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## Stimulating cognitive skills development in a German language class and language performance

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**Abstract:** Modern society requires new competences, among which are problem solving and critical thinking. Apart from specific knowledge and skills, new teaching concepts include the instruction in thinking skills in all curriculum areas.

The goal of this research was establishing if and to what extent enabling students to master inductive strategies in learning German as a foreign language, which surpasses the specifics of the profession, would improve the students' language competency in the domains of reading comprehension, vocabulary and grammar, as well as their intelligence. The results confirm that stimulating cognitive skills and inductive reasoning significantly improves the students' language competency, and that this is a result of the students' training in solving the same problem under different conditions and circumstances, in other words, a result of mastering the problem-solving method.

In der heutigen Informationsgesellschaft wird die Fähigkeit zum selbstständigen Herangehen an Probleme immer stärker erwartet. Neue Bildungskonzepte fordern daher neben dem fachspezifischen Wissen auch die Vermittlung von kognitiven Fertigkeiten in allen Ausbildungsbereichen. Diese Untersuchung geht der Frage nach, ob und in welchem Ausmaß ein DaF-Unterricht, der auf die Vermittlung von induktiven Strategien und das Entdecken von Gesetzmäßigkeiten abzielt, sein fachspezifisches Ziel – kommunikative Kompetenz – erreichen und die kognitive Fähigkeit der Lernenden verbessern kann. Die Ergebnisse der Untersuchung bestätigen, dass die Förderung des induktiven Denkens zugleich mit und durch den Unterricht statistisch signifikant größere sprachliche Leistung im Bereich Leseverstehen, Grammatik und Wortschatz zur Folge hat und dass sie auf der Anwendung der induktiven Strategien beruht.

**Keywords:** Cognitive skills, German as a foreign language, grammar, inductive strategies, inductive reasoning, language competency, language learning outcomes, reading comprehension

### 1. Introduction

In an attempt to meet the demands of the modern society, which can be articulated as focusing on problem solving, the constructivist learning theory provides a solution in the form of a teaching concept which enables the students to develop thinking skills, aside from acquiring specific types of knowledge and competences. Student training which surpasses the specifics of the profession should be carried out in all areas of education, including foreign language teaching (cf. Bruner 1973: 26).

The main characteristics of constructivist foreign language teaching can be summed up by Wolff's phrase "construction instead of instruction" (Wolff 1994: 427). As opposed to instructivism, the pedagogical-psychological concept which perceives the students as the "reactive" participants in the process of teaching and dissemination, Wolff sug-

gests constructivism, in which the students are active participants in class and constructors of their knowledge (cf. Bruner 1973: 21), who need tools and instruments in order to achieve that (cf. Wolff 1997).

### 1.1. Strategies

According to Tönshoff (2003: 331), tools are thought processes which direct and control construction, memory, recall, and information usage. He terms them strategies. The term itself, as well as the description and the classification of the construct are characterized by great unevenness (Bimmel & Rampillon 2000: 54; Dörnyei & Skehan 2003; Edmondson & House 2000; Ehlers 2003; Ellis 1999: 529; Medved Krajnović 2010: 81; O'Malley & Chamot 1990: 52; Oxford 1990; Terhart 2001: 26; Vielau 1997; Westhoff 2001: 686).

Foreign language learning strategies are applicable to all foreign languages (cf. Bimmel 1995: 17), and some of them are not only applicable to foreign language teaching, but to all classes, as well as to problem solving outside the class.

Language learning and language use as an interactive change of mental representations of the complex processes of constructing language knowledge and knowledge of the world (cf. Wolff 2002: 340) is unimaginable without not only strategic behavior of students (cf. Wolff 1997), but without strategy awareness as well (cf. Tönshoff 1992; 1997: 208ff), which has crucial importance within the theoretical concepts of cognitive and constructivist-oriented psychology. The effect of strategy application and strategy awareness, that is, verbalization of the problem-solving process, is evident in student's competency for solving the same problem under different conditions and circumstances (cf. Westhoff 2003: 80), and it should enable the learner to function in the fast-changing and highly competitive modern society. This brings us to the teaching concept of discovery learning, which enables the acquisition of new skills and knowledge, as well as learning to master novel and problematic situations (cf. Terhart 1989: 45). Moreover, this concept stresses mastering of the problem-solving method as the main characteristic of the learning process (cf. Bruner 1973: 26).

#### 1.1.1. Inductive strategies

Inductive strategies, which are the basis of discovery learning (cf. Neber 1981: 95), are defined by Klauer (1989, 1991, 1993a, 2001, 2003) as discovering regularities in analogies, sequences, classifications and matrices by comparing objects and relations between them in order to establish if they are alike, different, or both. Because of the processes on which inductive reasoning is based, it is placed in the domain of critical thinking, that is, higher-order thinking within the taxonomies of cognitive processes (Halpern 1998: 451). In the revised Bloom's taxonomy (cf. Anderson & Krathwohl 2001) cognitive processes are hierarchically classified in six categories, depending on the complexity of cognitive operations (remembering, understanding, applying, analyzing, evaluating and creating). There is a whole range of thought activities based on inductive strategies, that is, on discovering similarities and differences through comparison – for example, drawing conclusions based on the observed regularities, forming and questioning hypotheses, discovering patterns and distinguishing the relevant from the irrelevant (cf. Eggen & Kauchak 1994 as quoted in Vizek Vidović, Rijavec, Vlahović Štetić & Miljković 2003: 368, 369), discovering relations and event conditions, predicting or determining occurrence probability of events and phenomena (cf. Stangl 1989), distinguishing facts from values, distinguishing substantiated from unsubstantiated claims, discovering thinking perspectives, distinguishing expressed from unexpressed assumptions, and recognizing illogicality (Ennis 1962: 38; Kennedy, Fisher & Ennis 1991: 31; Thompson 1996).

##### 1.1.1.1. Cognitive abilities and cognitive skills

Cognitive abilities – intelligence and its central component, inductive reasoning – could not be realized without the application of cognitive skills. We could say that cognitive skills are cognitive abilities put into action. Sternberg (1985 as quoted in Vlahović-Štetić 2005: 29) describes them as learning skills, thinking skills, and metacognitive skills. *Learning* skills are the skills of acquiring knowledge and procedures used to connect pieces of information (the skill of distinguishing the relevant from the irrelevant, the skill of organizing relevant pieces of information into

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meaningful wholes, and connecting new information with the existing information in the long-term memory). *Thinking* skills include the skill of critical (analytical) thinking: judgment, analysis, comparison, opposition, assessment, and evaluation; the skill of creative thinking: detection, imagining, supposition, creation; and practical skills used for solving particular tasks and applying knowledge, in other words, for turning ideas into action. And finally, *metacognitive* skills are the skills of planning the approach to learning/problem-solving, the skills of tracking one's own progress, and readiness to change one's learning behavior if it is not producing the expected results.

There are programs for training cognitive skills. Different programs for training and stimulating cognitive skills focus on training and stimulating inductive reasoning as described in the previous section (cf. Vizek Vidović et al. 2003: 368).

### 1.1.1.2. The possibilities of influencing inductive reasoning

As previously mentioned, inductive reasoning is a central component of intelligence. Through optimal stimulation, training and exercise, the genetically determined IQ of 100 can be raised to 110 (the average IQ of German students in the final grade of a *gymnasium*), and without stimulation it can fall to 90 (cf. Roth 2007). Later sources (Roth 2009) claim that the growth of IQ can be influenced up to 20 %, and Roth considers this to be an unambiguous effect of exercise and stimulation. The possibility of influencing inductive reasoning as well as the possibility of influencing the learning at school through training has been documented in the meta-analysis of 72 studies of the efficiency of inductive reasoning training with more than 3,100 examinees (Klauer 2003; Klauer, Willmes & Phye 2002), which has shown the impact of training on intelligence test performance (Cattell and Weib' Culture Fair Test CFT or Raven's Standard Matrices). Even though Hager & Hasselhorn maintain that this is a result of nonspecific effects of treatment (Hager & Hasselhorn 1995), effects of coaching (Hager, Hübner & Hasselhorn 2000), or effects limited to cognitive stimulation (Hager & Hasselhorn 1993), the listed objections have been refuted by empirical evidence (cf. Klauer et al. 2002; Lipsey & Wilson 1993). It is unclear whether the factors influencing performance are the materials, that is, the tasks and their processing, or some general factors as social interaction, motivation and the like. However, as long as efficiency is achieved, everything that leads to it should be stimulated (cf. Rindermann 2003: 113). Until recently, scientists have regarded fluid intelligence and working memory as two independent cognitive domains, but this was refuted by research on the impact of working memory training on intelligence, conducted in 2008 by a group of American and Swiss psychologists from Michigan and Bern. The fact that the trained group performed significantly better in the fluid intelligence test was explained by the researchers as the result of process transfer which was activated during the solving of the complex tasks in the training program (cf. Jaeggi, Buschkuhl, Jonides & Perrig 2008).

The fact that the inductive reasoning tasks, no matter whether they are numerical, verbal or diagrammatic, are successfully solved using a unique basic problem-solving strategy, provided that the person has mastered it, led Klauer to conclude that similar results can be expected in different classes, that is, school subjects, if the students have mastered that unique basic strategy; this insight has served as the basis of the theory of efficiency transfer of inductive reasoning training (cf. Klauer 2003).

### 1.1.1.3. Inductive reasoning training and language

The first in the series of new research projects that Klauer conducted between 1992 and 1997 examining the influence of inductive reasoning training, which he designed himself (1989, 1991, 1993a) on the learning performance in certain school subjects, investigated the influence of inductive reasoning training on foreign language learning ability (cf. Klauer 1993b; Fries 2002: 68). This influence was scrutinized by the "Syntaktischer Regel- und Lexikon-erwerb" test (Harnisch 1985 as quoted in Klauer 1993b; Fries 2002: 68), in which inductive strategies of comparison and discovering similarities and differences have to be applied in discovering word meaning and syntactic relations in an imaginary language; these strategies are the basis of Klauer's inductive reasoning training. The results have shown that the foreign language learning ability test partially covers what is measured by the SPM, that is, inductive reasoning, but the transfer of training to foreign language learning ability is even greater than in Raven's APM test. Klauer concludes that this is not only the transfer of training to the test results, but considers these results as evi-

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dence of transfer to the learning processes which were necessary during problem solving. The results of another piece of Klauer's research, examining the mutual influence of reading comprehension training in the mother tongue and inductive reasoning training (1996) showed transfer as well. Reading training improved reading test performance, but not intelligence test performance, while inductive reasoning training improved not only intelligence, but also reading comprehension.

Ten years later Marx (2006: 144) also found that training of inductive reasoning improves not only the cognitive skills, but also the language skills of the trained children in all stages of first language acquisition without the training of the language skills themselves.

It was shown, as it was in Klauer's research, that inductive reasoning does not benefit from language stimulation, while children's language abilities are influenced not only by language training, but also by inductive strategies training. This is explained by the fact that both intelligence and language acquisition are based on discovering regularities, that is, on the same inductive strategies.

## 1.2. Research goals and problems

The present research raises the question whether a foreign language class emphasizing inductive strategies, common to language and intelligence, would improve both specific language goals and the students' cognitive abilities. The goal of this research was to establish if and to what extent enabling students to master inductive strategies in learning German as a foreign language, which surpasses the specifics of the profession, would improve the students' language competency in the domains of reading comprehension, vocabulary and grammar, as well as their intelligence.

Hypothesis 1: Students learning German using inductive strategies will solve more language tasks of inductive reasoning than the students following the traditional learning approach.

Hypothesis 2: Students learning German using inductive strategies will solve more inductive reasoning problems on the intelligence tests than students following the traditional learning approach.

## 2. Methodology

### 2.1. Sample

The research project lasted for one school year; it included 14 and 15-year old students in the first grade of high school, at the beginner's level of learning German. Out of the total of 214 students, 90 examinees were put in the experimental group and 124 were put in the control group. In both groups there were more female than male students. The first selection criterion was that the students had not previously learned German, which considerably limited the leeway for sample selection. Ten-year-olds in the fourth grade of elementary school in Croatia usually choose German as their second foreign language, which is taught as an elective course, and there are very few complete beginners by the time they enroll in (comprehensive) high school.

Within this limited room for action, another criterion was the teachers' consent to participate in the research. The teachers who agreed to conduct the described program and the written exam at the end of the school year were placed in the experimental group, and the teachers who agreed to conduct the written exam in their class at the end of the school year were placed in the control group. Each group included students from three comprehensive high schools and one vocational high school in three Croatian cities. Both the experimental and the control group included one of the most successful comprehensive high schools in Croatia, according to the results of the external state graduation exam. By including the best Croatian comprehensive school in the control group, and the one ranked ninth in the experimental group, we wanted to make sure that the results of the experimental group were not influenced by student performance not related to the program, but rather due to their greater study effort as a response to

the perception of the school as a high-expectations school. It was important for us to find out how “good” the experimental group was thanks to the program, and not how “poor” the control group was.

## 2.2. Procedure

At the beginning of the school year it was determined whether there are differences between the experimental and the control groups with regard to academic performance variables and cognitive variables.

During the school year the classes in both groups were based on the syllabus defined in the Curriculum for Beginners (CEFR level A1, 2 class periods per week). The control group used the existing textbooks based on the communicative approach, while the experimental group used the specially designed teaching materials and work instructions aimed at stimulating cognitive skills in the area of grammar and vocabulary, as well as the reading comprehension skill. Grammar, vocabulary and reading comprehension skills are areas which enable stimulating cognitive skills at the lowest language knowledge level, A1.

At the end of the school year, a language knowledge exam and the (repeated) intelligence test were administered in both groups.

## 2.3. Instruments

### 2.3.1. Teaching materials for the experimental and the control groups

In both groups German language classes were based on the communicative approach, and they were in accordance with the goals of modern foreign language classes – enabling students for language use through contact with people and the media, that is, for communication (CEFR 2001). This goal has influenced the choice of topics, texts and grammar materials, the design of exercises, and learning progression, observing the principle of situationality and contextualized exercises. It was achieved through the acquisition of language (declarative) knowledge (vocabulary and grammar) and through the mastering of skills – listening, reading, speaking and writing (procedural knowledge) (cf. Storch 1999: 17).

The materials for the experimental group were designed so as to stimulate and make students aware of the inductive strategies in the domains of reading comprehension, grammar and vocabulary. They were divided into thematic units consisting of texts, tasks, exercises and work instructions for teachers. Work instructions included the description of language and cognitive goals, as well as of the means of achieving them, that is, the description and the explanation of tasks and exercises, their sequence and strategies. Each thematic unit ended in a short written exam and the analysis of its results. While the students were working, the teachers were writing down their observations. The goal of *reading comprehension* was to stimulate higher order comprehension by activating the processes of recognizing supra-sentential ties and internal text structure (cf. Ehlers 2003: 289), as well as by activating macro-processes which link individual expressions through inferences and reveal the common thread in the text. On an even higher level, these are elaborative processes which relate what has been read to prior knowledge, and integrate it into an individual’s knowledge structures (cf. Blatt & Voss 2005). Christmann & Groeben’s (1999:196) term for higher order comprehension is “strategies of organization and elaboration”. If we wanted to describe higher order text comprehension in terms of mental representation of text (cf. Schnotz 2006: 227), we would choose hierarchically the highest form of mental representation of text, called the mental model. It includes prior knowledge in the previous - second - semantic, propositional level of mental representation of text, which enables relations and ties between propositions. Only then can we completely comprehend the text. In order to achieve the described goal, that is, to stimulate higher order comprehension, we focused on discovering relations in the text and forming and questioning hypotheses in class.

During the process of discovering relations in the text, insufficient language knowledge had to be compensated for by certain types of knowledge which are not specifically language-related – the knowledge of text structure, and the knowledge of the world (cf. Westhoff 2003: 74). The students systematically practiced recognizing the textual roles

of pronouns, adverbs, pronominal adverbs, platitudes, entire sentences, punctuation and conjunctions, which function as signals and indicators of text structure, as well as recognizing the types of logical connections between sentences and paragraphs, which are made possible by the above-mentioned textual features (cf. Westhoff 2003: 88, 90-91). Their application was practiced through the following types of exercises: establishing the chronological sequence in the text, “What does \_\_\_\_\_ refer to?”, picture story, exercises of putting sentences or paragraphs into the right sequence, inserting one out of several suggested paragraphs into the right place, choosing the right beginning or ending out of several suggestions, and making text diagrams. In order to master forming and questioning hypotheses, the experimental group had to learn to mobilize various types of previous knowledge. Mobilizing previous knowledge was practiced by filling in the blanks in the text using words, sentences or pieces of text, matching questions and answers, and other types of tasks (cf. Westhoff 2003: 95). Considering the fact that the types of tasks mentioned do not pose a high cognitive demand in themselves, they had to be designed in such a manner that they mobilized the processes of analysis, comparison and contrast during problem solving (cf. Sternberg 1985 as quoted in Vlahović-Štetić 2005: 29). This involved that in order to discover word meaning and syntactic relations, one needs to apply inductive strategies of comparison and discovering similarities and differences, which are the basis of Klauer's inductive reasoning training (cf. Klauer 2001). During grammar lessons the students were encouraged to find language regularities on their own through the series of three steps, based on the model called SOS (*Sammeln, Ordnen, Systematisieren* – *collecting, sorting, systematizing*). During the first step the students recognized and collected (*sammeln*) the new grammatical structures from a formal-linguistic standpoint, during the second step they sorted them according to a certain principle (*ordnen*), and lastly they systematized (*systematisieren*) them and formulated the rule (cf. Funk & Koenig 1991: 123; Koenig 2001: 298). By applying their prior knowledge, they created new language knowledge on their own, without excessive use of meta-language. The students first tried to understand the unfamiliar *vocabulary* from the context, and then practiced it through types of tasks usually found in verbal intelligence tests: sorting the items according to their own principle or a suggested one, completing sequences with or without suggested words, and finding superordinate terms for groups of words. The materials for the experimental group and the written exam were designed and tested for purposes of this research.

The *control* group used contemporary textbooks by Croatian and foreign authors in which the topics, grammar materials and types of tasks were determined by the communicative approach. The level of cognitive processes in the teaching materials, tasks and exercises did not exceed the level of reasoning of lower cognitive demand, according to the revised Bloom's taxonomy (cf. Anderson & Krathwohl 2001), which includes the first three levels – remembering, understanding and applying language. Grammar was taught using the deductive approach. The textbooks did not contain some of the types of tasks that the experimental group worked on.

### 2.3.2. Written test

The written exam in German language consisted of tasks of lower and higher cognitive demand; it comprised 42 items, organized into six tasks. Text reception, that is, reading comprehension was tested in 32 items, and grammar and vocabulary were tested in 10 items.

The written exam (see Appendix) included two types of tasks on which both groups had worked during the school year, and two types of tasks with which neither of the groups had dealt with. The types of tasks which both groups had worked with are: matching questions and answers, and filling in the blanks with and without a choice of possible words and phrases. The types of tasks which neither of the groups had worked on are: the odd-one-out task, and filling in the table by recognizing cause-and-effect relationships in an unfamiliar text.

In the items posing lower cognitive demand good performance depended on recognizing sentence relations and establishing relations between words (for example, between personal pronouns and verb forms (cf. Ehlers 2003: 289), that is, on micro-processes and integrative processes, the simpler reading processes which enable recognition and understanding of explicit pieces of information and words in a sentence or a paragraph, but they do not require understanding of the relations and ties between them (cf. Blatt & Voss 2005).

The majority of the items involve higher cognitive demand, and they are based on inductive reasoning (cf. Bloom 1973; Eggen & Kauchak 1994 as quoted in Vizek Vidović et al. 2003: 368, 369; Klauer, 2001). They examine:

- the skill of establishing supra-sentential ties and relations, that is, higher comprehension processes (cf. Ehlers 2003: 289),
- the skill of establishing intratextual relations, for example, distinguishing between cause and effect (cf. Bloom 1973; Westhoff 2003: 90, 95),
- the skills of analytical thinking, which Sternberg (1985 as quoted in Vlahović-Štetić 2005: 29) defines as analysis, comparison, and contrast,
- the cognitive skill of drawing conclusions by activating prior knowledge, that is, inference (cf. Westhoff 2003: 52, 96, 114),
- strategies of analytical thinking – analyzing words and phrases, making assumptions and questioning those assumptions, making conclusions based on language signals and reconstructing meaning from context (cf. Bimmel & Rampillon 2000: 114ff),
- strategies for establishing the main idea in the text, that is, organization strategies (cf. Christmann & Groeben 1999: 196).

### 2.3.2.1. Psychometric characteristics and analysis

The written exam proved to be highly reliable, Cronbach's alpha = .915; the test proved highly reliable for each age group individually: Cronbach's alpha<sub>E</sub> = .812, Cronbach's alpha<sub>C</sub> = .835. The average facility index is  $p = .452$ , and the average correlation among tasks was  $r = .196$ , which can be taken as a high correlation, considering that the tasks are binary. However, the test proved to be much harder for the control group, the average facility index being  $p = .329$ , and the average facility index for the experimental group being  $p = .653$ . In other words, the examinees in the control group solved on average 32.9 % of the tasks correctly, and the students in the experimental group solved on average 65.3 % of the tasks correctly. Table 1 shows the characteristics of the items in the written exam in German language, and the percentage of solved items in each group.

Table 1: The characteristics of the items in the written exam in German language, and the percentage of solved items in each group

Item	M	SD	Correlation with overall performance	M <sub>Kon</sub>	M <sub>Eks</sub>	Item	M	SD	Correlation with overall performance	M <sub>Kon</sub>	M <sub>Eks</sub>
1.1	.5705	.49660	.031	.5567	.6024	5a.1	.3397	.47515	.669	.1134	.6867
1.2	.7949	.40510	.162	.7423	.8795	5a.2	.3205	.46818	.591	.1237	.5783
1.3	.5513	.49897	.150	.4948	.6747	5a.3	.3654	.48309	.566	.1959	.6386
1.4	.8910	.31261	.346	.8351	.9759	5a.4	.3397	.47515	.515	.1546	.6145
1.5	.9423	.23391	.068	.9278	.9759	5a.5	.4487	.49572	.567	.2784	.6506
2.1	.4808	.50124	.232	.3814	.6441	5a.6	.4551	.49635	.612	.2577	.7590
2.2	.9167	.27728	.234	.8763	.9831	5b.1	.3269	.47060	.661	.1031	.6747
2.3	.1154	.32051	.050	.1237	.1017	5b.2	.4359	.49747	.708	.2474	.7470
2.4	.4231	.49564	.376	.2990	.6271	5b.3	.2564	.43806	.576	.1237	.5060
2.5	.2372	.42672	.127	.1753	.3390	5b.4	.5577	.49826	.713	.3608	.8795
2.6	.4295	.49660	.423	.2990	.6441	5b.5	.5256	.50095	.680	.3299	.8313
2.7	.3462	.47728	.302	.2268	.5424	5b.6	.5128	.50145	.705	.2887	.7952
2.8	.5641	.49747	.358	.3814	.8644	5b.7	.4808	.50124	.704	.2680	.7108
2.9	.4744	.50095	.411	.3196	.7288	5b.8	.2115	.40971	.549	.1031	.3373
2.10	.3718	.48484	.218	.2887	.5085	5b.9	.3077	.46302	.659	.1443	.5422
3.1	.5641	.49747	.463	.4227	.7349						
3.2	.6026	.49094	.461	.5052	.7831						

3.3	.6026	.49094	.415	.4742	.7952
3.4	.2308	.42268	.152	.1959	.3253
3.5	.5833	.49459	.378	.4742	.7470
4.1	.6474	.47931	.331	.5670	.8072
4.2	.1282	.33539	.375	.0722	.2169
4.3	.3269	.47060	.462	.1959	.5783
4.4	.6090	.48955	.508	.4742	.7229
4.5	.1795	.38500	.356	.1443	.2048
4.6	.2436	.43063	.393	.1753	.4458
4.7	.2564	.43806	.602	.1134	.4940

Considering the correlation between certain items and the overall performance, the items 1.1, 1.2, 1.3, 1.5, 2.3, 2.5 and 3.4 could be eliminated from future variants of the test without endangering its reliability (Cronbach's alpha = .926 in the repeated analysis without the mentioned items).

### 2.3.2.2. Factor analysis

Aside from reliability, we wanted to test the internal validity of the test as well, for which we used factor analysis, a statistical technique for reducing correlational data to a smaller number of dimensions or factors; a small number of components or factors are extracted that are regarded as the basic variables that account for the interrelations observed in the data. The common factors method was employed. The matrix proved suitable for factorization;  $KMO = .84$ , which means that the task correlation, that is, the share of common elements in the tasks on the scale from 0 to 1 is 84 %. Ultimately we kept one factor which explains 28.540 % of the variance. Table 2 shows the factor structure matrix for the written exam in German language.

Table 2: The factor structure matrix for the written test in German language

Item	Factor saturation	Item	Factor saturation
1.4	.339	5.1	.714
2.1		5.2	.640
2.2		5.3	.595
2.4	.371	5.4	.569
2.6	.437	5.5	.590
2.7	.311	5.6	.668
2.8	.362	5b.1	.708
2.9	.440	5b.2	.768
2.10		5b.3	.656
3.1	.448	5b.4	.748
3.2	.478	5b.5	.733
3.3	.420	5b.6	.741
3.5	.379	5b.7	.709
4.1	.370	5b.8	.551
4.2	.402	5b.9	.691
4.3	.476		
4.4	.453		
4.5	.330		
4.6	.431		
4.7	.603		

Factor saturation, that is the correlation of the several items with the factor, for items 2.1, 2.2, 2.10 is below the level of significance, that is, they do not belong to the obtained factor. But there is no meaningful multi-factor solution which would suit the data better than the obtained one-factor solution. We have to take into account the unfavorable examinee-to-item ratio, and the fact that the items are binary, which leads to hyper factorization, decreasing the



explained variance percentage of the obtained factor. The result, namely that one factor was obtained supports the hypothesis that the test measures what we wanted to examine, and that is the application of inductive strategies in foreign-language material. We named the obtained factor *the usage of cognitive skills in language knowledge*.

### 3. Results

#### 3.1. The group homogeneity test at the beginning of the school year

In order to be certain that the differences expected at the end of the school year between groups truly are a result of the learning program, it was necessary prior to the start of the program to establish whether the control group and the experimental group were equal in terms of the relevant cognitive variables and the academic performance variables. The data on the academic performance variables was gathered through a questionnaire which included the basic student information (first and last name, grade, school, place of residence) and the information on their grades in their mother tongue (Croatian), math and foreign language, as well as the overall grade at the end of the preceding grade. The information on the cognitive variables was gathered using Raven's Standard Matrices. Table 3 shows the descriptive statistics for the listed variables and the results of the equivalency test. All distributions used are negatively asymmetric to a similar extent, which enables the usage of parametric statistics.

Table 3: The descriptive statistics for cognitive ability variables and academic performance variables for both groups in the first testing at the beginning of the school year, and the differences measured by an independent sample t-test

	<i>Experimental group</i>			<i>Control group</i>			<i>t</i>	<i>df</i>	<i>p</i>
	<i>M</i>	<i>C</i>	<i>SD</i>	<i>M</i>	<i>C</i>	<i>SD</i>			
Grade in Croatian language at the end of the previous grade	4.49	5.00	0.6075	4.64	5.00	0.5783	0.239	191	.812
Grade in Math at the end of the previous grade	4.32	4.00	0.7699	4.33	4.00	0.8245	1.733	204	.085
Grade in English language at the end of the previous grade	4.51	5.00	0.8194	4.54	5.00	0.7106	0.052	204	.959
Overall grade at the end of the previous grade	4.77	5.00	0.4006	4.77	5.00	0.4334	0.300	204	.765
Participant's result on the Standard Progressive Matrices test	47.29	48.50	6.1220	47.07	48.00	6.8118	0.059	202	.953

Table 3 shows that the initial test did not reveal any significant differences between the control group and the experimental group in terms of the academic performance variable or the cognitive ability variable. Therefore, the potential differences at the end of the program should not be a reflection of initial differences between the groups of examinees.

#### 3.2. Differences in the performance on the German language test

Table 4 shows the differences between the experimental group and the control group measured by an independent sample t-test.

Table 4: Overview of the descriptive statistics and the results of the t-test for the variable of performance on the German language test

	<i>Experimental group</i>			<i>Control group</i>			<i>t</i>	<i>df</i>	<i>p</i>
	<i>M</i>	<i>C</i>	<i>SD</i>	<i>M</i>	<i>C</i>	<i>SD</i>			
Performance on the German language test	27.13	28.00	6.7205	13.76	13.00	6.2612	13.805	178	.000

The t-test for the variable of performance on the German language exam is  $t = 13,805$ , with  $p = .000$ , so we can say with certainty that the obtained results support the first hypothesis, which states that the students in the experimental group achieve significantly better results on the German language exam ( $M_E = 27.13$ ,  $M_C = 13.76$ ). The absolute difference is 13 points, 39 being the maximum number of points achieved.

### 3.3. Differences in cognitive abilities

The test results for the second hypothesis are shown in Table 5, and they do not confirm the second hypothesis.

Table 5: The descriptive statistics for the variable of cognitive ability for both groups in the second testing at the end of the school year, and the differences measured by an independent sample t-test

	<i>Experimental group</i>			<i>Control group</i>			<i>t</i>	<i>df</i>	<i>p</i>
	<i>M</i>	<i>C</i>	<i>SD</i>	<i>M</i>	<i>C</i>	<i>SD</i>			
The participants' result on the Standard Progressive Matrices test	49.59	50.00	5.3999	49.78	50.00	6.1220	0.229	199	.819

The students in the control group and the experimental group do not differ in their performance on the Raven's Standard Progressive Matrices test, and there is no statistically significant difference in their cognitive abilities, which is reflected in  $t = 0.229$ , with the risk level of  $p = .819$ .

## 4. Discussion

### 4.1. Analysis of the German language test

The analysis has shown that the items in the written exam which do not correlate with the overall performance pose a lower cognitive demand. Therefore, the cause for a very low or a very high success percentage can be language knowledge or the lack thereof, and not the *usage of cognitive skills in language knowledge*. By contrast, the cause of the low success percentage for the items with high correlation to the overall performance and with high saturation (e.g. tasks 5a and 5b) is the insufficiency in analytical thinking and inductive strategies, that is, insufficient *usage of cognitive skills in language knowledge*. This is especially evident in the difference in success percentages between the experimental group and the control group for tasks 5a and 5b, as shown in Table 6.

Table 6: The score percentages for items with a high correlation with the overall performance and high saturation

Task 5.a	Percentage score: control group	Percentage score: experimental group	Task 5.b	Percentage score: control group	Percentage score: experimental group
5a.1	.1134	.6867	5b.1	.1031	.6747
5a.2	.1237	.5783	5b.2	.2474	.7470
5a.3	.1959	.6386	5b.3	.1237	.5060
5a.4	.1546	.6145	5b.4	.3608	.8795
5a.5	.2784	.6506	5b.5	.3299	.8313
5a.6	.2577	.7590	5b.6	.2887	.7952
			5b.7	.2680	.7108
			5b.8	.1031	.3373
			5b.9	.1443	.5422

#### 4.2. Difference in performance on the German language test

The results of the written exam show that the students in the experimental group outperformed the students in the control group by 13 points (out of 42), which means that they solved, on average, twice as many (65.3 %) tasks as the control group (32.9 %). The variable which can explain this difference – taking into consideration the equivalency test results, which have shown that the groups are balanced – is membership in the experimental group and exposure to a different type of teaching – namely to inductive strategies and strategy awareness. The fact that the knowledge of strategies is the best predictor of the reading comprehension skill is confirmed by the results of the PISA research as well (cf. Baumert, Stanat & Demmrich 2001: 278, 296).

Aside from the described approach to reading comprehension, the performance of the experimental group could have been affected by the method of teaching grammar and vocabulary. Research has shown that the rules discovered and formulated by the students themselves are memorized and applied more effectively (cf. Kleinschrott 1992: 126; Thurmair 1997: 39f; Zimmermann 1992: 12) and that this process stimulates curiosity and motivation (cf. Fortune 1992: 161; Harden 1990: 228; Thurmair 1997: 39f).

It seems that the learning processes in the experimental group have succeeded not only to initiate the processes of constructing declarative and procedural language knowledge, that is, language knowledge and skills (cf. Schmidt 2010), but they also resulted in a better quality of knowledge structure and a more suitable mastering of cognitive and meta-cognitive strategies. Aside from the specific language knowledge and skills, the students acquired the skill of mastering novel and problematic situations (cf. Terhart 1989), which surpasses the syllabus (cf. Bruner 1973: 26; Terhart 1989: 145). A case in point is the fact that the experimental group could not have solved the test successfully if they had not mastered problem-solving skills and inductive strategies. This is confirmed by the result of the control group, which is affected by the lack of that training.

These results can also address the objections found in the scientific literature about the immeasurability and unverifiability of discovery-learning results. The analysis of the written exam and the results have shown that both specific language knowledge and the skill of mastering novel and problematic situations, that is, methodical competence, are measurable and verifiable. Furthermore, the results of the written exam have shown that discovery learning does result in the acquisition of new knowledge as well, and not only in gaining skills and abilities to master novel and problematic situations, as claimed by Eickhorst (1998: 142). Without the adequate level of language knowledge, which they had acquired during the school year, neither the experimental nor the control group could have achieved even minimal results. It can be concluded that the results confirm that the students in the experimental group acquired learning skills and analytical thinking skills (cf. Sternberg 1985). The fact that in the foreign language teaching practice, as opposed to theory, constructivism as a learning theory is not very present (cf. Willkop 2002), is confirmed by the results of the control group. Although the efforts to make textbooks more discovery-learning-oriented are certainly commendable, the resulting inductive approach for teaching German as a foreign language is almost nonexistent, according to Willkop (2002: 11). It is also unclear which role teaching materials

could or should have in the future, to what extent they could contribute to the acquisition of strategies, and how they should be designed in order to guarantee student-orientedness and flexibility (Willkop 2002: 14). It seems that the cognitive demand of reading comprehension tasks did not sufficiently often surpass the level of establishing ties between words and recognizing sentence relations, but was primarily limited to recognizing explicit pieces of information in the sentences (cf. Blatt & Voss 2005; Christmann & Groeben 1999: 196), while understanding was reduced to understanding the meaning of individual words. Grammar is taught using a deductive or pseudo-inductive approach, and vocabulary lessons and exercises are still often limited to translation and mechanical memorization of new words. Therefore, from the constructivist perspective, the result obtained by the control group can be explained within the paradigm of traditional didactics, which considers learning and teaching to be a transmission model of transfer and memorization of information and content, and the acquired knowledge is often inadequately structured and linked to prior knowledge (cf. Richardson 1997), with relatively frail and isolated ties between stimulus and reaction (cf. Edelmann 1996; Tönshoff 1992). Of course, the results do not eliminate the need to design a systematic theory of discovery learning, which is still to be achieved, but they do support the claim that the described program for discovery learning of German language would be possible to implement in schools, which would fill the void articulated by Neber (1981: 13) in his objection to Bruner that he did not design a program that could be implemented in schools. This research can also refute the objection about the highly time-consuming class preparations for guided discovery learning, as well as the one about the great demands it places before the teachers who are not qualified for that type of work. The teachers' tasks in the experimental group was to teach the class following a pre-designed sequence of steps, that is, to follow the instructions, and not to design the class independently. There are two reasons for this type of approach to research: it makes sure that the experimental class is influenced by as few uncontrolled factors as possible, and at the same time it avoids placing potentially too high demands on teachers who are not qualified for that type of work. The teachers' time consumption in the experimental group, when following the pre-designed and elaborated sequence of steps is comparable to the time consumption of teachers of any school subject when working with a new textbook.

An attempt to compare these results to the results of similar research leads us to the conclusion that up to now there has been no similar research for foreign languages. Aside from the above-mentioned Klauer's research of the impact of inductive reasoning training on the general ability of learning foreign languages (Klauer 1993b), there is no known research which examines the success in learning a specific foreign language through the prism of stimulating cognitive skills. However, there is a link between this research and that by Klauer (1993b; Fries 2002) and Marx (2006: 144), and this is to be found in the language results: inductive reasoning improved language performance in this case as well. The explanation lies in the fact that both intelligence and language acquisition are based on discovering regularities, that is, on the same inductive strategies. If they are stimulated and used, language performance will be better. This is true for foreign language learning as well as for native language acquisition.

In relation to this we should mention the previously described working memory training conducted by Jaeggi et al. (2008), which included solving more complex tasks as well. The trained group performed significantly better in the fluid intelligence test. Considering that the tasks in the training were different from those in the fluid intelligence test, and that they could not influence the result, the researchers concluded that the better performance of the trained group is a result of transfer of the processes which had been activated during the solving of these tasks, and not a result of practice in solving of the tasks. It is possible that the results of the experimental group in our research were also influenced by transfer of the processes which had been activated through the solving of more complex tasks during the school year, and not by practice in solving of the familiar type of tasks. Since both groups had equally familiar and equally unfamiliar types of tasks to solve, only the application of the processes which were or were not activated through their work during the school year could have influenced the performance on the test in the experimental and control group.

#### 4.3. Difference in cognitive abilities

The second hypothesis aimed at examining the impact of stimulating inductive reasoning on intelligence in the regular class context. This research has not, however, confirmed the hypothesis about an increase in the measured intelligence of the students in the experimental group. There are several possible explanations for this. Firstly, we should

re-evaluate the comparability of class and training, that is, whether the results of stimulating inductive reasoning through discovery learning *in class* can be compared to the results of inductive reasoning *training* and its focus on the inductive reasoning as the goal of the training. Compared to the inductive reasoning training, the German class lacked inductive and temporal accumulation and sublimation, which is achieved by intensive exercises in "inductive content". By contrast, the goal of foreign language class is the automatization of language behavior, which is achieved by intensive exercises with language content, which somewhat attenuates the effects of strategic inductive behavior whose sublimity is the basis of successful inductive reasoning training. This is connected to the potential limitations in the effects that can be achieved by an inductive curriculum in regular class circumstances if it is implemented for only one subject. And finally, in opposition to Klauer's empirical findings and expectations that the transfer of the trained general skills will occur in specific areas, other research has shown that high-level reasoning in a particular, specific area can be achieved only through training of reasoning and inference in that specific context (cf. Stenberg 1986; Resnick 1987 as quoted in Vizek Vidović et al. 2003: 369). We can conclude that intelligence should be measured by instruments suited to specific contexts, and not by Raven's Standard Matrices.

#### 4.4. Research limitations

In interpreting research results, it should always be kept in mind that there are variables which are beyond the researcher's control. The first potential limitation of this research is the way in which the sample was selected. In order to ensure that the results were really influenced only by the program, the best comprehensive school in Croatia, the *Fifth Gymnasium* in Zagreb, which is known for being the most demanding school, and as such it is linked to greater student and teacher effort as a response to this perception of the school, was placed in the control group, and the *Gymnasium* in Karlovac, which was ranked ninth, was placed in the experimental group. Thereby we took the risk of not getting a true picture of the results in the control group because this way it would seem to have done better than it really had. However, we wanted to find out how "good" the program in the experimental group was, and not how "poor" it was in the control group. Even though the descriptive statistics has shown that the groups were balanced, there may still be room for a different approach to sample selection which would reduce the impact of this variable.

It cannot be excluded that the results were influenced by the enthusiasm of the experimental group teachers, related to the challenging new approach and the expectation of results. They considered the program to be stimulating, and they tried to devise inductive reasoning tasks on their own for other classes they were teaching. They noticed the students' interest, but not a shift in language performance. They think that the key to success is an integral and stable concept, and not to be accomplished in individual tasks. We asked them if they could achieve similar results on the same test in a comparable class in which they would not use this approach. Again the answer was clear and related to the previous one: they think that without an approach conceived in this manner, they would only be able to achieve the results they have been achieving so far.

Furthermore, we cannot exclude with certainty the influence of the new teaching method compared to other school subjects, which could have enhanced students' interest and engagement, affecting the results.

#### 4.5. Future research and practical contributions

Future research should examine and compare the effects of inductive reasoning *training* to the effects of stimulating cognitive skills *in class*, that is, discovery learning. A longitudinal study which would cover grades 1 through 4 of high school might confirm the influence of stimulating inductive reasoning to language expertise, cognitive skills and cognitive abilities, as well as point out the potential problems. Conducting this type of research in elementary school and comparing the results to the ones obtained in high school would be a firm basis for certain decisions in the education system. It would be interesting to implement this method of teaching to other foreign languages and some other school subjects, and to compare the results. Furthermore, the question should be examined what the effect of a potential transfer of stimulating inductive reasoning in a German language class to other school subjects is. It would be useful to see the results of the experiment in which joint inductive reasoning training would precede the division of students into the experimental group and the control group. Another potential contribution to teacher

training would be an experiment in which one group of teachers would work using the instructions on the material for stimulation, and the other group would work without the instructions.

The applied linguistic contribution of this research is its potential influence on the change of approach to the teaching and learning of German and other foreign languages, designing methodological instruments and materials for German language learning, the changes in training of teachers of German, which would qualify them for the new approach, and the influence on further research for other languages and other school subjects.

#### 4.6. Conclusion

Based on the conducted research, we have come to the conclusion that a German language class based on inductive strategies, which are common both to language and intelligence, achieves two goals: a statistically significant improvement of subject-specific competence, as well as a statistically significant improvement in the competence which surpasses the specifics of the profession. The results confirm that stimulating cognitive skills significantly improves the students' language competence in the domains of reading comprehension, vocabulary and grammar, and that this is a result of the students' training in solving the same problem under different conditions and circumstances, that is, a result of mastering the problem-solving method. In other words: if during German language class students are not trained in thinking skills, they will acquire significantly less specific language knowledge and they will have significantly less success in mastering novel and problematic situations. The Raven's Standard Matrices test results did not show an increase in the students' intelligence. The research has refuted the prejudice that discovery learning can be successfully implemented only in natural sciences.

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## Appendix

LESEVERSTEHEN, WORTSCHATZ, GRAMMATIK /  
ČITANJE S RAZUMIJEVANJEM, VOKABULAR, GRAMATIKA*Kontrollaufgabe am Schuljahresende*

1. Verbinde Fragen und Antworten. Zwei Antworten passen nicht ins Interview./Poveži pitanja i odgovore u intervjuu. Dva su odgovora suvišna.

## PLÄNE FÜR DAS WOCHENENDE

1.	Was machst du am Wochenende?	A	Also, wir ... Wir wollen in den Ferien nach Kroatien fahren, an die Adria. Wir surfen am Wochenende im Internet und machen unseren Routenplan. Unsere Bekannte sagen, das Innenland ist auch toll.
2.	Ehrlich?	B	Sehr gerne.
3.	Und du?	C	Bitte.
4.	Und ihr, Hanno und Peter?	D	Montags gebe ich Nachhilfestunden, ich bin gut in Deutsch und Mathematik. Nachmittags spiele ich mit dem Hund im Park.
5.	Danke!	E	Ich gehe lieber mit meiner Clique in den Zirkus. Das Programm ist Spitze. Tiger, Elefanten, Artisten und Clowns. Nach dem Programm gehen wir noch einen Hamburger essen.
		F	Ich gehe ins Prljavo kazalište-Konzert, eine kroatische Band... Ich habe alle CD-s von ihnen. Sie machen eine Tournee in Deutschland und gastieren bei uns in Bielefeld. Sie sind super, besonders Houra. Er spielt toll Gitarre, singt und komponiert.
		G	Ehrlich.

1.	2.	3.	4.	5.

5 Punkte

2. Was passt nicht in die Reihe? Kreuze an./ Zaokruži ono što ne pristaje u niz.

1. Physik, Kunst, die Mathematik, Geschichte 2. e, st, t, wir, t, en	6. schwimmen, Rad fahren, Briefmarken sammeln, Hausaufgaben machen, tanzen
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3. sieben nach halb sechzehn, Viertel vor neun, sieben nach halb vier	7. hielfst, gibst, liest, siehst
4. ein, zwei, drei, vier, fünf	8. sollen, dürfen, wollen, kennen, müssen
5. F, G, H, I, J, K	9. aufräumen, einkaufen, verkaufen, aufpassen
	10. meinem, meiner, meinen, mein

10 Punkte

3. Lies den Text und ergänze die Tabelle: Ursache oder Folge? Uzrok ili posljedica? Dopuni tablicu tako da prepíšeš odgovarajuću rečenicu iz teksta. 0. ist ein Beispiel

### NEBENJOBS

Viele Schüler jobben am Wochenende und in den Ferien.

**Charlotte** arbeitet bei Mcdonald's schon den zweiten Sommer. Den ganzen Juli verkauft sie acht Stunden am Tag Hamburger. Die Arbeit ist nicht leicht. Die meisten Leute kommen in der Mittagspause und am Abend. Ist zehn Euro die Stunde viel oder eher wenig Geld? Das ist ihr nicht wichtig. Sie verdient so ihr Taschengeld, und ist glücklich. Nicht jeder hat einen Ferienjob.

**Erich** kommt mit seinem Taschengeld nicht aus und will dazuverdienen. In einem Tierheim hat er einen Job gefunden. Dort kümmert er sich jedes zweite Wochenende um die Katzen.

**Alexandra** ist in der Schule oft gestresst und arbeitet in den Ferien nicht. Sie entspannt sich und spielt einfach ihre Geige. Sie mag Musik.

**Renate** steht jeden Samstag früh auf. Sie arbeitet in einem Nahrungsmittelgeschäft. Dort verkauft sie samstags frische Brötchen. Viele Leute kaufen morgen früh frische Brötchen. Sie spricht manchmal mit ihnen. Das macht ihr Spaß.

	<i>Ursache/uzrok</i>	<i>Folge/posljedica</i>
0.	Die meisten Leute kommen in der Mittagspause und am Abend.	Die Arbeit ist nicht leicht.
1.	Charlotte verdient so ihr Taschengeld.	
2.		Erich will dazuverdienen.
3.		Alexandra arbeitet in den Ferien nicht.
4.	Renate arbeitet in einem Nahrungsmittelgeschäft.	
5.	Das macht ihr Spaß.	

5 Punkte

4. Irene und Michaela beschreiben ihre Probleme. Lies ihre Texte und fülle die Lücken aus. / Irene i Michaela opisuju svoje probleme. Ispuni praznine.  
Irene

Ich gehe in die achte Klasse und \_\_\_\_\_ 14. Meine Mutter ist sehr streng, ich darf in der Woche nicht raus, und am Wochenende muss ich schon um 20 Uhr zu Hause \_\_\_\_\_. Ich finde das \_\_\_\_\_ normal. Alle Freunde dürfen länger draußen bleiben. Ich finde so bestimmt niemals einen Freund. \_\_\_\_\_ kann ich machen?

*Michaela*

Hilfe – ich muss mit meiner älteren Schwester ein Zimmer teilen! Jeden Tag streiten \_\_\_\_\_ uns. Ich will in Ruhe Musik hören, aber ich kann das \_\_\_\_\_. Sie stört mich auch bei den Hausaufgaben. Ich muss auch immer unser \_\_\_\_\_ aufräumen. Ich bin dann immer böse, aber sie lacht mich nur aus. Ich kann das nicht mehr aushalten!

7 Punkte

Sie schicken ihre Texte an eine Psychologin. Hier sind die Antworten der Psychologen.

*5. Fülle die Lücken aus. In ihren Antworten unten passt je ein Vorschlag nicht. / Ispuni praznine. Jedan je prijedlog u svakome odgovoru suvišan.*

**A** Liebe \_\_\_\_\_ !

Deine Mutter ist tatsächlich sehr streng mit dir. Aber sie hat Angst, du tust etwas

\_\_\_\_\_ dir vertrauen. Nur  
\_\_\_\_\_ ihr dabei helfen. Du sollst \_\_\_\_\_  
\_\_\_\_\_.

Du darfst \_\_\_\_\_.

1. also keine Dummheiten machen
2. sie will
3. „Gefährliches" oder "Verbotenes"
4. musst du
5. dann auch länger ausbleiben
6. darfst du

6 Punkte

**B** Liebe \_\_\_\_\_ !

Du bist so unglücklich, und das tut mir Leid.

Sprich \_\_\_\_\_

Macht \_\_\_\_\_

Überlegt, 1. \_\_\_\_\_

2. \_\_\_\_\_

3. \_\_\_\_\_

4. \_\_\_\_\_

Hängt \_\_\_\_\_

Dann \_\_\_\_\_

1. wann du Musik hören kannst
2. muss sich auch deine Schwester an den Plan halten
3. wann Ruhe sein muss
4. wann deine Schwester etwas unternehmen kann
5. mit der ganzen Familie über dein Problem
6. das Poster an die Wand
7. wer wann aufräumen muss
8. einen Tagesplan
9. den Tagesplan an eure Zimmertür

9 Punkte