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The effects of Multiple Representation Method and Prior Knowledge Level on Problem Solving Skills and Cognitive Load

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In this study, the effect of multiple representation method and prior knowledge level in solving ill-structured problems was investigated. Quasi-experimental and 2x2 (multiple representation method x prior knowledge level) factorial designs were used in the study. The study group consists of 39 undergraduate students. The dependent variables of the study were determined as problem solving skills, cognitive load, and permanence. The independent variables were considered as multiple representation method (step-by-step, holistic) and prior knowledge levels (novice, expert). Prior knowledge level test, problem solving skills test and cognitive load scale developed to measure the variables were used as data collection tools within the scope of the study. The data was analysed with two-way analysis of variance and independent groups t-test as the data obtained from the data collection tools exhibited normal distribution. In the results that were significant in the analysis, Cohen (d) in the independent groups t-tests and eta-square (η2) in the two-way analysis of variance were also shown. As a result of the research, it is evident that the level of prior knowledge and the interaction (interaction effect) of the level of prior knowledge and the multiple representation method affect problem solving skills. In addition, it was concluded that the interaction of multiple representation method and prior knowledge level was statistically significant in terms of cognitive load variable. The findings supported the expertise reversal effect.

Introduction

Database Design

Databases are media where information is stored in an organized manner. The data necessary for the smooth running of many tasks in daily life are accessed through databases

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stored in digital media. It is possible to access these databases with software that works online or offline. The use of a database, which is an important part of software, is used more and more with the widespread use of mobile devices and the internet, and the need for developing new ones is increasing rapidly.

Databases are designed in accordance with the target and have a schema representing the field in which they want to contain information. Even the schemas of databases used in similar domains may differ from each other. For example, a database that focuses on students' information at one university may be different from a database used for similar purposes at another university. This difference is mainly due to the differences in the workflows where the data are used. This need for different databases makes database design more important, especially with widespread use. The database design process, like other design processes, requires high-level cognitive skills. Considering the types of problems put forward by Jonassen (2011), we can state that database design is among the design problems that require the highest cognitive skills.

Database Design as Ill Structured Problem

Jonassen (2011) revealed the types of problems in his studies. He states that different kinds of knowledge and skills are needed in solving different kinds of problems, and therefore, the teaching process should be different. When he classified the types of problems according to their structures, he stated that there are well-structured problems at one end and ill-structured ones at the other. Well-structured problems require the knowledge of a certain number of concepts and the application of rules and principles for the solution of a predetermined problem. Therefore, a well-structured problem statement includes a set of logical operations with certain boundaries (Greeno, 1978; Sinnot, 1989; Jonassen, 2011). Jonassen (2011) states that most of the problems given at the end of the chapters in the textbooks are well-structured problems. Ill-structured problems, unlike well-structured problems, are those whose problem statement is not well-defined.

In addition, they are problems in which information belonging to more than one field must be used together and / or may have more than one different solution, and also there is no single correct solution. A solution accepted by one person as correct may be accepted wrong by another person. Generally, ill-structured problems can have different solutions and more than one alternative path to these solutions (Simon, 1978; Kitchner, 1983; Chi & Glaser, 1985; Jonassen, 2011). Because of this unclear/incomplete structure, the learning and teaching process of ill-structured problems is more uncertain and difficult, whereas this process is relatively clear and easy in well-structured problems. Database design is one of the ill-structured problems in this problem typology (Connolly & Begg, 2006). Therefore, learning the database design process is also a difficult process (Connolly & Begg, 2006; Rashkovits & Lavy, 2021).

Entity Relationship Diagrams Method

One of the most widely used methods in database design is the entity relationship diagrams introduced by Chen (1976) and Silberschatz, et al. (2019). Entity relationship diagrams enable us to identify the entities, their properties, and relationships between entities in the area where the database will be used, and to show them in the schema. As stated by Connolly & Begg (2006), creating entity relationship diagrams is the first step in the database design process. These diagrams are called conceptual models. The database design process continues with the transformation of this conceptual model into a logical model. In the logical model, entities turn into tables, properties into columns, and relationships into tables or columns. In the next stage, a transition from the logical model to the physical model is made. In the physical model, a database is created, all kinds of tables, table columns, primary keys, and foreign key definitions are made. After these stages, as in every design process, there is a process of testing the designed database with mockup data. This enables us to check whether the data suitable for the user system interaction scenarios created before the design is entered into the database and whether these data are kept without any problems.

Use of Multiple Representation in Entity Relationship Diagrams

A decision made at any point in these steps followed in the database design process may impact the next steps and ultimately prevent the data from being kept as we want. The student must understand the relationship among these four steps for database design to be carried out healthily. Otherwise, many errors may appear in the early stages of the design process (see also Rashkovits & Lavy, 2021). Giving these four stages followed in the database design process together in the teaching process may allow the student to see different stages of the design simultaneously, thus creating a healthier problem scheme and making a more successful database design. Showing the problem in different ways in the problem-solving process is a common practice used in the teaching process and has been used for a long time (Ainsworth, 1999). However, the use of multiple representation does not directly guarantee better learning. Many researchers have discussed that some design elements should be paid attention and support elements should be included in the environment to reveal the benefits of multiple representation (Ainsworth, 2006; Seufert, 2003).

Representations are also regarded as external or internal structures. They are used to profound the relationship between a concept and its essence (Bossé et al., 2011). Representations are grouped in two as internal and external representations. Internal representations are defined as individual cognitive configurations. These derive from behaviors that describe several aspects of physical processes and problem-solving. External representations are the structured physical situations like the embodiment of physical ideas (Bayraka & Bayramb, 2010; Chandrasegaran et al., 2007). It is evident that if multiple representation is successfully incorporated into the teaching environment, it will provide some advantages to the student. These advantages are divided into three by Ainsworth (1999). The first of these is that the presentation of different representations reveals different features related to the field and provides support to the student who interacts with these features to learn different ideas and processes. The second advantage is stated as presenting different representations together, that the student can learn a point that he does not understand in a representation by making use of another representation that he is more familiar with, which will ultimately reduce misconceptions. The last benefit was expressed as the learner interacting with different representations to understand more complex information about the field more easily and to be able to use them in more effective and/or newer ways. In a more succinct way, the advantages of using multiple representations can be summarized as understanding the subjects that the student will have difficulty in learning, preventing misconceptions while learning, and allowing a deeper understanding of the subject.

Multiple Representation and Cognitive Load

However, it should not be overlooked that there are some costs, such as cognitive load, that must be paid to achieve the advantages of providing multiple representations

(Ainsworth, 1999, Renkl et al., 2009). Students should first understand and read what each representation is, then understand the place of this representation in the relevant field, and finally understand how all representations are related to each other for them to reach the benefits of multiple representations, (Ainsworth, 1999, Schwartz, 2011). For example, in order for students to benefit from the multiple representations presented in the database design teaching process, they should first understand what the shapes and lines in the entity relationship diagram mean. They should then know what each line and shape correspond to in the database, and finally they should be able to express the changes that a change in an existing line or shape would cause in other representations at this stage. At the end of his study, Ainsworth stated that the use of multiple representations brought new opportunities and challenges to educators and pointed out that sometimes the problem caused using multiple representations may be more than the advantage.

Multiple Representation Presentation Techniques for Cognitive Load

It can be easily said that students need to specialize at a certain level to see the benefits of multiple representations based on the statements of Ainsworth (1999). However, until the students reach this stage, there is no clear approach to how to use multiple representations. Wu et al. (2013) stated that the simultaneous use of multiple representations would increase the cognitive load on the student and stated that multiple representations should be shown sequentially to reduce this load. The thesis is put forward that the amount and the effect of cognitive load that may occur can be reduced because less information will be given to the student at each step in sequential representations. However, there is no clear approach to how this sequential presentation should be. Wu et al. dealt with the case as teaching one representation before another and stated that there is not enough research on the criteria for which this order should be. Ainsworth (2006) mentioned that this ordering may have rules specific to the field in which teaching occurs and stated that there is a need for more research on ordering similarly.

Level of Expertise in Using Multiple Representations

Wu et al. (2013) argued that the approach to be used here can also interact with the individual differences in students. In their study, they looked at the interaction of students' spatial abilities and multiple representation presentation and reported that these factors interacted and that students with different spatial abilities were affected by the presentation style of multiple representations and obtained different results in terms of success. It has been discussed in the literature that another individual difference that the use of multiple representations can interact with is the level of expertise of the students in the field (Ainsworth, 2006). As explained earlier, students should reach a certain level of expertise to see the benefits of multiple representations. Additionally, it is important for the solver to create a quality problem representation in the problem-solving process to be successful. Problem representation is based on the solver's knowledge and is formed by organizing this information. The accuracy of the problem representation depends on the quality of this information organization (Jonassen & Strobel, 2006). Considering that expert students and problem solvers have more information than novice students and can create better quality problem representations, we can think that it will be easier for them to perceive and understand the multiple representations presented in problem -solving environments than for novice students. As a matter of fact, many researchers state that expert students are generally more successful in problem solving than novice students (de Croock & van Merriënboer, 2007; Lee et al., 2019; Armougum et al., 2020).

Holistic and Step-by-step Multiple Representation

In environments where problem solving is taught since novice students have not yet created a quality problem representation even though they have basic knowledge, giving the problem-solving process step-by-step in a structured way is beneficial for novice problem solvers and they learn the problem -solving process more quickly. However, these structured environments are not as beneficial for expert students. It has even been stated that these structured environments are sometimes an obstacle for expert students, and they are more unsuccessful compared to novice students. Based on this phenomenon, which researchers call the expertise reversal effect, it has been reported in studies that a teaching material that is beneficial for novices loses its effectiveness as the student's expertise increases, and even negatively affects it (Khacharem et al., 2015).

Blayney, Kalyuga, and Sweller (2015) examined the effect of different problem-solving environments on the interaction and skills of students with their expertise level in two studies. In their research, the students tried to solve well-structured problems related to the budget that needed to be solved in three to four stages. While students are solving these problems, they are provided with examples with target solutions that they can always reach. However, the problem-solving environment is presented in different ways. A group was asked to present and solve the problem step -by step, and they could enter the final answer after answering each step. In the other group, step-by-step solution was not requested, and only the final answer was requested. It has been observed that expert students are more successful when they work in an environment that is highly interactive and do not repeat their acquired knowledge (only the final answer is requested). However, the same situation was not found for novice students. Therefore, as a result of their study to examine the expertise reversal effect, they argued that the information that should be presented to novice students should be presented piecemeal, and it would be more effective to present all the necessary parts to solve the problem at the same time to expert students. They also emphasized that if there is a problem-solving situation, the information about the problem should be presented simultaneously. However, they stated that it is important to realize a design considering their level of knowledge regarding this simultaneous presentation. Therefore, they emphasized that it would be an ideal way to present all the parts related to the problem using smaller steps in the simultaneous presentation of the novices, while to the experts, it would be an ideal way to present all the parts holistically at the same time.

Multiple Representation and Permanence

The permanence and transfer of problem-solving skills is based on several factors, including the problem solver's ability to recognise the structure of the problem and to relate it to previously solved problems (Cooper & Sweller, 1987; Fuchs et al., 2003). Many problem-solving practices have a specific instructional construct of recognizing problem structures and categorising them according to previously solved problems (Fuchs et al., 2003). However, the categories formed by the students themselves do not reach a sufficient level and even remain limited to superficial information (Bassok, 1990). Therefore, appropriate problem-solving methods should be investigated and tried to help students expand their knowledge. In this context, while some studies on the transfer of problem-solving skills yielded negative results (see also Ritchhart & Perkins, 2005; Novick & Bassok, 2005; Phye, 2011), some studies (see also Eilam & Poyas, 2008; Schwartz et al., 2011) yielded positive results on both permanency and transfer of problem solving skills. When the study of Eilam & Poyas (2008) is analyzed, it is clearly concluded that the use of multiple representations provides this success. Hence, within the framework of this study, it was investigated whether the use of different multiple representations would have a positive effect on permanency.

The Aim of the Study

The following questions were investigated to understand whether the recommendations put forward in the study of Blayney, Kalyuga, and Sweller (2015), which focuses on well-structured and problem-solving activities, will also work in the process of teaching database design from ill-structured problems with entity relationship diagrams, and whether these effects are long-lasting:

(1) Is there a significant difference in the problem-solving skills between novice and expert students studying with step-by-step and holistic multiple representation methods?
(2) Is there a significant difference in cognitive load between novice and expert students who are educated with step-by-step and holistic multiple representation methods?
(3) Is there a significant difference in permanence between novice and expert students who study with step-by-step and holistic multiple representation methods?

Limitations of the Study

The research is limited to the topic of entity relationship diagrams in the database management systems course. It is also limited to the prior knowledge level test used to identify novice and expert students within the scope of the research.

Methods

In this part of the study, information about the research design, research sample, data collection tools, and data analyses are presented.

Participants and Design

It consists of 39 students studying in the third year of the Computer and Instructional Technologies program at the undergraduate level. All students were randomly assigned to four different groups as novice-step-by-step instructional method (n=10), novice-holistic instructional method (n=10), expert-step-by-step instructional method (n=9) and expert-holistic instructional method (n=10).

According to the prior knowledge level test scores, students whose scores were below the average were considered as novice and students whose scores were above the average were considered as expert. Novice students were randomly divided into two groups and expert students were randomly divided into two groups. Thus, all students were divided into four groups in total. These groups are as follows: novice-step-by-step instructional method (n=10), novice-holistic instructional method (n=10), expert-step-by-step instructional method (n=9) and expert-holistic instructional method (n=10).

The research model was determined as quasi-experimental and 2x2 (prior knowledge level x instructional method) factorial design, which is one of the experimental research designs. The experimental groups applied instructional methods and research design are shown in the Table 1.

Table 1: Research Design

Groups	Instructional Method	Pre-test	Method	Post-test
Group 1 (Novice, n=10)	Step-by-step	-	X_1	O_1
Group 2 (Novice, n=10)	Holistic	-	X_2	O_2
Group 3 (Expert, n=9)	Step-by-step	-	X_1	O_3
Group 4 (Expert, n=10)	Holistic	-	X_2	O_4

Data Collection Tools

Prior knowledge level test

An achievement test was developed by the researchers to measure the students' prior knowledge levels. Since the research is entity relationship schemes, 10 learning objectives related to database systems have been determined. Two questions were developed for each objective. Thus, a pool of questions consisting of 20 multiple-choice questions was created. The prepared questions were first sent to five different subject matter experts within the scope of validity and reliability studies. Afterwards, semi-structured interviews were conducted with two students. As a result of the feedback obtained, one question was eliminated and a total of 19 questions remained in the question pool. The remaining questions were applied to a total of 156 students studying in the computer and instructional technologies program.

As a result of the analyzes, a significant difference was found between the lower and upper 27% groups measured by item analysis, item difficulty index (p_j), item discrimination index (r_{jx}), and independent groups t-test. Additionally, the significance values (p) of each item were also examined. In line with the data obtained, 5 questions were eliminated. Therefore, a valid and reliable achievement test related to the relevant subject, consisting of 14 multiple-choice questions, was obtained. For the prior knowledge-level test, 1 point is given to each correct answer. Thus, the maximum score that can be obtained from the prior knowledge level test was determined as 14.

Table 2: Prior Knowledge Level Test Analysis Results

N	$\bar{x}$	Median	Peak Value	ss	Skewness	Cronbach Alpha
156	7,37	7	12	2,42	-0,053	0,72

The results of the prior knowledge level analysis are shown in Table 2. The fact that the skewness coefficient is in the range of -1.00 - +1.00 reveals that the scores do not deviate significantly from the normal distribution (Hair et al., 2013). In addition, the fact that the mean and median values are equal can be interpreted as an indicator of normal distribution. Table 2 shows that the skewness coefficient is (-0.053). This shows that the skewness is towards the left side with a very small deviation (Büyüköztürk, 2016). The reliability coefficient of the prior knowledge level test was measured by Cronbach alpha value and found to be 0,72. According to the data obtained, it was concluded that the prior knowledge level test is a valid and reliable test.

Moreover, the equality of mean and median values is an indicator of normal distribution. can be interpreted as a skewness coefficient. Table 4 shows that the skewness coefficient is (-0.053).

Problem solving skills test

An achievement test was developed to measure whether the instructional method applied to each experimental group was effective or not within the scope of the research. Eight open-ended questions about entity relationship diagrams were submitted to the evaluation of five different subject matter experts. Then, the opinion of a Turkish field expert was taken in terms of language. Finally, the validity of the relevant achievement test was ensured by interviewing two students with the semi-structured interview method. For reliability, since the developed achievement test consists of open-ended questions, inter-rater reliability was evaluated. For this, a rubric was prepared first, and the opinion of the field expert was sought. Afterwards, two field experts evaluated the exams according to the prepared rubric. Within the scope of the study, the exams of eight students randomly selected from a total of 39 students were evaluated by two subject matter experts. The percentage of agreement and Cohen's Kappa value were calculated as stated by Chiapetta, Fillman, and Sethna (2004) to evaluate the reliability among the evaluators. According to the calculation result, the inter-rater reliability was found to be 0.83. This indicates that the inter-rater agreement is at an excellent level since it is above 0.75 according to Cohen's Kappa value classifications. In this context, all data belonging to the relevant achievement test were evaluated according to the rubric. In the scoring part, thanks to the rubric developed for the problem-solving skills test, the first six questions were evaluated over 10 points, the seventh and eighth questions were evaluated over 20 points, and a total of 100 points were evaluated.

Cognitive load scale

A nine-point Likert-type, single-item cognitive load scale developed by Paas and van Merriënboer (1994) and adapted into Turkish by Kılıç and Karadeniz (2004) was used to measure the amount of perceived cognitive load. The Cronbach Alpha of the adapted scale was given as (α=0.780). The scale was applied after each application within the scope of the study. The reliability of the scale, which was applied to each research group thrice, was determined as 0.778 for this study. It was evaluated by giving the lowest score 1 and the highest 9 points as the scale is a nine-point Likert-type scale.

Worked Examples

In the research, presentations consisting of solution samples belonging to the subject of entity relationship schemes were prepared. As shown in Figure 1, the problem statement is given at the top. Just below the problem statement, the solution of that problem is numbered step by step. The conceptual, logical, physical and live representation areas of each stage are updated continuously. At each stage, each step of the changes in these areas is presented simultaneously and holistically. Sample problem and solutions for each stage are presented in the appendices.

In the lecture and presentations, Çağıltay and Tokdemir's (2010) “Database Systems Course from Theory to Practice” book was used. The contents of the prepared presentations were kept the same for each research group, and the instruction process was carried out by the same researcher. The presentation of the solutions for each problem given in the instruction process was given in two different ways. Solutions for the above-mentioned Group 1 and Group 3 problems were presented step-by-step in such a way that each representation area was visible and a change in one area would affect other areas. For Group 2 and Group 4, the solutions of the problem were presented holistically with their final form in all representation areas. The general template of this instructional material, which is prepared in two different ways, is given in Figure 1, the example of presenting the solutions in the form of multiple representation step-by-step is given in figure 5-10, and the example of presenting the solutions holistically is given in figure 4.

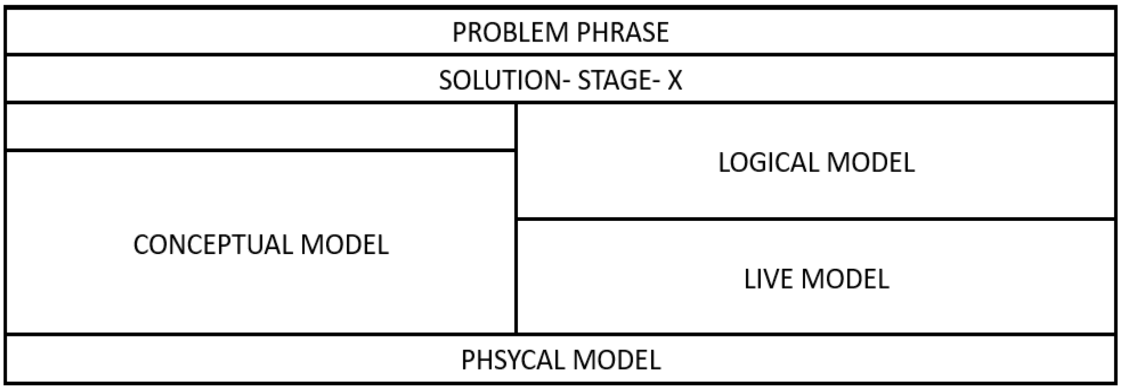

Figure 1: General Template

In this template, the visualization of the instructional material developed within the scope of the study is presented. It shows how multiple representation is used as worked examples within the scope of the study.

Procedure

A preliminary knowledge-level test was applied first to be able to group the students according to their levels. According to the results obtained from the preliminary knowledge-level test, the students below the average were included in the novice group, and the students above the average were included in the expert group. Additionally, since two different instructional methods will be applied in both novice and expert groups, each group was randomly divided into two groups within itself. Thus, four experimental groups were formed as novice-step-by-step instructional method, novice-holistic instructional method, expert-step-by-step instructional method, and expert-holistic instructional method.

Due to the limitation of course hours, the groups that were taught with the same instructional material were trained at the same time. Thus, each group was given 6 h of training in 3 weeks and 2 h a week. During this period, the presentations were shown only by the instructor in the class so that the groups did not share the instructional materials among themselves.

After the lecture, each group was presented with a problem statement and solution in accordance with their instructional method. At the end of the lesson, the students were given a problem and their solutions were collected by the researcher. At the end of the lesson, cognitive load situations were determined by applying Paas' cognitive load scale. At the end of the three-week training, a problem-solving skills test was administered. As the last step, the permanence test was applied four weeks after the problem-solving skills test. This whole procedure is visualized in Figure 2 below.

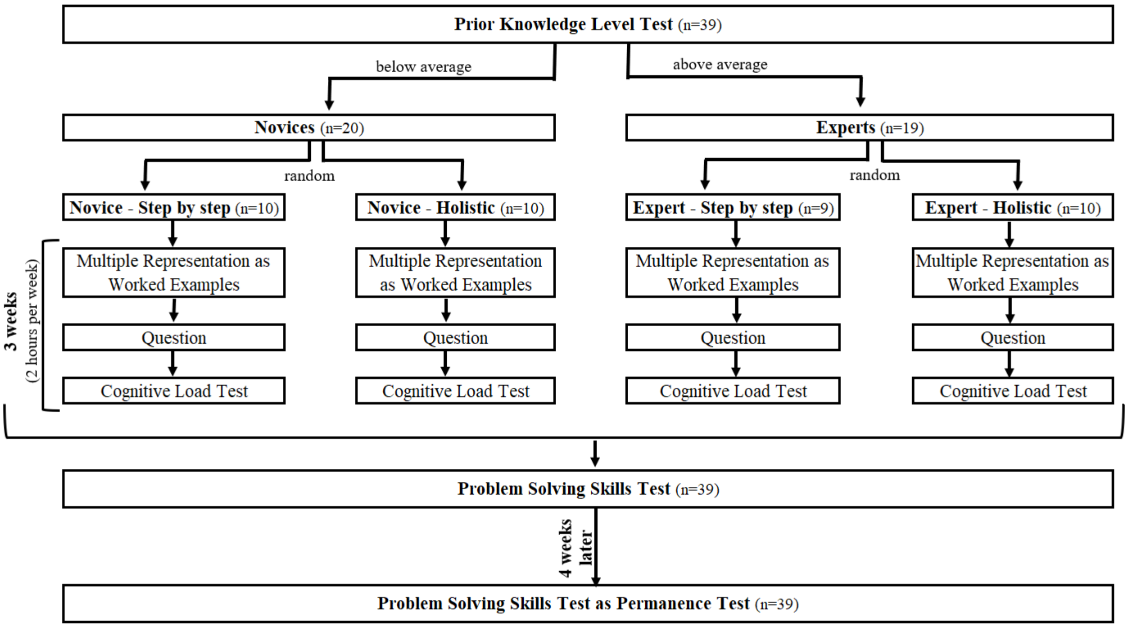

Figure 2: Procedure of the research

Findings

Before data analysis, it was checked whether there are extreme values that may adversely affect the analysis of the data. If the sample size is larger than 35, the Kolmogorov-Smirnov test (McKillup, 2011) can be used, and if it is small, the Shapiro-Wilk test can be used (Shapiro & Wilk, 1965). In this study, the Shapiro-Wilk normal distribution test was applied due to the sample size. Parametric tests were used in the analysis of the data upon all dimensions showed normal distribution.

Table 3: Normal Distribution Values of Variables

		Shapiro - Wilk					
		Problem Solving Skills		Cognitive Load		Permanence	
		sd	p	sd	p	sd	p
Instructional Method	Step-by-step	19	0,877	19	0,175	19	0,066
	Holistic	20	0,076	20	0,606	20	0,067
Prior Knowledge	Novice	20	0,131	20	0,230	20	0,148
	Expert	19	0,257	19	0,405	19	0,207
Instructional Method x Prior Knowledge	Step-by-step – Novice	10	0,136	10	0,440	10	0,057
	Step-by-step – Expert	9	0,426	9	0,225	9	0,445
	Holistic – Novice	10	0,484	10	0,484	10	0,575
	Holistic – Expert	10	0,544	10	0,322	10	0,145

Table 3 shows the normal distribution values of all independent variables of the study.

Table 4: Descriptive values

Variables			Novice	Expert	Total
Problem -Solving Skills	Step-by-step	M	72,3	70,2	71,3
		SD	5,8	9,2	7,5
	Holistic	M	62,1	82,2	72,2
		SD	4,3	6,2	11,5
Cognitive Load	Step-by-step	M	4,2	4,9	4,5
		SD	0,9	1,3	1,2
	Holistic	M	5,9	4,3	5,1
		SD	0,9	5,0	1,3
Permanence	Step-by-step	M	19,7	31,9	25,5
		SD	8,7	11,8	11,8
	Holistic	M	22,7	36,3	29,5
		SD	7,5	12,4	12,2

Table 3 shows descriptive statistics about problem solving skills, cognitive load, and permanence. Two-way analysis of variance with a significance level of .05 was applied for each independent variable (problem solving skills, cognitive load, permanence) due to two different prior knowledge levels and two different instructional method variables. In the analyses in which a significant difference was detected, eta-square (η^2) effect size coefficients were calculated to determine the effect of the independent variable on the dependent variable for the eta-square value, the effect size close to 0.01 is expressed as “small”, close to 0.06 as “medium”, and close to 0.14 as “large” (Richardson, 2011).

Table 5: Two-Way Anova Results of Problem-Solving Skills Scores According to Instructional Method and Prior Knowledge Level

	Sum of Squares	sd	Mean of Squares	F	p	η^2
Instructional Method	7,688	1	7,688	0,180	0,674	0,005
Prior Knowledge	790,055	1	790,055	18,532	0,000	0,346
Instructional Method x Prior Knowledge	1196,401	1	1196,401	28,063	0,000	0,445
Error	1492,156	35	42,633			
Total	204278,000	39				
Corrected Total	3539,436	38				

Levene Test for Variance Homogeneity: F=2,15; sd=3; p=0,112

According to the results of the two-way analysis of variance, the main effect of the instructional method and the level of prior knowledge, and the effect of the interaction of the instructional method and the level of prior knowledge on the skills of problem solving were examined. In this context, it was observed that only the instructional method did not have a significant effect on problem solving skills ($F_{(1-35)}$= 0.180; p> 0.05). It was determined that the main effect of the prior knowledge level variable had a significant ($F_{(1-35)}$= 18,532; p< 0.05) large effect (η^2= 0.346). The significant difference was found to be in favor of students with high prior knowledge ($\bar{x}_{expert}$= 76.5, sd= 9.7; $\bar{x}_{novice}$= 67.2, sd= 7.2). It was also found that the interaction of both variables (instructional method x prior knowledge level) had a significant ($F_{(1-35)}$= 28,063; p< 0.05) large effect (η^2=0.445) on problem solving skills. This interaction is given in figure 2.

Table 6: Two-Way Anova Results of Cognitive Load Scores According to Instructional Method and Prior Knowledge Level

	Sum of Squares	sd	Mean of Squares	F	p	η^2
Instructional Method	2,724	1	2,724	2,324	0,136	0,062
Prior Knowledge	2,007	1	2,007	1,712	0,199	0,047
Instructional Method x Prior Knowledge	13,914	1	13,914	11,868	0,002	0,253
Error	41,031	35	1,172			
Total	961,625	39				
Corrected Total	60,183	38				

Levene Test for Variance Homogeneity: F=0,896; sd=3; p=0,453

When the results of the two-way analysis of variance on the cognitive load variable were evaluated, it was determined that the instructional method ($F_{(1-35)}$= 2.324; p> 0.05) and the prior knowledge level ($F_{(1-35)}$= 1.712; p> 0.05) did not have a significant effect. On the other hand, the interaction of both variables was found to have a significant ($F_{(1-35)}$= 11,868; p< 0.05) large effect (η^2= 0.253) on cognitive load. This interaction is given in figure 3.

Table 7: Two-Way Anova Results of Permanence Scores According to Instructional Method and Prior Knowledge Level

	Sum of Squares	sd	Mean of Squares	F	p	η^2
Instructional Method	133,6	1	133,6	1,272	0,267	0,035
Prior Knowledge	1617,73	1	1617,73	15,398	0,000	0,306
Instructional Method x Prior Knowledge	4,844	1	4,844	0,046	0,831	0,001
Error	3677,189	35	105,063			
Total	35040,000	39				
Corrected Total	5463,692	38				

Levene Test for Variance Homogeneity: F=1,942; sd=3; p=0,141

When the results of the two-way analysis of variance on the permanence variable were examined, it was seen that only the prior knowledge level variable had a significant ($F_{(1-35)}$= 15,398; p< 0.05) large effect (η^2= 0.306) on the permanence variable. The significant difference was found to be in favor of students with high prior knowledge ($\bar{x}_{expert}$= 34.21, sd= 11.95; $\bar{x}_{novice}$= 21.2, sd= 8.09; $\bar{x}_{expert}$-$\bar{x}_{novice}$= 12,894). However, neither the instructional method ($F_{(1-35)}$= 1.272; p> 0.05) nor the interaction between the instructional method and prior knowledge level ($F_{(1-35)}$= 0.046; p> 0.05) had a statistically significant effect on the permanence test score.

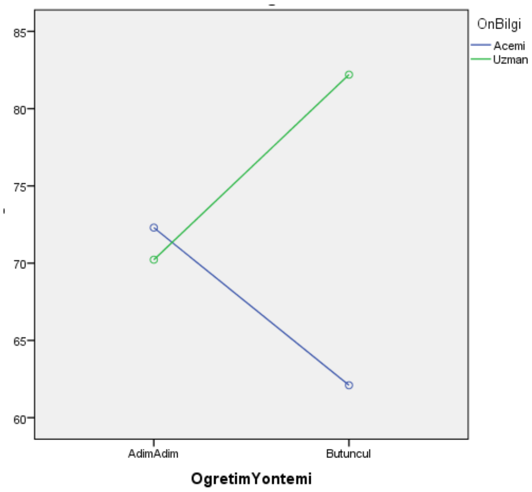

Figure 3: The Interaction of Teaching Method and Prior Knowledge Level on Problem Solving Skills

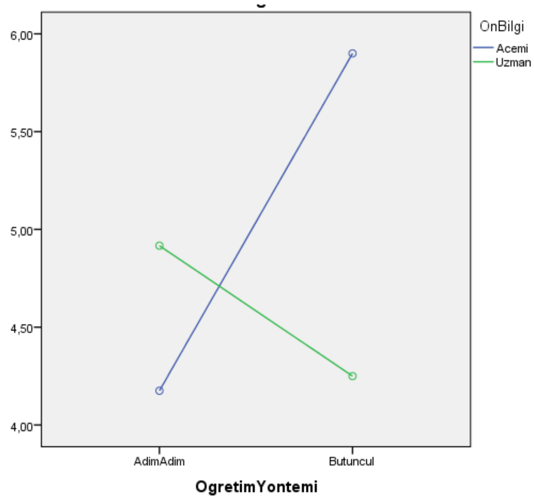

Figure 4: The Interaction of Teaching Method on Cognitive Load and Prior Knowledge Level

Results and Discussion

Problem Solving Skills

It is evident that multiple representation instructional methods did not have a significant effect considering the effect of multiple representation instructional methods (step-by-step, holistic) on the problem-solving skills. It was stated that a step-by-step task approach would be more appropriate for low cognitive skills, and a holistic task approach would be more appropriate for more complex cognitive tasks in terms of cognitive skills teaching in general (Naylor & Briggs, 1963; Spector & Anderson, 2000; van Merriënboer et al., 2003); Lim et al., 2009, Sommerhoff et al., 2020). When the main effect was considered, although our findings seem to conflict with the existing literature, the result of our study also support this result in the literature. This situation will be explained below in detail.

When the effect of prior knowledge level on the problem-solving skills was examined, it was observed that expert students were more successful than novice students. It is evident that experts can recognize patterns in problems better than novices, categorize new problems better according to these patterns, and solve these new problems more efficiently (Chi et al., 1981; Schrader & Kalyuga, 2022). Similarly, it is known that expert students with content knowledge are more successful than novice students for ill-defined problem types (Voss et al., 1991; Larkin et al., 1980; Reimann & Chi, 1989; Kalyuga et al., 2003; Armougum et al., 2020). Similar results were obtained with the previous findings within the scope of this study. Thus, the level of prior knowledge emerges as an important factor affecting the skills of problem solving.

When the interaction between the prior knowledge level and the multiple representation instructional method (step-by-step, holistic) used in the research is examined, it is evident that it affects the skills of problem solving. When novice students studied with the holistic multiple representation instructional method, they were the most unsuccessful group in terms of problem solving skills among the four groups compared. Therefore, it can be said that the holistic multiple representation instructional method is not suitable for novice students. On the other hand, novice students have been successful with the step-by-step multi-representation instructional method, and it has even been revealed that they have reached the level of the expert students working with the step-by-step multi-representation instructional method, or even more successful. In line with this result, it can be suggested that a step-by-step multiple representation instructional method should be preferred for novice students to gain the ability to solve ill-structured problems. Although expert students working with step-by-step multi-representation instructional method are less successful than novice students, when they work with the holistic multi-representation instructional method, they appear as the most successful group in terms of problem-solving skills. From this perspective, for students who have a certain level of knowledge about the subject to be learned, choosing the holistic multiple representation instructional method to gain and develop the ability to solve ill-structured problems may affect skills positively. These obtained data support the expertise reversal effect. As stated before, it has been stated that a instructional material that is useful for novices will not be beneficial or even an obstacle as they become proficient (Khacharem et al., 2015; Blayney et al., 2015). From this viewpoint, it is argued that the step-by-step multiple representation instructional method, which is primarily beneficial for novices, should be replaced by the holistic multiple representation instructional method as the specialization occurs. The study findings also overlap with most studies in the literature (Naylor & Briggs, 1963; Sweller, 2012; Spanjers et al., 2012; Kyun et al., 2013; Kalyuga et al., 2003; Spector & Anderson, 2000; van Merriënboer et al., 2003; Lim et al., 2009; Ahmed et al., 2021).

Cognitive Load

In this study, it is evident that the multiple representation method alone did not affect the cognitive load at a statistically significant level. Considering the cognitive load in the literature, it has been stated that allowing the imitation of the processes of problem solving makes it easier to learn the way that leads to a solution (Van loon-Hillen et al., 2012). Because it has been emphasized that presenting a complex problem with many solution stages in a holistic way rather than step-by-step can create an insurmountable load on working memory. However, it has also been revealed that this does not always have the same effect, and that it produces different results according to the students' prior knowledge levels (Van Gogh & Sweller, 2015). Therefore, within the scope of the research, although the multiple representation method did not produce significant results when considered alone, it will be demonstrated that results supporting the literature were obtained in the interaction part.

The reason why prior knowledge level did not make a statistical difference in cognitive load may be that both a step-by-step and holistic task approach-based instructional methods were applied to each novice and expert student group within the scope of the study. Considering the averages of cognitive load that novice and expert students are exposed to in total, it has been observed that there is no statistically significant difference from each other. That is, in line with the study of van Gogh and Sweller (2015), although the cognitive load that novice students are exposed to is less in the step-by-step instructional method, the cognitive load they are exposed to from the holistic instructional method is just as high. Contrary to this, it has been determined that expert students are exposed to less cognitive load in the holistic instructional method than in the step-by-step instructional method, in contrast to the novice students. It is seen that this situation has been reported similarly in the literature (Spector & Anderson, 2000; van Merriënboer et al., 2003; Lim et al., 2009).

As shown and stated in Figure 2, the interaction between the prior knowledge level and the multiple representation instructional method (step-by-step, holistic) used was found to be statistically significant. It was observed that the group with the highest amount of cognitive load was the group of novice students studying with the holistic instructional method when compared to other groups. From this perspective, it can be said that the holistic instructional method is not an instructional method that should be used primarily for novice students. In addition to this information, it has been observed that novice students are exposed to less cognitive load than expert students with the step-by-step instructional method. It can be suggested that this situation should be preferred as one of the first ways to teach novice students a step-by-step instructional method, which can make their learning effective by keeping the cognitive load as low as possible while instruction a new subject. When the expert students were examined, it was seen that the opposite situation emerged for the novice students. It has been determined that the expert students who are educated with the step-by-step instructional method are exposed to more cognitive load than the expert students who are educated with the holistic instructional method. This observed situation coincides with the studies described in the literature by linking to the redundancy effect in the cognitive load theory (Kalyuga et al., 2000; Renkl & Atkinson, 2003). In this context, considering the integrity of the subject in terms of cognitive load, it can be recommended that while instruction the solution of ill-structured problems, novice students should be supported using a step-by-step instructional method that supports them to create and develop solution-oriented diagrams, and that holistic instructional methods should be adopted after the transition from novice to expert. This result obtained within the scope of the study is supported by most studies in the literature (Spector & Anderson, 2000; van Merriënboer et al., 2003; Lim et al., 2009; Naylor & Briggs, 1963; Van Gogh & Sweller, 2015; Sweller et al., 2011).

Permanence

According to the results of the two-way analysis of variance regarding the persistence variable, only the level of prior knowledge was found to be statistically significant. It was determined that neither the instructional method nor the common effect (interaction) of the prior knowledge level and the instructional method did not make a statistically significant difference on permanence within the scope of the study.

Schrader and Kalyuga (2022) reported that experts could recognize and categorize problems better than novices. It was also mentioned that this situation creates a situation in favor of expert students in terms of skills (Voss et al., 1991; Larkin et al., 1980; Reimann & Chi, 1989; Kalyuga et al., 2003; Armougum et al., 2020). In addition, Sweller (2020) defined information based on secondary information type as knowledge when it is transferred to long-term memory, and as skills when it is recalled from long-term memory and transformed into appropriate action. In line with this information, it can be said that experts store their acquired knowledge in long-term memory differently than novices. When the relevant situation is considered in terms of permanence, it has produced similar results with the literature. It has been observed that experts can recall meaningful patterns in large, organized chunks, whereas novices, in contrast, can recall information in smaller units and superficially (Chase & Simon, 1973; Jiang et al., 2023). Additionally, several studies on the permanence and recalling of information presented in schematic or perceptual formats have also yielded results in favor of experts. Experts can transfer information to long-term memory in the form of both organized and meaningful units (Hassebrock et al., 1993).

As discussed in the literature, methods that enable rapid learning in the learning process and positively affect skills can have a negative effect on the permanence and transfer of learned information (Helsdingen, van Gogh & van Merriënboer, 2011). Although not statistically significant, this situation occurred in novice students in our study. Persistence scores are higher for novice students who work holistically compared with students who work step-by-step. However, this did not occur in the experts. This situation, which can be ignored because it is not statistically significant, can be stated that the cognitive load faced by novices is germane and beneficial for learning, while the cognitive load faced by experts is an external cognitive load and does not contribute to learning.

In summary, this study presents some evidence supporting the expertise reversal effect in the step-by-step and holistic presentation of the solved examples prepared by the multiple representation method. For this reason, it is recommended that if the skills in the learning process is aimed while preparing instructional materials with the multiple representation method, the prior knowledge level of the students should be taken into account, and the step-by-step method should be preferred for novices and the holistic method should be preferred for experts to reduce the high cognitive load brought about by multiple representations. However, when permanence is taken as the target, it is clear that a clear answer cannot be given with the current study and more studies are needed on this subject. Additionally, it has been seen that expertise is effective for the knowledge gained to be permanent. Therefore, it is argued that students should be specialized with methods not limited to superficial information and enable the schema categories developed for problem solving to reach a sufficient amount (Fuchs et al., 2003; Schwartz et al., 2011).

Recommendations

- It is evident that the common effect of prior knowledge level and instructional method significantly affects problem solving skills according to results obtained from the research. For this reason, the development of instructional materials and the planning of instructional by considering students' prior knowledge levels can increase skills.
- Likewise, it has been determined that the common effect of prior knowledge level and instructional method significantly affects the cognitive load. Accordingly, designing instructional materials according to prior knowledge levels can reduce the cognitive load.
- In future studies, it is recommended to use scales that will allow us to measure internal, external, and germane cognitive load separately, not with a single dimension of cognitive load, which benefits novice students but does not benefit expert students. Measuring different types of cognitive load will help to better explain their effects on both the learning process and permanence.
- It has been determined that the level of expertise is of great importance for the success of permanence. Developing schema categories for problem -solving skills and supporting this situation until a sufficient amount is provided can increase the success of permanence.

Note

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References

Ahmed, A., Hurwitz, D., Gestson, S., & Brown, S. (2021). Differences between Professionals and Students in Their Visual Attention on Multiple Representation Types While Solving an Open-Ended Engineering Design Problem. *Journal of Civil Engineering Education, 147*(3), 04021005.

Ainsworth, S. (1999). The functions of multiple representations. *Computers & education, 33*(2-3), 131-152.

Ainsworth, S. (2006). DeFT: A conceptual framework for considering learning with multiple representations. *Learning and instruction, 16*(3), 183-198.

Armougum, A., Gaston-Bellegarde, A., Joie-La Marle, C., & Piolino, P. (2020). Expertise reversal effect: Cost of generating new schemas. *Computers in Human Behavior*, 111, 106406.

Bayrak, B. K., & Bayram, H. (2010). Effect of computer aided teaching of acid-base subject on the attitude towards science and technology class. *Procedia-Social and Behavioral Sciences, 2*(2), 2194-2196.

Blayney, P., Kalyuga, S., and Sweller, J. (2015). Using cognitive load theory to tailor instruction to levels of accounting students' expertise. *Journal of Educational Technology & Society, 18*(4), 199–210.

Büyüköztürk, Ş. (2016). *Deneysel desenler: öntest-sontest kontrol grubu, desen ve veri analizi* [Experimental designs: pretest-posttest control group, design and data analysis], 5th Edition, Ankara: Pegem Academy Publishing.

Bossé, M. J., Adu-Gyamfi, K., & Cheetham, M. (2011). Translations Among Mathematical Representations: Teacher Beliefs and Practices. International Journal for Mathematics Teaching & Learning.

Chandrasegaran, A. L., Treagust, D. F., & Mocerino, M. (2007). Enhancing pre-service science teachers' use of multiple levels of representation to describe and explain chemical reactions. *School Science Review, 88*(325), 115.

Chase, W. G., & Simon, H. A. (1973). Perception in chess. *Cognitive psychology, 4*(1), 55-81.

Chen, P. P. S. (1976). The entity-relationship model—toward a unified view of data. *ACM Transactions on Database Systems (TODS), 1*(1), 9-36.

Chi, M. T. H., Feltovich, P. J., and Glaser, R. (1981). Categorization and representation of physics problems by experts and novices. *Cognitive Science*, 5, 121-152.

Chi, M. T. H., and Glaser, R. (1985). Problem-solving ability. In R. J. Sternberg (Ed.), *Human abilities: An information-processing approach* (pp. 227-250). New York: W. H. Freeman and Company.

Chiappetta, E. L., Fillman, D. A., & Sethna, G. H. (2004). *Procedures for conducting content analysis of science textbooks.* Available from the University of Houston, Department of Curriculum and Instruction, Houston, Texas, USA.

Connolly, T. M., & Begg, C. E. (2006). A constructivist-based approach to teaching database analysis and design. *Journal of Information Systems Education, 17*(1), 43.

Çağıltay, N. E., Tokdemir, G. (2010). *Veritabanı Sistemleri Dersi: Teoriden Pratiğe* [Database Systems Course: From Theory to Practice] (1st ed.). Ankara: Ada Printing House Limited Company.

Fuchs, L. S., Fuchs, D., Prentice, K., Burch, M., Hamlett, C. L., Owen, R., Hosp, M., and Jancek, D. (2003). Explicitly teaching for transfer: effects on third grade students 'mathematical problem solving. *Journal of Educational Psychology*, 95, 293-305.

de Croock, M. B. M., van Merriënboer, J. J. G. (2007). Paradoxical effect of information presentation formats and contextual interference on transfer of a complex cognitive skill. *Computers in Human Behavior*, 23, 1740–1761.

Greeno, J. (1978). *Natures of problem-solving abilities*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Hassebrock, F., Johnson, P. E., Bullemer, P., Fox, P. W., & Moller, J. H. (1993). When Less Is More: Representation and Selective Memory in Expert Problem Solving. *The American Journal of Psychology*, *106*(2), 155–189. https://doi.org/10.2307/1423166

Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E., ve Tatham, R. L. (2013). Multivariate Data Analysis: *Pearson Education Limited.*

Helsdingen, A. S., Van Gog, T., & Van Merriënboer, J. J. (2011). The effects of practice schedule on learning a complex judgment task. *Learning and Instruction*, *21*(1), 126-136.

Jiang, D., Chen, O., Han, Y., & Kalyuga, S. (2023). Improving English language skills through learning Mathematic contents: From the expertise reversal effect perspective. *British Journal of Educational Psychology*, 00, 1–16. https://doi.org/10.1111/bjep.12596

Jonassen, D. H. (2011). *Learning to Solve Problems. A Handbook for Designing Problem-Solving Learning Environments.* New York and London: Routledge Taylor and Francis Group.

Jonassen, D., & Strobel, J. (2006). *Modeling for Meaningful Learning Engaged Learning with Emerging Technologies*, 1-27. University of Missouri, USA; Concordia University, Canada.

Kalyuga, S., Ayres, P., Chandler, P., ve Sweller, J. (2003). The expertise reversal effect. *Educational Psychologist*, 38, 23-33.

Kalyuga, S., Chandler, P., and Sweller, J. (2000). Incorporating learner experience into the design of multimedia instruction. *Journal of educational psychology*, *92*(1), 126.

Khacharem, A., Zoudji, B., and Kalyuga, S. (2015). Expertise reversal for different forms of instructional designs in dynamic visual representations. *British Journal of Educational Technology*, *46*(4), 756–767. doi:10.1111/bjet.12167.

Kılıç, E., and Karadeniz, Ş. (2004). Specifying Students' Cognitive Load and Disorientation Level in Hypermedia. *Educational Administration in Theory and Practice*, *10*(4), 562579.

Kitchner, K. S. (1983). Cognition, metacognition, and epistemic cognition. *Human development*, *26*(4), 222-232.

Kyun, S., Kalyuga, S., and Sweller, J. (2013). The effect of worked examples when learning to write essays in English literature. *Journal of Experimental Education*, *81*(3), 385–408.

Larkin, J., McDermot, J., Simon, D. P., and Simon, H. A. (1980). Expert and novice performance in solving physics problems. *Science*, 208, 1335-1342.

Lee, J. Y., Donkers, J., Jarodzka, H., & Van Merriënboer, J. J. (2019). How prior knowledge affects problem-solving performance in a medical simulation game: Using game-logs and eye-tracking. *Computers in Human Behavior*, 99, 268-277.

Lim, J., Reiser, R. A., and Olina, Z. (2009). The effects of part-task and whole-task instructional approaches on acquisition and transfer of a complex cognitive skill. *Educational Technology Research and Development*, *57*(1), 61-77.

McKillup, S. (2011). *Statistics explained: An introductory guide for life scientists*. Cambridge University Press.

Naylor, J. C., ve Briggs, G. E. (1963). Effects of task complexity and task organization on the relative efficiency of part and whole training methods. *Journal of Experimental Psychology,* 65, 217-224.

Paas, F. G., Van Merriënboer, J. J., & Adam, J. J. (1994). Measurement of cognitive load in instructional research. *Perceptual and motor skills, 79*(1), 419-430.

Rashkovits, R., & Lavy, I. (2021). Mapping Common Errors in Entity Relationship Diagram Design of Novice Designers. *International Journal of Database Management Systems, 13*(1), 1-19.

Reimann, P., and Chi, M. T. H. (1989). Human expertise. In K. J. Gilhooly (Ed.), *Human and machine problem solving* (pp. 161-191). New York, Plenum Press.

Renkl, A., Atkinson, R. K. (2003). Structuring the transition from example study to problem solving in cognitive skill acquisition: A cognitive load perspective. *Educational psychologist*, *38*(1), 15-22.

Richardson, J. T. (2011). Eta squared and partial eta squared as measures of effect size in educational research. *Educational Research Review, 6*(2), 135-147.

Schrader, C., & Kalyuga, S. (2022). Expertise reversal effect in a pen-tablet-based learning environment: The role of learningcentered emotions in the interplay between learner expertise and task complexity. *British Journal of Educational Psychology,* 00, 1– 14. https://doi.org/10.1111/bjep.12547

Schwartz, D. L., Chase, C. C., Oppezzo, M. A., and Chin, D. B. (2011). Practicing verses inventing with contrasting cases: the effects of telling first on learning and transfer. *Journal of Educational Psychology*, 103, 759-775.

Seufert, T. (2003). Supporting coherence formation in learning from multiple representations. *Learning and instruction, 13*(2), 227-237.

Shapiro, S. S., & Wilk, M. B. (1965). An analysis of variance test for normality (complete samples). *Biometrika, 52*(3/4), 591-611.

Simon, H. A. (1978). Information-processing theory of human problem solving. In W. K. Estes (Ed.), *Handbook of learning and cognitive processes* (Vol. 5, pp. 271-295). Hillsdale, NJ: Lawrence Erlbaum Associates.

Simon, H. A. (1980). Problem solving and education. In D. T. Tuma and F. Reif (Eds.), *Problem solving and education: Issues in teaching and research* (pp. 81-96). Hillsdale, NJ: Lawrence Erlbaum Associates.

Sinnott, J. D. (1989). A model for solution of ill-structured problems: Implications for everyday and abstract problem solving. In J. D. Sinnott (Ed.), *Everyday problem solving: Theory and applications* (pp. 72-99). New York: Praeger.

Sommerhoff, D., Kollar, I., & Ufer, S. (2020). Supporting Mathematical Argumentation and Proof Skills: Comparing the Effectiveness of a Sequential and a Concurrent Instructional Approach to Support Resource-Based Cognitive Skills. *Frontiers in psychology*, 11, 3664.

Spanjers, I. E., van Gog, T., and van Merriënboer, J. G. (2012). Segmentation of worked examples: Effects on cognitive load and learning. *Applied Cognitive Psychology, 26*(3), 352–358. doi:10.1002/acp.1832.

Spector, J. M., and Anderson, T. M. (2000). *Holistic and integrated perspectives on learning, technology, and instruction: Understanding complexity*. Mahwah, NJ: Lawrence Erlbaum. W.H. Freeman.

Sweller, J. (2012). Human cognitive architecture: Why some instructional procedures work and others do not. In K. R. Harris, S. Graham, T. Urdan, C. B. McCormick, G. M. Sinatra, & J. Sweller (Eds.), *APA educational psychology handbook, Vol. 1. Theories,* *constructs, and critical issues* (pp. 295–325). American Psychological Association. https://doi.org/10.1037/13273-011

Sweller, J. (2020). Cognitive load theory and educational technology. *Education Tech Research Dev* **68**, 1–16. https://doi.org/10.1007/s11423-019-09701-3

Sweller, J., Ayres, P., and Kalyuga, S. (2011). *Cognitive load theory*. New York, NY: Springer.

van Gog, T., and Sweller, J. (2015). Not new, but nearly forgotten: The testing effect decreases or even disappears as the complexity of learning materials increases. *Educational Psychology Review*, *27*(2), 247–264. doi:10.1007/s10648-015-9310-x.

van Loon-Hillen, N., Van Gog, T., & Brand-Gruwel, S. (2012). Effects of worked examples in a primary school mathematics curriculum. *Interactive Learning Environments, 20*(1), 89-99.

van Merriënboer, J. J. G., Kirschner, P. A., and Kester, L. (2003). Taking the load off a learners'mind: Instructional design for complex learning. *Educational Psychologist*, 38, 5–13.

Voss, J. F., Wolfe, C. R., Lawrence, J. A., and Engles, R. A. (1991). From representation to decision: an analysis of problem solving in international relations. In R. J. Sternberg (Ed.), *Complex problem solving*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Appendices

Example Task: A company has more than one store. Each store has its own unique code and name. In addition, the products offered for sale in these stores have their code and name. The company wishes to keep a record of the number of products sold from these stores. For this, they want to see which product has been sold and in what quantity. According to this:

- A store can have at least one or more products.
- A product may be available in one or more stores or may not be available in any store.

Design the database based on this information.

Figure 5: Holistic

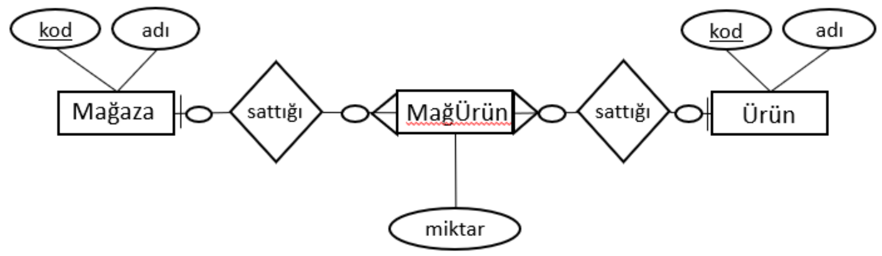
Bir şirket bünyesinde birden fazla mağaza barındırmaktadır. Her bir mağazanın kendine özgü bir kodu ve adı bulunmaktadır. Ayrıca bu mağazalarda satışa sunulan ürünlerin, kodu ve adı bulunmaktadır. Şirket bu mağazalardan satılan ürünlerin miktarını kayıt altında tutmak istemektedir. Bunun için hangi mağazadan hangi ürün ne miktarda satılmış görmek istemektedirler. Buna göre;

- Bir Mağazada en az bir veya daha çok ürün yer alabilir.
- Bir ürün bir veya daha çok mağazada yer alabileceği gibi hiçbir mağazada da yer almayabilir.

Bu bilgiler doğrultusunda veritabanını tasarlayınız.

ÇÖZÜM- AŞAMA-3

KAVRAMSAL MODEL



MANTIKSAL MODEL

Magaza (kod, adi)
Urun(kod, adi)
MagUrun(MagKod *(YA:Magaza-kod)*, **UrunKod** *(YA:Urun-kod)*, **miktar)**

CANLI GÖSTERİM

Magaza

kod	adi
1	Mağaza A
2	Mağaza B

Urun

kod	adi
1	Gömlek
2	Pantolon

MagUrun

MagKod	UrunKod	miktar
1	3	13
2	7	27

FİZİKSEL MODEL

```
CREATE TABLE Magaza(
kod      INT NOT NULL,
ad             VARCHAR (255) NOT NULL,
PRIMARY KEY (kod));
```

```
CREATE TABLE Urun(
kod      INT NOT NULL,
ad             VARCHAR (255) NOT NULL,
PRIMARY KEY (kod));
```

```
CREATE TABLE MagUrun(
MagKod      INT NOT NULL,
UrunKod        INT NOT NULL,
Miktar      INT NOT NULL,
PRIMARY KEY (MagKod, UrunKod)
FOREIGN KEY (MagKod) REFERENCES Magaza (kod),
FOREIGN KEY (UrunKod) REFERENCES Urun (kod));
```

Figure 6: Step-by-step – 1

Bir şirket bünyesinde birden fazla mağaza barındırmaktadır. Her bir mağazanın kendine özgü bir kodu ve adı bulunmaktadır. Ayrıca bu mağazalarda satışa sunulan ürünlerin, kodu ve adı bulunmaktadır. Şirket bu mağazalardan satılan ürünlerin miktarını kayıt altında tutmak istemektedir. Bunun için hangi mağazadan hangi ürün ne miktarda satılmış görmek istemektedirler.
Buna göre;

- •Bir Mağazada en az bir veya daha çok ürün yer alabilir.
- •Bir ürün bir veya daha çok mağazada yer alabileceği gibi hiçbir mağazada da yer almayabilir.

Bu bilgiler doğrultusunda veritabanını tasarlayınız.

<table>
<tr><td></td><td colspan="2">ÇÖZÜM- AŞAMA-3</td><td></td></tr>
<tr><td colspan="2">KAVRAMSAL MODEL</td><td colspan="2">MANTIKSAL MODEL</td></tr>
<tr><td colspan="2" rowspan="3"></td><td colspan="2"></td></tr>
<tr><td colspan="2">CANLI GÖSTERİM</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td colspan="4">FİZİKSEL MODEL</td></tr>
</table>

Figure 7: Step-by-step – 2

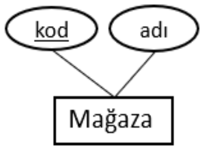
Bir şirket bünyesinde birden fazla mağaza barındırmaktadır. Her bir mağazanın kendine özgü bir kodu ve adı bulunmaktadır. Ayrıca bu mağazalarda satışa sunulan ürünlerin, kodu ve adı bulunmaktadır. Şirket bu mağazalardan satılan ürünlerin miktarını kayıt altında tutmak istemektedir. Bunun için hangi mağazadan hangi ürün ne miktarda satılmış görmek istemektedirler. Buna göre;

- Bir Mağazada en az bir veya daha çok ürün yer alabilir.
- Bir ürün bir veya daha çok mağazada yer alabileceği gibi hiçbir mağazada da yer almayabilir.

Bu bilgiler doğrultusunda veritabanını tasarlayınız.

ÇÖZÜM- AŞAMA-3

KAVRAMSAL MODEL



MANTIKSAL MODEL

Magaza (kod, adi)

CANLI GÖSTERİM

Magaza

kod	adi
1	Mağaza A
2	Mağaza B

FİZİKSEL MODEL

```
CREATE TABLE Magaza(
kod        INT NOT NULL,
ad                VARCHAR (255) NOT NULL,
PRIMARY KEY (kod));
```

Figure 8: Step-by-step - 3

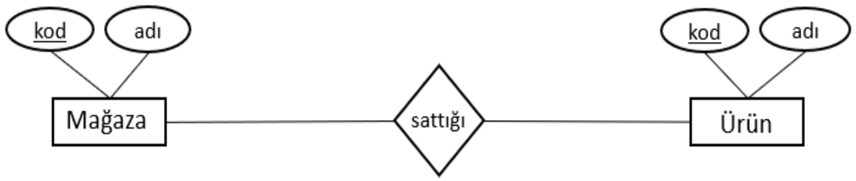
Bir şirket bünyesinde birden fazla mağaza barındırmaktadır. Her bir mağazanın kendine özgü bir kodu ve adı bulunmaktadır. Ayrıca bu mağazalarda satışa sunulan ürünlerin, kodu ve adı bulunmaktadır. Şirket bu mağazalardan satılan ürünlerin miktarını kayıt altında tutmak istemektedir. Bunun için hangi mağazadan hangi ürün ne miktarda satılmış görmek istemektedirler.
Buna göre;

- •Bir Mağazada en az bir veya daha çok ürün yer alabilir.
- •Bir ürün bir veya daha çok mağazada yer alabileceği gibi hiçbir mağazada da yer almayabilir.

Bu bilgiler doğrultusunda veritabanını tasarlayınız.

ÇÖZÜM- AŞAMA-3

KAVRAMSAL MODEL



MANTIKSAL MODEL

Magaza (kod, adi)
Urun(kod, adi)

CANLI GÖSTERİM

Magaza

kod	adi
1	Mağaza A
2	Mağaza B

Urun

kod	adi
1	Gömlek
2	Pantolon

FİZİKSEL MODEL

```
CREATE TABLE Magaza(
kod        INT NOT NULL,
ad                  VARCHAR (255) NOT NULL,
PRIMARY KEY (kod));
```

```
CREATE TABLE Urun(
kod        INT NOT NULL,
ad                  VARCHAR (255) NOT NULL,
PRIMARY KEY (kod));
```

Figure 9: Step-by-step - 4

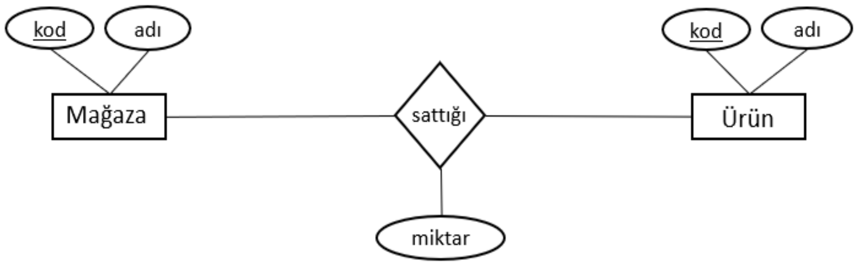
Bir şirket bünyesinde birden fazla mağaza barındırmaktadır. Her bir mağazanın kendine özgü bir kodu ve adı bulunmaktadır. Ayrıca bu mağazalarda satışa sunulan ürünlerin, kodu ve adı bulunmaktadır. Şirket bu mağazalardan satılan ürünlerin miktarını kayıt altında tutmak istemektedir. Bunun için hangi mağazadan hangi ürün ne miktarda satılmış görmek istemektedirler. Buna göre;

- •Bir Mağazada en az bir veya daha çok ürün yer alabilir.
- •Bir ürün bir veya daha çok mağazada yer alabileceği gibi hiçbir mağazada da yer almayabilir.

Bu bilgiler doğrultusunda veritabanını tasarlayınız.

ÇÖZÜM- AŞAMA-3

KAVRAMSAL MODEL



MANTIKSAL MODEL

Magaza (kod, adi)
Urun(kod, adi)

CANLI GÖSTERİM

Magaza

kod	adi
1	Mağaza A
2	Mağaza B

Urun

kod	adi
1	Gömlek
2	Pantolon

FİZİKSEL MODEL

```
CREATE TABLE Magaza(
kod        INT NOT NULL,
ad                  VARCHAR (255) NOT NULL,
PRIMARY KEY (kod));
```

```
CREATE TABLE Urun(
kod        INT NOT NULL,
ad                  VARCHAR (255) NOT NULL,
PRIMARY KEY (kod));
```

Figure 10: Step-by-step - 5

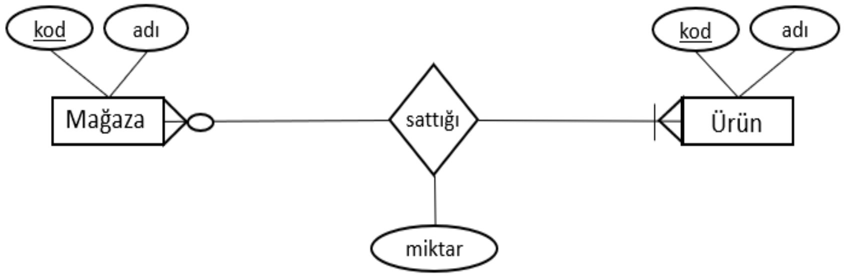
Bir şirket bünyesinde birden fazla mağaza barındırmaktadır. Her bir mağazanın kendine özgü bir kodu ve adı bulunmaktadır. Ayrıca bu mağazalarda satışa sunulan ürünlerin, kodu ve adı bulunmaktadır. Şirket bu mağazalardan satılan ürünlerin miktarını kayıt altında tutmak istemektedir. Bunun için hangi mağazadan hangi ürün ne miktarda satılmış görmek istemektedirler.
Buna göre;

- Bir Mağazada en az bir veya daha çok ürün yer alabilir.
- Bir ürün bir veya daha çok mağazada yer alabileceği gibi hiçbir mağazada da yer almayabilir.

Bu bilgiler doğrultusunda veritabanını tasarlayınız.

ÇÖZÜM- AŞAMA-3

KAVRAMSAL MODEL



MANTIKSAL MODEL

Magaza (kod, adi)
Urun(kod, adi)

CANLI GÖSTERİM

Magaza

kod	adi
1	Mağaza A
2	Mağaza B

Urun

kod	adi
1	Gömlek
2	Pantolon

FİZİKSEL MODEL

```
CREATE TABLE Magaza(
kod       INT NOT NULL,
ad              VARCHAR (255) NOT NULL,
PRIMARY KEY (kod));
```

```
CREATE TABLE Urun(
kod       INT NOT NULL,
ad              VARCHAR (255) NOT NULL,
PRIMARY KEY (kod));
```

Figure 11: Step-by-step - 6

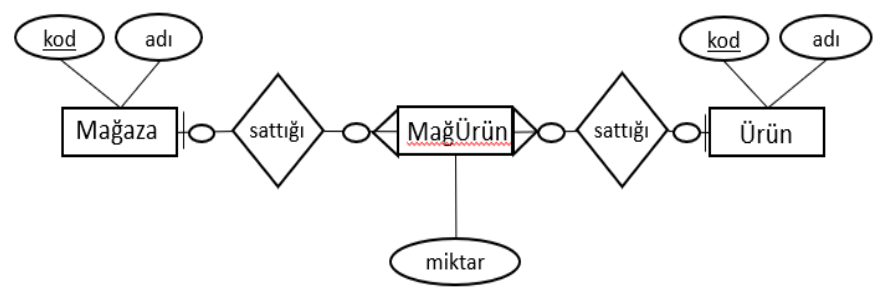
Bir şirket bünyesinde birden fazla mağaza barındırmaktadır. Her bir mağazanın kendine özgü bir kodu ve adı bulunmaktadır. Ayrıca bu mağazalarda satışa sunulan ürünlerin, kodu ve adı bulunmaktadır. Şirket bu mağazalardan satılan ürünlerin miktarını kayıt altında tutmak istemektedir. Bunun için hangi mağazadan hangi ürün ne miktarda satılmış görmek istemektedirler.
Buna göre;

- Bir Mağazada en az bir veya daha çok ürün yer alabilir.
- Bir ürün bir veya daha çok mağazada yer alabileceği gibi hiçbir mağazada da yer almayabilir.

Bu bilgiler doğrultusunda veritabanını tasarlayınız.

ÇÖZÜM- AŞAMA-3

KAVRAMSAL MODEL



MANTIKSAL MODEL

Magaza (kod, adi)
Urun(kod, adi)
MagUrun(MagKod *(YA:Magaza-kod)*, **UrunKod** *(YA:Urun-kod)*, **miktar)**

CANLI GÖSTERİM

Magaza

kod	adi
1	Mağaza A
2	Mağaza B

Urun

kod	adi
1	Gömlek
2	Pantolon

MagUrun

MagKod	UrunKod	miktar
1	3	13
2	7	27

FİZİKSEL MODEL

```
CREATE TABLE Magaza(
kod      INT NOT NULL,
ad             VARCHAR (255) NOT NULL,
PRIMARY KEY (kod));
```

```
CREATE TABLE Urun(
kod      INT NOT NULL,
ad             VARCHAR (255) NOT NULL,
PRIMARY KEY (kod));
```

```
CREATE TABLE MagUrun(
MagKod      INT NOT NULL,
UrunKod         INT NOT NULL,
Miktar      INT NOT NULL,
PRIMARY KEY (MagKod, UrunKod)
FOREIGN KEY (MagKod) REFERENCES Magaza (kod),
FOREIGN KEY (UrunKod) REFERENCES Urun (kod));
```