the person's ability to solve problems. The design is structured as follows:

In a first step, students' ability to solve problems is ascertained by means

([12]) What was tested was the ability to use cognitive processes in order to solve real, interdisciplinary problems in which the solution is not immediately obvious. The questions set three types of problem (making decisions, analysing and outlining systems and looking for errors) and related to requirements for life outside school (e.g. in leisure and professional situations), in which problem-based action is required. The international test involves paper and pen questions, in particular skill at solving analytical problems.

of Stäudel's skills questionnaire ([13]) (1987) in 5 classes (N ≈ 100). Using these preliminary test values, the whole group is divided into two equal subgroups that should be indistinguishable with respect to students' ability to solve problems. This should prevent the findings being distorted by a systematic ability effect (a person's ability to solve problems) in one group ([14]).

In a second step, the groups are given identical problems. As it cannot be expected that all classes in an educational subject area will have the same knowledge, a problem is chosen from students' everyday life. This should prevent an uneven distribution of prior knowledge falsifying the results. One group tackles the open problem that is evaluated according to the AIT system. The other group is given the problem according to MAPS, which is linked with specific questions and evaluated according to the MAPS system. In both groups, the solutions are evaluated by to encoders each.

Using this design – on the basis of the problem-solving of one subgroup – the MAPS interrater reliability can be rechecked. It is thereby possible to establish how effective the instrument is in a school environment. As there are three measures of a person's ability to solve problems in this procedure, it is also possible to examine whether the instruments measure a similar or identical construct. For each instrument there are in this case two 'external criteria' which enable assessments to be made regarding validity. ■

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([13]) The subscales 'adequate problem-solving behaviour' and 'heuristic skill' are used here to measure a person's ability to solve problems irrespective of the subject.

([14]) In principle, it would also be possible to form the groups on the basis of their demonstrated ability to solve problems (measured by AIT or MAPS). However, this procedure is very expensive and recognition effects could distort the subsequent findings.

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