The Effects of Mastery Learning Method of Instruction and Laboratory Experiments on Achievement Levels and Science Misconception Scores of Secondary School Turkish Students

by

Kamil Arif Kırkıç

B.A. in Science Education,

Boğaziçi University, Turkey, 1991

Submitted to the Institute for Graduate Studies in

Social Sciences in partial fulfillment of

the requirements for the degree of

Master of Arts

in

Educational Sciences

Boğaziçi University

1994

Table of Contents

Acknowledgements

I am truly indebted to my thesis advisor, Prof. Dr. Güzver Yıldıran, for the time she devoted to my study and for her scientific supervision, continuous encouragement, the moral support, and constructive suggestions.

I would like to thank Prof.Dr. Necla Öner for her valuable guidance and helpful suggestions in writing my dissertation.

I would also like to thank Dr. Dilek Ardaç for helping me in the construction of the Density Misconception Test, for her guidance in writing theoretical parts of my dissertation and for her encouragement.

I am also grateful to Dr. Emine Erktin for her help in the computer analyses of the research.

I would like to thank Doç.Dr. Semiha Atakan who gave me valuable support to start doing this research.

My special thanks are extended to Faysal Duruöz and İnciser Akpınar, principals of the schools where my study was conducted, for giving me opportunity to empirically test in a school situation the theories that were the concerns of this study.

I would like to express my thanks to my classmates and colleagues for their cooperation, encouragement and sincerity.

Finally, I am especially indebted to my mother Rahime Kırkıç and my father Hakkı Kırkıç for their emotional support, encouragement and patience.

List of Tables

List of Figures

Abstract

The aim of this study is to test whether or not the combined effects of Mastery Learning Method of Instruction and Laboratory experiments have an impact on the achievement levels of science students at a secondary school over control conditions as well as decreasing scientific misconceptions.

Three ninth grade classes of a private secondary school in İstanbul were used. The first class was assigned as the Mastery Learning with laboratory experiments group, the second class as the Mastery Learning group. The third class was divided into two ; one division was utilized as the control condition with laboratory experiments, the other half as the control group.

The hypotheses of the study are :

Hypothesis 1) The science achievement level of the groups under Mastery Learning Method of instruction will be significantly higher than the control groups.

Hypothesis 2) The achievement level of the groups using laboratory experiments will be significantly higher than the control group.

Hypothesis 3) Laboratory experiments will have an additive effect to the Mastery Learning method of instruction. Therefore, the class under the Mastery Learning method of instruction combined

with laboratory experiments will not only score higher than the control group, but will also have the highest mean scores when compared to the Mastery Learning or the group using laboratory experiments on the summative test.

Hypothesis 4) Students in Mastery Learning and / or Laboratory experiment groups will have a lesser amount of science misconceptions due to their higher achievement levels. Therefore, students of the most successful group will have the least amount of science misconceptions.

To test the first and the second hypotheses, a one - way analysis of variance, Newman - Keuls formula, and effect size analyses were used. To test the third hypothesis, a two - way analysis of variance and E correlation ratios were utilized. To analyze the fourth hypothesis, a one - way analysis of variance, Newman - Keuls formula, effect size analyses, a two - way analysis of variance and E correlation ratios were used.

Analyses of the data indicated that :

1 . Mastery Learning and laboratory experiments have strong effects on summative achievement. But the effect of Mastery Learning is much stronger than that of laboratory experiments.

2. The Mastery Learning with laboratory experiments group achieved highest on the summative test, followed by the Mastery Learning, followed by the control with laboratory experiments, followed by the control group.

3. The impact of laboratory experiments is greater under control conditions in comparison to Mastery Learning conditions.

4. The effect of Mastery Learning and laboratory experiments is additive and greater than the single effect of either alone.

5. The effect of Mastery Learning seems strong in decreasing the amount of science misconceptions, while laboratory experiments have no significant effect in preventing the occurrence of these type of misconceptions.

The findings indicate that Mastery Learning which is able to increase achievement levels of students to one standard deviation over the control conditions, raises science achievement levels to 4 standard deviations over control conditions when utilized with laboratory experiments.

Although these two interventions increase achievement levels, only Mastery Learning increases the probability of correct conceptualization, but this effect is not as strong on the misconception test (DEMIT) as it is on the summative test.

Özet

Bu çalışmanın amacı Tam Öğrenme yönteminin ve laboratuvar deneylerinin lise birinci sınıf öğrencilerinin fen dersindeki erişi düzeylerine ve yanlış kavramlaştırmaların azalmasına etkilerini incelemektir.

İstanbul'da bulunan bir özel lisenin mevcut üç dokuzuncu sınıfı(lise 1) bu çalışmada kullanılmıştır. Bu sınıflardan birincisinde Tam Öğrenme yöntemi kullanılmış ve öğrenciler üçer veya dörder kişilik gruplar halinde öğretilen konularla ilgili deneyleri laboratuvarlarda yapmışlardır. İkinci lise1 sınıfında ise sadece Tam Öğrenme yöntemi kullanılmış, öğrenciler konularla ilgili deneyleri yapmamışlardır. Üçüncü sınıfta ise öğretim süreci geleneksel öğretim metodu ile gerçekleştirilmiştir. Bu sınıtaki öğrencilerin yarısı ilk sınıftaki öğrenciler gibi labarotuvarda ilgili deneyleri yaparken diğer öğrenciler bu deneylerle uğraşmamıştır.

Bu çalışmanın denenceleri şunlardır :

Denence 1 . Tam Öğrenme yöntemi uygulanan grupların başarı düzeyi kontrol gruplarınkinden daha yüksek olacaktır.

Denence 2 . Laboratuvar deneylerinin yapıldığı grupların başarı düzeyi kontrol grubunun düzeyinden daha yüksek olacaktır.

Denence 3. Laboratuvar deneylerinin, Tam Öğrenme yöntemine çoğalgan etkisi olacaktır. Bu nedenle, laboratuvar deneylerinin yapıldığı Tam Öğrenme uygulanan grubun başarı düzeyi kontrol grubundan yüksek olmasının yanında, hem sadece Tam Öğrenmenin uygulandığı hem de sadece deneylerin yapıldığı kontrol grubunun başarı düzeylerinden de yüksek olacaktır.

Denence 4. En başarılı sınıfın öğrencileri, bütün öğrenciler arasında en az yanlış kavramlara sahip olacaklardır.

Birinci ve ikinci denenceleri sınamak için, tek-yönlü vayans analizi, Newman-Keuls formülü ve etki oranları analizi uygulanmıştır. Üçüncü denence için iki-yönlü varyans analizi ve E korelasyon oranları kullanılmıştır. Dördüncü denence için ise tek-yönlü vayans analizi, Newman-Keuls formülü, iki-yönlü varyans analizi, E korelasyon oranları ve etki oranları analizleri uygulanmıştır.

Çalışma sonucunda elde edilen bulgular şunlardır :

1 . Tam Öğrenme yöntemi ve laboratuvar deneylerinin başarı üzerinde kuvvetli etkileri vardır. Tam Öğrenmenin etkisi, laboratuvar deneylerinin etkisinden daha büyüktür.

2 . Başarı sırası en büyükten en küçüğe doğru şöyledir : Labaoratuvar deneylerinin yapıldığı Tam Öğrenme grubu, Tam Öğrenme grubu,

Labaoratuvar deneylerinin yapıldığı konrol grubu, ve kontrol grubu.

3 . Laboratuvar deneylerinin başarıya etkisi geleneksel yöntemlerin kullanıldığı koşullarda, Tam Öğrenme koşullarındakinden daha fazladır.

4 . Laboratuvar deneylerinin, Tam Öğrenme yöntemine etkisi çoğalgandır.

5 . Bütün öğrenciler arasında en az yanlış kavramlara sahip olanlar, en başarılı sınıfın öğrencileridir.

Tam Öğrenme yöntemi, laboratuvar deneyleriyle kullanıldığında başarıyı, kontrol sınıfının başarısının 4 standart sapma üzerine çıkarmaktadır. Tam Öğrenme yönteminin yanlış kavramları azaltmada etkisi olmasına rağmen, laboratuvar deneylerinin etkisi yok denecek kadar azdır.

Chapter I

Statement of the Problem

The main purpose of the study is to test whether or not the combined effects of Mastery Learning Method of Instruction and Laboratory experiments have an impact on the achievement levels of science students at a secondary school over control conditions as well as decreasing scientific misconceptions.

As the results of ÖSYM entrance examinations are examined, it is seen that the means of the science test scores were lower than the means of the other tests, although the number of items in these tests was approximately equal, (sixty - seventy items). For example, in 1992, the mean of the science subtest was 8.11 out of 62 and its standard deviation was 10.34, whereas the means of Mathematics, Turkish, Social Sciences and Foreign Language subtests were 9.56 out of 51, 34.96 out of 67, 27.35 out of 72, and 17.29 out of 75, the standard deviations of these subtests being 9.88, 11.31, 13.19 and 21.00, respectively (İSEM, 1993).

Although there is little information which indicates the existence and prevalence of scientific misconceptions among Turkish high school students, in one of these studies Yontar (1988) found that 54 % of eightyfive 5^{th} grade, seventythree 8^{th} grade and seventyone 11^{th} grade students had misconceptions about density. The results of university entrance examinations also show that there is an important problem related to science concepts and problem solving skills.

Why are scientific concepts so important in learning science? The answer, simply and shortly, is that science topics are sequential. That is, if a basic scientific concept is not learnt and conceptualized correctly, the higher level (complex) concepts for which basic concepts are prerequisites will not be conceptualized in a proper way. For instance, if the concepts "mass" and "volume" are not conceptualized in the desired manner, the concept of "density" which can be formed by using the concepts of "mass" and "volume" will also not be learnt correctly. Misconceptualizing of the concept of "density" will influence students' learning level of higher concepts for which the "density" concept is a prerequisite (for instance concepts of "mixture", and "buoyancy") will also be low .

What are scientific misconceptions? In recent studies, science misconceptions are defined as conceptualizations which diverge partially or completely from those of scientists. More simply, misconceptions are views which vary from the scientists' viewpoints (Yontar,1988).

According to Fisher (1985),some alternative conceptions,judged to be erroneous ideas or misconceptions have these characteristics in common:

1) They are at variance with conceptions held by experts in the field.

2) A single misconception, or a small number of misconceptions, tend to be pervasive (shared by many different individuals).

3) Many misconceptions are highly resistant to change or to alteration,at least by traditional teaching methods.

4) Misconceptions sometimes involve alternative belief systems comprised of logically linked sets of propositions that are used by students in systematic ways.

5) Some misconceptions have historical precedence.That is , some erroneous ideas put forth by students today mirror ideas espoused by early leaders in the field.

6) Misconceptions may be a result of :

a) the neurological "hardware" or genetic programming (as in the case of automatic language-processing structures, which may be invoked when "reading" an equation);

b) certain experiences that are commonly shared by many individuals or those due to instruction in schools or other settings (Fischer 1985, p.53).

If scientific misconceptions are important in learning science, and traditional methods are insufficient and inappropriate to enhance them, which methods can be used to prevent misconceptualizations about science concepts? Stavy (1991) used experiments to show that anological reasoning could be functional to bridge the gap between the known and the unknown to overcome misconceptions about the conservation of matter. She found that by representing each new thing as though it resembles something the students already know, increased the level of learning and performance. Hewson and Hewson (1981) proposed that it is important to reconcile the scientific view with each student's existing knowledge.

The importance of the prerequisite knowledge for further learning is mentioned by the Mastery Learning Method of Instruction. According to Bloom who originally developed the method (Bloom, 1968), one of the important factors affecting the students' level of learning is Cognitive Entry Behaviors, which are "those prerequisite type of knowledge, skills and competencies which are essential to the learning of a particular new task or set of tasks" (Bloom,1976,p.32).

Odubunmi and Bologun (1991) found that laboratory (hands-on) experiments would have positive effects on the understanding level of science students. In this study, the experimental groups were taught by a laboratory-based method which allowed students to practice such processes as experimenting, manipulating and collecting data.

According to Ausubel (1968), the laboratory "gives the students appreciation of the spirit and method of science ..... promotes problem-solving , analytic and generalization ability,.......provides students with some understanding of the nature of science" (Ausubel in Hofstein, 1982 p.52). Shulman and Tamir (1973) proposed a classification of the following goals for laboratory activities in which students interact with materials to observe phenomena in science education. These are

1) to arouse and maintain interest, attitude, satisfaction, open mindedness and curiosity in science;

2) to develop creative thinking and problem solving ability;

3) to promote aspects of scientific thinking and scientific method (e.g.,formulating hypotheses and making assumptions);

4) to develop conceptual understanding and intellectual ability;

5) to develop practical abilities (e.g., designing and executing investigations, observations, recording data, and analyzing and interpreting results).

Since Mastery Learning method of instruction which was originally developed by Benjamin S. Bloom in 1968 mentions the importance of prerequisite knowledge for further learning units, it can be used to prevent scientific misconceptions. According to the study done by Dillashow and Okay 1983, (in Guskey 1988), 10^{th} grade students taught under Mastery Learning method of instruction had better science test scores than those under traditional methods (effect size[1] =0.74) . Tennebaum 1982, (in Guskey 1988) showed that 9^{th} grade science students under Mastery Learning method of instruction had better scores on higher mental process items than the students under traditional

[1] Effect size is the mean of the experimental group minus the mean of the control group divided by the standard deviation of the control group.

method (effect size=0.96). If there is a positive relation between cognitive achievement in science courses and conceptualization of science concepts, by increasing the cognitive achievement levels of students by means of any method, the frequency of occurrence of scientific misconceptions can be reduced.

All of these studies show that laboratory experiments and an appropriate instructional method can be used to increase the level of cognitive achievement and to prevent scientific misconceptions. Mastery Learning method of instruction as an appropriate one, can raise achievement levels of students about one standard deviation above the mean of the traditional method. Sayar (1986) found that Mastery Learning method of instruction alone leads to levels of achievement about 1.76 standard deviations, while the combined effects of Mastery Learning and Cognitive Entry Behaviors scored 2.76 standard deviations over the control class. In another study done by Afreşa(1983), it was found that there is a difference of 2.2 standard deviations between the mean scores of Mastery Learning and control groups on summative test scores . Nwabueze and Yıldıran (1991) found that there is a difference of 1.5 standard deviations between the mean performance of the class under both interventions (Mastery Learning and Improved Teaching) and the control class.

The following become the focus of this study.

Hypothesis 1) The science achievement level of the groups under Mastery Learning Method of instruction will be significantly higher than the control groups.

Hypothesis 2) The achievement level of the groups using laboratory experiments will be significantly higher than the control group.

Hypothesis 3) Laboratory experiments will have an additive effect to Mastery Learning method of instruction. Therefore, the class under Mastery Learning method of instruction combined with laboratory experiments will not only score higher than the control group, but will also have the highest mean scores when compared to the Mastery Learning or the group using laboratory experiments on the summative test.

Hypothesis 4) Students in Mastery Learning and / or Laboratory experiment groups will have a lesser amount of science misconceptions due to their higher achievement levels. Therefore, students of the most successful class will have the least amount of science misconceptions.

The next chapter will deal with the survey of literature on the impact of Mastery Learning and Laboratory experiments on science achievement levels and scientific misconceptions.

Chapter II

Survey of Literature

The main concerns of the study are to test whether or not the combined effect of Mastery Learning in addition to the use of Laboratory experiments produces higher achievement levels in comparison to control conditions than those obtained through Mastery Learning alone, and to check whether there is a direct relation between high level science achievement and the lack of scientific misconceptions which students hold about basic science concepts.

The title of the article published in Science Education in April 1940 was "An Evaluation of Certain Popular Science Misconceptions " (Hancock, 1940). A " misconception" was defined in this article as "...any unfounded belief that does not embody the element of fear, good luck, faith or supernatural intervention " , (Hancock, 1940, p.208). Hancock considered misconceptions to arise from faulty reasoning.

In the studies that were examined (Za'rour,1975;Osborne,1983; Marek, 1986) conceptualization can be categorized in four groups :(1) sound understanding of concepts (correct concept formation), (2) partial understanding of concepts (incomplete or transitional concept formation), (3) specific misunderstanding of concepts(misconceptions), and (4) no response (no concept formation).

Many studies done in different countries at different grade levels and in different subject areas showed the existence of scientific misconceptions among science students. Marek (1986) conducted a study to determine the mis - conceptions about two complex concepts, food chain and ecosystem. In the study using 58 ninth and tenth grade students (30 females ,28 males with a mean age of 16 years, 2 months), Marek found that only 2% of the students had a sound understanding of the concept of food chain. But no one understood the concept of ecosystem correctly and completely. In the same study, fifty seven percent and thirtythree percent of the students held misconceptions about the concepts,food chain and ecosystem , respectively.

Solomon and Longden (1991) showed that 60% of 246 sixth grade and 58% of 196 eighth grade students had misconceptions about the dissolving process. Fifty one percent of 6th and 38% of 8th graders had difficulties with the particulate nature of matter. In Za'rour's study in Lebanon (1975), most of 1444 high school (freshman and junior) and university (sophomore) students held misconceptions about different physical and chemical concepts such as density, heat, force and speed.

In the study conducted by Abraham, Gryzbowski, Renner and Marek (1992), it was found that only 14.3% of 247 eighth grade students had complete or sound understanding of five selected chemical concepts such as chemical change, dissolution, conservation of atoms, periodicity and phase changes. In another study related to physical states of water , Osborne and

Cosgrove (1983) concluded that pupils understood scientific concepts superficially. Furthermore, students would not give up an idea unless there was a better one to replace it. According to the study conducted by Shepherd and Renner in 1982 , 23% of 74 tenth and 61 twelfth graders with a mean age of 17 years had misconceptions about the concept of density while 50% of them had misconceptions about the states of matter.

Hewson (1986) found that 50% of 40 South African high school students (27 boys and 13 girls with an average age of 18 years whose native language was Sesotho and school language was English) held misconceptions about the states of matter while 40% of them had misunderstandings about density. In the study, it was also found that important and basic concepts, such as volume in explaining the density concept, were missing.

Some researchers attempted to derive appropriate and effective methods to prevent scientific misconceptions. For instance,Saxena (1992) used a strategy involving experimentation and guided investigation to remove misconceptions related to electricity. After completing experimentation, 80% of 25 university students (5 males & 20 females) altered their misconceptions about electricity. As a conclusion of another study done by Yvonne (1992), it was found that engaging in experiments that provided students with meaningful , concrete experiences would lead to a better understanding of science concepts. Hewson & Hewson (1981) tried to design a teaching technique according to a theoretical perspective which emphasized the importance of a student's existing knowledge in influencing that person's subsequent learning.

There are other similar attempts to prevent misconceptions. Overcoming misconceptions through activating prior knowledge regardless of whether students read the text that supports or refutes those misconceptions, was also indicated by some researchers such as Hynd and Alvermonn (1989). Hammer (1989) showed that college students' understanding levels had a positive effect on problem solving, and correct conceptualization.

According to the results of the studies related to misconceptions and their prevention, students have various kinds of simple or complex science misconceptions. Findings also suggest that using hands-on experiments, facilitating prior knowledge and increasing understanding or achievement levels of students may be helpful in decreasing the occurrence of misconceptions. In one recent study, Odubunmi and Bologun (1991) found that laboratory (hands-on) experiments would have positive effects on the understanding level of science students. In this study, the experimental groups were taught by a laboratory-based method which allowed students to practice such processes as experimenting, manipulating and collecting data. In all the experimental classes, students interacted with materials, whereas, students in the control classes never interacted with scientific apparatus during the teaching-learning processes. The results of this study showed that students exposed to the laboratory method performed better than those exposed to the lecture method.

As an effective instructional method, Mastery Learning Method of Instruction introduces the basic idea that most students can achieve high levels of learning in any subject matter (mathematics, science, history, biology, geography, arts e.t.c), if all learners have the necessary prerequisite knowledge for a new learning task, and if the Quality of Instruction is appropriate to their needs (Bloom,1976). Block(1971) showed that Mastery Learning Method of Instruction enable 80% of students to reach a high level of achievement while only 20% of the students under traditional (non-mastery) conditions attain the same level.

According to Bloom (1976), if errors during a learning task or a unit are determined and corrected before getting confounded with the errors in subsequent units, almost all students will attain mastery. As a result of this corrective procedure, students will become more similar in their learning outcomes, and the variation in students' learning levels as an observed phenomenon in all educational programs will decrease.

There are three important variables which produce an effect on school learning,according to Bloom (1976). Two of them are Cognitive Entry Behaviors (CEB) and Affective Entry Characteristics (AEC). The third one is Quality of Instruction. The first one, Cognitive Entry Behaviors, are "those prerequisite type of knowledge, skills and competencies which are essential to the learning of a particular new task or set of tasks" (Bloom,1976,p.32). The results of both macro and micro level studies indicate a strong relation between Cognitive Entry Behaviors of learners and their achievement levels in subsequent units or learning tasks (Bloom, 1976). Studies demonstrated that Cognitive Entry Behaviors explain one half (r= .70) of the variance in achievement scores.

The second student characteristic, Affective Entry Characteristics, is a complex combination of learners' interests and attitudes. Affective Entry Characteristics account for one fourth of the variation(r= .50) in achievement level .

The Quality of Instruction is the third factor which affects the level of learning. Its subvariables are feedback and correctives, cues, reinforcement and participation. Bloom (1976) claims that students can attain high levels of learning if systematic feedback and correctives exist in the instruction. Formative tests, which are diagnostic in nature and are used after each learning task to determine the learning level of the students, are common examples of the feedback procedure. Correctives are the information packages given to each student who has not reached the specified level of learning, in order to remediate the errors that have occurred on that level. Cues are the announcements of the teacher about what is to be learned and how it is to be learned before beginning a learning task. This subvariable accounts for 14 % of the variance (r = .38) in achievement. Participation is either overt or covert and accounts for 20 % of the variation in achievement (r = .42). Reinforcement is the teacher's behavior that increases the students' effectiveness in learning outcomes. Its correlation with achievement is .26 and it explains 6% of the variance in achievement.

Yıldıran (1977) examined the effects of high levels of achievement on other learning criteria such as retention, transfer of knowledge to new tasks, the uses of higher as well as lower mental processes, and positive affect or interest in the learning task. The results of her study (the micro study included 5 ninth grade beginning algebra classes of 138 students, and the macro study included 433 Junior College students) indicate that level of achievement affects retention, and the use of higher mental processes. She also found that retention, transfer, higher and lower mental processes and affective outcomes are influenced by the level of learning. According to Yıldıran, students can be successful on other learning criteria, provided that they learn the given material adequately by the help of Mastery Learning Method of Instruction, (Yıldıran, 1982).

Chapter III

Methodology

This section is composed of the research design which includes the subjects and subject area of the study, and the statement of the hypotheses. The procedure of the study is also presented in this section.

1. Research Design

Subjects

Sixtytwo, 9th grade students studying science in English at a private high school in İstanbul comprised the sample of the study . There were four groups in three sections. One section studied science under Mastery Learning Method of Instruction with laboratory experiments. This class is called the ML+LAB class. Another section studied science under Mastery Learning Method of Instruction without laboratory experiments. This class is called the ML class. Both of the Mastery Learning classes had 20 students each. The third class, being the control condition was divided into two sections. One section studied science in a traditional fashion but with laboratory experiments, (called the control+lab group, C+LAB), while the other did not have any laboratory experiments, the control group (C). Each of the control sections had 11 students.

The subject area of the study was ninth grade science. There were three learning tasks: mass, volume and density. Mass and volume took approximately three hours of instruction and the third learning task, density, took five hours of instruction. Altogether, there were 8 hours of instruction for the 4 groups, spread over 4 weeks of school.

Design of the Study

The study was a field experiment. The two major independent variables of the study were Mastery Learning Method of Instruction and laboratory experiments. The laboratory instruction included laboratory activities and experiments which were performed by students in small groups . Students taught under this type of instruction practiced processes such as setting up experimental apparatus, experimenting, observing, and collecting data. Dependent variables of the study are the level of achievement (scores on the summative test) and the amount or the degree of misconceptions (scores on Density Misconceptions Test, DEMIT).

MASTERY LEARNING	LABORATORY EXPERIMENTS (+)	LABORATORY EXPERIMENTS (-)
(+)	ML+LAB 20 students	ML 20 students
(-)	C+LAB 11 students	C 11 students

Figure 1 - The design of the study

There were four groups in the study as shown in the figure.

The first class was taught under Mastery Learning method of instruction and students conducted the related experiments in the laboratory in small groups. This group is called Mastery Learning with Laboratory Experiments (ML + LAB).

The second class was taught under Mastery Learning method of instruction. This class is called Mastery Learning group (ML) .

The third group was taught under traditional methods, and the students performed laboratory experiments. This is called the Control with Laboratory Experiments (C + LAB).

The fourth group was taught under traditional methods without laboratory experiments. This group was called the Control group (C).

Hypotheses of the Study

The Hypotheses of this study are the following:

Hypothesis 1) The science achievement level of the groups under Mastery Learning method of instruction will be significantly higher than the control groups.

Hypothesis 2) The achievement level of the groups using laboratory experiments will be significantly higher than control group.

Hypothesis 3) Laboratory experiments will have an additive effect to the Mastery Learning method of instruction. Therefore, the class under Mastery Learning method of instruction combined with laboratory experiments will not only score higher than the control group, but will also have the highest mean scores when compared to the Mastery Learning or the group using laboratory experiments on the summative test.

Hypothesis 4) Students in Mastery Learning and / or Laboratory experiment groups will have a lesser amount of science misconceptions due to their higher achievement levels. Therefore, students of the most successful class will have the least amount of science misconceptions.

Variables and their Operationalization

The dependent variables of the study are students' science achievement scores and the misconception scores about the concept of density. In order to check the effects of different teaching methods on science achievement levels of students, a summative test which included all three learning tasks taught during the intervention process was administered to all sections.

To determine the amount of misconceptions about the concept of density, a test which was developed and called " Density Misconception Test " (DEMIT) was used. DEMIT was issued to all four sections one day after administering the summative test.

The independent variables of the study are the instruction type (Mastery Learning method of instruction or traditional methods), and laboratory experiments (whether or not students had laboratory experiments).

The teacher of (ML+LAB) and (ML) classes ensured the high Quality of Instruction by using feedback and correctives, cues, reinforcements, and stimulating a high level of participation. In these Mastery Learning groups, the criterion level was set at the 80% level of learning. Students' degree of attainment of objectives was checked by giving a formative test after teaching a learning task. If students had not reached 80 % level of learning, correctives were given after the formative tests on that learning task, followed by the parallel form of the formative test.

Students in (ML+LAB) and (C+LAB) groups conducted 14 experiments (five experiments about volume, four about mass and five about density) in the laboratory. Students worked in small groups (three or four students together), while they were conducting these experiments.

The teacher of (C+LAB) and (C) groups used the same traditional instructional method in teaching all three learning tasks. As the same teacher taught all four groups, teacher effect was well controlled.

2 . Procedures

Three types of measures were used; namely the pre-measures, the process measures, and the final measures.

Pre-measures

There were two pre-measures in the study. Students' eighth grade science grades to check the classes' science achievement levels were obtained from their files. In addition, English preparatory class grades were obtained to determine each student's English achievement levels.

Process Measures

After teaching each learning task, a formative test was given to both of the Mastery Learning groups (ML and ML+LAB) to check each student's attainment level of the objectives. The teacher of the Mastery Learning groups assigned the correctives to the students who had not reached the criterion level. After giving correctives, the teacher administered the parallel form of the formative test. This cycle occurred for all learning tasks.

The first formative test included eight questions, tapping the four objectives of Learning Task "Mass" ; there were twelve questions, tapping the six objectives of Learning Task "Volume" in the second formative test ; and the third formative test consisted of twelve questions, tapping the seven objectives of Learning Task "Density", (for these tests, see Appendix II).

Final Measures

1) The first final measure was the summative achievement test which represented all three learning tasks and included eighteen items (five items

from the Learning Task "Volume"; four from the Learning Task "Mass" and eighth from the Learning Task "Density").

2) The second final measure, DEMIT , (Density Misconception Test), was used after the summative test.

Development of DEMIT : The development process of the DEMIT started with the first form of the test which contained thirty multiple- choice items, each consisting of three distracters and one correct response as well as three short- answer items. This form was developed by the researcher using the most frequently observed scientific misconceptions presented in previous studies (Fisher,1985; Hewson & Hewson,1981; Hewson, 1986; Marek,1986 ; Shepperd & Renner ,1982; Za'rour,1975), and his teaching experiences.

There were 27 eighth and 43 ninth grade students between the ages 14 and 17 in the pilot study. They were selected on the availability basis. This pilot study was conducted at Şener Private Highschool in İstanbul.

According to the results of the studies cited above and researcher's experiences, misconceptions related to density were classified into four categories in terms of variables which were used to explain the concept of density or density changes. The first category of misconceptions was the domination of mass over other independent variables in explaining the concept of density. The other categories were the domination of volume over mass and temperature; the domination of temperature over mass and volume and the misuse of mass-volume relationship. There were 10 items for the domination of mass; 11 items for the domination of volume; 6 for temperature domination and six for the misuse of mass-volume domination in the original form of the test.

The test was administered at the same period to all eighth and ninth graders. The time allowed for responding to the test was fiftyfive minutes. The results were analyzed to check the reliability of the instrument and to yield data to be used in shaping the final form of the test. In order to select the items for the final form of the test, three criteria were used : the frequency of the correct response, the item-total correlation and the discrimination power of the items. For three short-answer questions, answers containing misconceptions were determined. The misconceptions found in the answers were used as distracters of the two additional multiple-choice items in the final form of DEMIT, (for the test see Appendix III).

First, the item-total correlation was observed. Items with high item total correlations were identified. Item - total correlations over .15 were selected. Secondly, the discrimination power[1] of the items were identified comparing the top 30 % of students with the bottom 30 %. Items with very high discrimination power as well as items with very low discrimination powers were selected; the former for discriminating well between the two

[1]Discrimination Power is the difference between the ratio of correct answers given for an item by the top 30 % of students to the number of these students and the ratio of correct answers given for the same item by the bottom 30 % of students to the number of these students.

groups, the latter for items on which most students make errors. Frequency of correct responses showed what percent of students responded to the item correctly. An item with a high discrimination power and a low frequency of correct response meant that the item was discriminating well among the top and bottom groups, with the correct response showing a low frequency. The combination of three criteria gave the best 12 items of the new instrument.

Table 1 shows the first form of the test, while Table 2 shows the final form of DEMIT.

Table 1 - Item-total Correlation, Discrimination Power, and Frequency of Correct Response Values of the Items in the Original Form of DEMIT.

Item Number	Item-Total Correlation	Discrim. Power	Freq. of Correct Response (%)
1	-.1054	.52	14.5
2	-.0174	.46	10.1
3	.3122	.42	43.5
4	-.1470	.68	27.5
5	.1001	.78	7.0
6	.3243	.75	14.5
7	-.0606	.45	4.3
8	.2757	.67	17.4
9	.2429	.19	27.5
10	.0641	.32	39.1
11	.0642	.39	11.6
12	.0570	.07	21.7
13	.0281	.30	21.7
14	.1108	.07	15.9
15	.0667	.34	29.0
16	.1310	-.04	13.0
17	-.1851	-.05	13.0
18	-.0241	-.19	7.2
19	-.0979	.14	55.1
20	-.0252	.12	29.0
21	.2997	.14	21.7
22	-.2385	.17	17.4
23	-.0908	.13	26.1
24	.0097	-.02	14.5
25	.0264	-.03	14.5
26	.2062	.53	20.3
27	.1354	.08	10.1
28	.2231	.22	43.4
29	.1592	.29	39.1
30	.1491	.23	23.1

As a result fourteen items were included in the final form of Density Misconception Test, (DEMIT); two items for the domination of mass; four items for the domination of volume; two for temperature domination and six for misuse of mass-volume domination comprised the final form of the test, (Table 2).

Table 2 - Item-Total Correlation, Discrimination Power, and Frequency of Correct Response Values of the Items Selected for the Final Form of DEMIT.

Item Number	Item-Total Correlation	Discrim. Power	Freq. of Correct Response (%)
3	.3122	.42	43.5
5	.1001	.78	7.0
6	.3243	.75	14.5
8	.2757	.67	17.4
9	.2429	.19	27.5
16	.1310	-.04	13.0
21	.2997	.14	21.7
26	.2062	.53	20.3
27	.1354	.08	10.1
28	.2231	.22	43.4
29	.1592	.28	39.1
30	.1491	.23	23.1

The next section will present the results of the study.

Chapter IV

Results

Data Analyses Prior to Instruction

Prior to intervention, the four groups of the study were compared in terms of the students' previous class science grades and preparatory class English grades. Students' previous science grades were compared by using one - way analysis of variance (Table 3).

Table 3 - One - Way Analysis of Variance of the Previous Year Science Grades of the Groups

Source	DF	MS	F	Signf Level
Between Groups	3	.5975	1.0507	.3771 N.S
Within Groups	58	.5687		

According to results of this analysis as shown in Table 3, there are no significant differences among the four groups of the study in terms of their previous year science grades.

A comparison of the students' preparatory English grades was conducted by using one-way analysis of variance as shown in Table 4.

Table 4 - One - Way Analysis of Variance of the EnglishGrades of the Four Groups of Students Obtained at the End of the English Preparatory Year

Source	DF	MS	F	Signf Level
Between Groups	3	2.7761	2.0887	.1116 N.S
Within Groups	58	1.3292		

The results of Table 4 indicate that there are no significant differences among the groups in terms of preparatory English grades.

According to both of these analyses carried out prior to interventions, the groups are not significantly different from each other in terms of students' previous class science grades and their preparatory year English grades.

Analysis Done on Hypotheses

The analyses done to test hypotheses of the study are presented in this section.

Hypotheses 1 and 2

Hypothesis 1: The science achievement level of the groups under Mastery Learning method of instruction will be significantly higher than the control groups.

Hypothesis 2: The achievement level of the groups using laboratory experiments will be significantly higher than control group.

In order to test these hypotheses, one - way analysis of variance, the Newman - Keuls formula, and effect size analyses were used.

Table 5 indicates the means and standard deviations of the four groups on the summative test.

Table 5 - The Means, Standard Deviations of the Summative Achievement Test.

Groups	N	Possible Points	$\bar{x}$	s
ML_{Total}	40	18	15.40	1.86
C_{Total}	22	18	9.59	2.26
ML+LAB	20	18	16.00	1.55
ML	20	18	14.80	1.98
C+LAB	11	18	10.454	2.42
C	11	18	8.727	1.79

The one - way analysis of variance of the summative achievement test scores of the four groups was used to check whether there are differences among the students. This analysis is indicated in Table 6.

Table 6 - One - Way Analysis of Variance of the Summative Test Scores of the Four Groups

Source	DF	MS	F	Signf Level
Between Groups	3	169.9260	46.4653	.0000
Within Groups	58	3.6571		

It is seen that there are significant differences among the groups in terms of their summative test scores at = .0000 level

Newman - Keuls formula was used to compare the groups' summative achievement test scores in more detail. Table 7 presents the results of this analysis.

Table 7- Comparison of the Summative Test Scores of the Four Groups Using the Newman-Keuls Formula

Class Comparison	DF	MS Error	Calcul. q	Significance Level
ML_{TOTAL} + C_{TOTAL}	60	3.671	16.15	$q_{r,\alpha}$ = .01 (3.76)
ML+LAB and ML	58	3.671	2.36	NS (2.83)
C+LAB and C	58	3.671	3.40	$q_{r,\alpha}$ = .05 (2.83)
ML+LAB and C+LAB	58	3.671	10.92	$q_{r,\alpha}$ = .01 (4.28)
ML+LAB and C	58	3.671	14.33	$q_{r,\alpha}$ = .01 (4.60)
ML and C+LAB	58	3.671	8.56	$q_{r,\alpha}$ = .01 (3.76)
ML and C	58	3.671	11.96	$q_{r,\alpha}$ = .01 (4.28)

Table 7 indicates that there are very significant differences (q=16.15) between Mastery Learning groups taken together (ML_{total}) and control groups taken together (C_{total}), whereas, there are no significant differences between the groups which were taught under Mastery Learning method of instruction although the Mastery Learning group with Laboratory experiments (ML+LAB) had higher summative achievement than Mastery Learning group without Laboratory experiments (ML). However, the differences between control groups, (control with Laboratory experiments (C+LAB) and control group without Laboratory experiments (C)), are significant at the α = .05 level.

Table 7 shows that the second largest summative achievement difference is between ML+LAB and Control (C) groups. This difference is significant at $\alpha = .01$ level. This is followed by the difference between ML and C groups ($q = 11.92$). When the differences between ML+LAB and C+LAB groups are examined, table 5 indicates that there is a significant difference between their summative achievement test scores ($q = 10.92$). The difference between ML and C+LAB groups is ($q = 8.56$).

These comparisons mean that even using laboratory experiments in control conditions can not make students to reach the level of Mastery Learning method of instruction.

Effect Sizes

In order to see the observed differences between treatments of the study , an effect size analysis was used. The results of the effect size analysis is shown in Table 8.

Table 8 indicates that there is an effect size of 2.56 standard deviations between Mastery Learning groups together (ML+LAB and ML) and control groups together (C+LAB and C). That is, Mastery Learning groups achieved 2.56 standard deviations higher than students under traditional instruction. Between control groups (C+LAB and C) themselves, there is an effect size of .96 standard deviations difference, while this value between Mastery Learning groups (ML+LAB and ML) themselves is .60 .

Table 8 - Comparison of the Differences on Summative Achievement Scores of the Four Groups Using Effect Size Analysis

Class Comparison	Mean Difference	Stan.Dev.	Effect Size
ML_{Total} and C_{Total}	5.8091	2.260	2.56
ML+LAB and ML	1.2000	1.989	.60
C+LAB and C	1.7272	1.794	.96
ML+LAB and C+LAB	5.5455	2.423	2.28
ML+LAB and C	7.2727	1.794	4.05
ML and C+LAB	4.3455	2.423	1.79
ML and C	6.0727	1.794	3.38

The largest effect size was found between ML+LAB and C groups. The ML+LAB group achieved about four standard deviations higher than the control group. The next highest effect size is found between the ML and C groups, namely 3.38 standard deviations. Between ML+LAB and C+LAB groups, an effect size of 2.28 standard deviation exists. In the last comparison between ML and C+LAB groups, there is a difference of 1.79 standard deviations in terms of the effect size analysis.

The results of the Table 8 indicate that the summative achievement level of Mastery Learning with Laboratory experiments group (ML+LAB) is the highest, followed by ML group, followed by C+LAB, and finally control group (C).

Hypothesis 3 :

Hypothesis 3) Laboratory experiments will have an additive effect to the Mastery Learning method of instruction. Therefore, the class under Mastery Learning method of instruction combined with laboratory experiments will not only score higher than the control group, but will also have the highest mean scores when compared to the Mastery Learning or group using laboratory experiments on the summative test.

To analyze the third hypothesis, two-way analysis of variance and E correlation ratios were used.

Table 9 - Two-Way Analysis of Variance Showing the Effect of Instruction (Mastery Learning), and Laboratory Experiments on Summative Achievement Levels of Students.

Sourceof Variation	Sum of Squares	DF	Mean Square	F	Signifi. Level
Instruction (ML)	478.969	1	478.969	130.971	.000
Lab. Experiments	29.823	1	29.823	8.155	.006
Interaction	.987	1	.987	.270	.605 N.S.
Error	212.109	58	11.834		

The two-way analysis of variance was used to check whether there is any effect due to instruction type (Mastery Learning) and laboratory experiments on achievement levels of students.

Table 9 shows that Mastery Learning has a very strong impact on summative achievement ($F= 130.971$; $p < .000$). Laboratory experiments have also a significant effect ($F = 8.15$; $p < .006$), but it is less than that of Mastery Learning. The table also shows that effect of Mastery Learning on summative achievement is sixteen times greater than that of laboratory experiments ($MS_{instruction} = 478.969$; $MS_{lab.\ exper.} = 29.823$).

In order to show the amount of variance accounted for by each

Table 10 - E Correlation Ratios and the Amount of Variance in Achievement Accounted for by Mastery Learning and Laboratory Experiments; Calculated on the Basis of the Two-Way Analysis of Variance (Table 8)

	E Correlation Ratio	Amount Variance Accounted for (%)
Mastery Leanning and Achivement	.814	66.27 %
Lab. Experiments and Achievement	.203	4.12 %
Multiple E Correlation Ratio	.839	70.39 %

independent variable, E correlation ratios were calculated. Table 10 shows the results of this analysis.

As seen from Table 10, Mastery Learning explains 66.26 % of the variance in summative achievement, whereas laboratory experiments account for 4.13 % of the variance. Mastery Learning explains 16.06 times more of the variance in achievement, in comparison to laboratory experiments.

The percentage of students who reached the 80 % criterion level of achievement on each of formative tests and the summative test is another way of examining the impact of instruction type on students' achievement levels. Table 11 indicates these data.

It is seen that Mastery Learning with laboratory experiments

Table 11 - The Number and Percentage of Students in the Four Groups (ML+LAB, ML, C+LAB, C) Reaching the Criterion Level of Mastery.

Typeof Test	ML+LAB	ML	C+LAB	C
Formative Test 1	16/20 80 %	16/20 80 %	-	-
Formative Test 2	17/20 85 %	16/20 80 %	-	-
Formative Test 3	16/20 80 %	16/20 80 %	-	-
Summative Test	16/20 80 %	12/20 60 %	2/11 18 %	1/11 9 %

(ML+LAB) group has more students who reached the criterion level on all of these learning tasks. This group also enabled 4 / 5 of its students to each the 80 % criterion level of learning, followed by ML group for which this value is 3 / 5. This ratio is very low for both control groups; for C+LAB group, it is about 1 / 5 and for C group, it is less than 1 / 10.

Hypothesis 4:

Hypothesis 4) Students in Mastery Learning and/or Laboratory experiment groups will a have lesser amount of science misconceptions due to their higher achievement levels. Therefore, students of the most successful group will have the least amount of science misconceptions.

The following analyses were used to indicate the effect of instruction type (Mastery Learning) and Laboratory experiments on DEMIT (Density Misconception Test) : One - way analysis of variance, two - way analysis of variance, E correlation ratios, effect size analyses, and the Newman-Keuls formula.

One - way analysis of variance on DEMIT scores of the students

Table 12 - One - Way Analysis of Variance of DEMIT Scores of the Four Groups

Source	DF	MS	F	Signf Level
Between Groups	3	35.5855	6.0310	.0012
Within Groups	58	5.9005		

is shown in Table 12. It indicates that there are significant differences among the four groups in terms of their DEMIT scores at the α = .0012 level.

Newman - Keuls formula was applied to analyze the differences among the groups. Table 13 presents the comparison between DEMIT scores of these groups. The high DEMIT score means less amount of misconceptions held by the students.

Table 13 - Comparison of DEMIT Scores of the Four Groups Using the Newman-Keuls Formula

Class Comparison	DF	MS Error	Calcul. q	Significance Level
ML_{Total}+ C_{Total}	60	5.9000	7.74	$q_{r,\alpha}$ = .01 (3.86)
ML+LAB and ML	58	5.9000	1.70	NS (2.83)
C+LAB and C	58	5.9000	.14	NS (2.83)
ML+LAB and C+LAB	58	5.9000	4.78	$q_{r,\alpha}$ = .01 (4.28)
ML+LAB and C	58	5.9000	4.92	$q_{r,\alpha}$ = .01 (4.70)
ML and C+LAB	58	5.9000	3.08	$q_{r,\alpha}$ = .05 (2.83)
ML and C	58	5.9000	3.22	NS (3.40)

The differences between Mastery Learning groups together (ML+LAB and ML) and control groups together (C+LAB and C) are significant (q = 7.74).

Between Mastery Learning groups themselves, there are no significant differences. The Mastery Learning with laboratory experiments group (ML+LAB), which reached the highest summative achievement, had higher scores than had the ML group, although not significantly so. Similarly, between control groups C+LAB group had a slightly higher score (less amount of misconceptions related to density) on DEMIT than had control (C) group, the difference not being statistically significant.

When Mastery Learning groups are compared with the control groups, it is seen that there are significant differences between the following pairs of groups : (ML+LAB and C+LAB) ; (ML+LAB and C) ; (ML and C+LAB) . However, the difference between (ML and C) groups approaches the significance level ($q = 3.22$).

The difference between Mastery Learning groups themselves, ($q=1.70$), in terms of their DEMIT scores is larger than that of control groups themselves, ($q = .14$). This comparison indicates that when laboratory experiments are used with Mastery Learning method of instruction, their impact on decreasing the amount of misconceptions (getting higher scores on DEMIT) may be stronger than using experiments with traditional methods.

Effect Size Analyses

Table 14 shows the effect sizes among all groups in terms of their DEMIT scores.

Table 14 - Comparison of the Differences on DEMIT Scores of the Four Groups Using Effect Size Analysis

Class Comparison	Mean Difference	Stan. Dev.	Effect Size
ML_{Total} and C_{Total}	2.306	2.589	.89
ML+LAB and ML	1.100	1.927	.57
C+LAB and C	.0909	2.901	.03
ML+LABand C+LAB	3.086	2.378	1.29
ML+LAB and C	3.177	2.901	1.09
ML and C+LAB	1.986	2.378	.83
ML and C	2.077	2.901	.71

The results are parallel to those of Newman - Keuls formula. The largest effect size of 1.29 standard deviations is found between ML+LAB and C+Lab groups. Between Mastery Learning groups themselves, the difference is about .57 standard deviation, whereas between control groups (C+LAB and C), there is only .03 standard deviation difference in terms of their DEMIT scores. It means that the amount of misconceptions held by students of both groups is approximately the same. Between ML+LAB and C+LAB groups, an effect size of 1.09 standard deviations is evident as the second highest effect size. An effect size of .83 standard deviation exists between ML and C+LAB groups. Finally, an effect size of only .71 is obtained between ML and C groups.

The results of all these analyses indicate that the students taught under Mastery Learning with laboratory experiments (ML+LAB) got the highest scores in DEMIT, followed by ML students, followed by C+LAB students, and the lowest scores were obtained by the students of the control group.

In order to understand the effect of instruction type (Mastery Learning) and laboratory experiments on DEMIT scores, a two - way analysis of variance was conducted.

<u>Table 15</u>- Two-Way Analysis of Variance Showing the Effect of Instruction (Mastery Learning), and Laboratory Experiments on DEMIT Scores of Students.

Sourceof Variation	Sum of Squares	DF	Mean Square	F	Signifi. Level
Instruction (ML)	94.611	1	94.611	16.035	.000
Lab. Experiments	8.532	1	8.532	1.446	NS (.234)
Interaction	3.613	1	3.613	.612	NS (.437)
Error	342.227	58	5.900		

In Table 15, it is seen that Mastery Learning has a very significant effect on DEMIT scores ($F = 16.035$; $p < .000$), while no such effect for laboratory experiments exists ($F = 1.446$; $\alpha = .234$ NS).

The E correlation ratios indicate the amount of variance accounted for by each independent variable on the amount of misconceptions.

Table 16 - E Correlation Ratios and the Amount of Variance in DEMIT Scores Accounted for by Mastery Learning and Laboratory Experiments; Calculated on the Basis of the Two-Way Analysis of Variance (Table 14)

	E Correlation Ratio	Amount Variance Accounted for (%)
Mastery Leanning and Achivement	.459	21.06 %
Lab. Experiments and Achievement	.137	1.87 %
Multiple E Correlation Ratio	.478	22.93 %

As seen from Table 16, Mastery Learning accounts for 21.06 % of the variance in DEMIT, whereas laboratory experiments explain 1.87 % of the variance.

In order to analyze the fourth hypothesis, mean scores on summative achievement test and on DEMIT of the groups are presented in Table 5 and 17, respectively. As seen in these tables, Mastery Learning with laboratory experiments (ML+LAB) group had the highest scores on both tests.

As is evident from tables 5 and 17, students of the most successful class (ML+LAB) had the least amount of misconceptions. The control group (C) had the lowest mean from summative achievement test and its mean score on DEMIT was also the lowest one among the DEMIT scores of the four groups.

Table 17 - The Means, Standard Deviations of DEMIT.

Groups	N	Possible Points	$\bar{X}$	s
ML_{Total}	40	14	8.625	2.59
C_{Total}	22	14	6.318	2.58
ML+LAB	20	14	9.450	2.62
ML	20	14	8.350	1.92
C+LAB	11	14	6.363	2.37
C	11	14	6.272	2.90

As a conclusion, order of the groups from the most successful to the least on both tests is the same. Therefore, the fourth hypothesis can be assumed to be confirmed, if the amount of misconceptions related to the concept " density " held by all students was the same before intervention, (an analysis of the DEMIT as a pre-test was not conducted.

The next section deals with the summary and conclusions of this study.

Chapter V

Summary and Conclusions

The summary of the problem, methodology, and the results of this study are presented in this chapter. The conclusions derived from the study and its limitations are also explained.

The Problem

The aim of this study was to investigate the effects of Mastery Learning method of instruction and laboratory experiments on science achievement of 9th grade students and on the amount of misconceptions related to the concept " density ".

It was expected that Mastery Learning raises the achievement level of students one standard deviation above the achievement obtained under traditional instruction. Moreover, Mastery Learning can result in achievement levels up to more than one standard deviations, over control conditions, and approaches to two standard deviations when it is used with other interventions. Therefore, it can be claimed that students taught under Mastery Learning combined with laboratory experiments reach higher achievement levels than students taught under Mastery Learning alone.

Finally, students taught under more effective and efficient nstructional methods may have less amount of science misconceptions due to their high level of understanding.

The instructional topics of this study, mass, volume and density were taught under four different learning environments: (1) Mastery Learning with laboratory experiments (ML+LAB) ; (2) Mastery Learning alone (ML) ; (3) control with laboratory experiments (C+LAB) and finally, control alone (C).

The highest summative achievement and the least amount of misconceptions were expected from ML+LAB group while the control group (C) was expected to have the lowest summative achievement scores and the highest amount of misconceptions.

Methodology

This research was conducted in a private high school in İstanbul, Turkey. There were 64 students in three parallel classes. Of these, 62 participated in this study. These were all 20 of the 21 students of the class that was assigned the ML+LAB group, 20 of the 21 students of the class was called ML group, and 22 students of the class taught under traditional instruction. This class was divided in to two groups. Eleven students in one of these groups conducted experiments in the laboratory and was called control with laboratory experiments (C+LAB). The other half of this class was not engaged in laboratory experiments and was called the control group (C). All classes were instructed by the same teacher.

One year before to the beginning of the study, the instructional topics, mass, volume, and density, were analyzed by the researcher and his advisor. The book "Physical Science " (Polat,R., Arık,A., Ülker,N., İçbudak,I. 1992)was used to set up behavioral objectives related to each of the three learning tasks. After writing behavioral objectives, formative tests to be used under Mastery Learning in order to see whether or not each student who reached the criterion level, were constructed. Parallel formative tests to be used after correctives were also prepared to check the level of students received the first formative test.

By using behavioral objectives, a summative test was constructed as one of the dependent measures of this study.

The second dependent measure, DEMIT (Density Misconception Test) was also constructed by using teaching experiences of the researcher and his findings from different studies done related to science misconceptions. The original form of DEMIT contained 30 multiple- choice and three short-answer type items. This form was given to eighth and ninth grade students of a private high school at İstanbul. According to the results, 14 most appropriate items were selected to be used in the final form of DEMIT.

For the students of Mastery Learning groups, the criterion level of achievement was set at 80 % level of learning for each learning task. The formative tests were used to measure whether or not satisfactory mastery was reached. At the completion of every learning task, a formative test was given to both of the Mastery Learning groups, ML+LAB and ML. If a student could not get the minimum score which was 14 out of 16, he / she was given correctives in the classroom. All students reached the criterion level of learning of 80 % for two learning tasks, mass and volume. But for the third learning task, density, students of the ML group were able to reach the criterion level after the parallel formative test. Students of the control groups were not given either formative tests or correctives.

At the completion of feedback - corrective procedures of the third learning task, a summative achievement test was given to all groups. One day later, DEMIT was also administered to all groups. Summative achievement and the amount of misconceptions were the dependent variables of this study and the groups were compared in terms of these variables by using the summative test and DEMIT scores, respectively.

Results

The purpose of this study was to estimate the effects of Mastery Learning and laboratory experiments on summative achievement and the amount of science misconceptions. Four instructional conditions were used in this study: ML+LAB, ML, C+LAB, and C. The results can be summarized as follows:

1. The four groups were compared in terms of their mean previous semester science grades and mean English grades obtained at end of the English preparatory year. One - way analysis of variance (Table 3,4) showed that there were no significant differences either in their mean previous semester science grades or in the mean grades obtained at the end of English preparatory year, before teaching began.

2. One - way analysis of variance was used to determine whether there was any difference among the four groups in terms of their summative achievement tests (Table 6). According to the results of this analysis, it was found that the differences among these four groups were significant.

3. To see the differences among the means of the four groups, Newman - Keuls formula (Table 6) was used. It was evident that there were significant differences among Mastery Learning groups together (ML_{total}) and control groups together (C_{total}), ($q = 16.15$). While, between two ML groups (ML+LAB and ML), there were no significant differences, between two control groups (C+LAB and C) differences were significant ($q = 3.40$; $p < .05$). When other pairs of groups were compared , very significant differences were found between ML+LAB and C+LAB groups

($q = 10.92$; $p < .01$); ML+LAB and C groups ($q = 14.33$; $p < .01$) which was the largest difference; ML and C+LAB groups ($q = 8.56$; $p < .01$); and finally ML and C groups ($q = 11.96$; $p < .01$). So, the Mastery Learning with laboratory experiments group had the highest achievement scores, followed by the Mastery Learning group, followed by the control with laboratory experiments, and finally by the control group.

4. When effect size analyses (Table 7) were used, it was seen that ML groups together (ML+LAB and ML) achieved 2.56 standard deviations higher than the two control groups (C+LAB and C) taken together. While, this difference between control groups themselves was .96 standard deviation, favoring the C+LAB group, it was .60 standard deviations between ML groups themselves, favoring ML+LAB group. The largest achievement difference was observed between ML+LAB and control (C) with an effect size of 4.05, followed by 3.38 effect size between ML and C, followed by 2.28 between ML+LAB and C+LAB, and finally 1.79 standard deviations between ML and C+LAB groups. These values indicated that the effect of laboratory experiments on summative achievement was stronger in control conditions.

5. A two - way analysis of variance of Mastery Learning and laboratory experiments was carried out to estimate their effects on

summative achievement (Table 8). According to the table, Mastery Learning had a very significant effect on summative achievement (F = 130.971 ; p< .000). Although the effect of laboratory experiments was significant on summative achievement (F = 8.155 ; p < .006), the impact of Mastery Learning on achievement was approximately sixteen times greater than that of laboratory experiments.

6. E correlation ratios (Table 9) indicated that Mastery Learning explained 66.27 % of the variance in science achievement, whereas, laboratory experiments were able to account for 4.12 % of the variance in the achievement.

7. In the Mastery Learning with laboratory experiments group, 4/5 ths of the students reached the 80 % criterion level summative achievement test. Whereas, this ratio was 3/5 for ML, 1/5 for C+LAB, and 1/10 for C group (Table 11). These are the first findings which are exactly equal to the values cited in the theory of Mastery Learning.

8. Table 11 indicated that there were significant differences among the four groups in terms of their DEMIT scores. In order to see the difference between these groups with respect to their DEMIT scores, the Newman - Keuls formula (Table 12) was used. It was evident

that, while there were no significant differences in terms of DEMIT scores between the two ML groups themselves and control groups themselves, there was a very significant difference between the Mastery Learning groups together and and the control groups taken together ($q = 7.74$; $p < .01$). ML+LAB group with the highest DEMIT scores was followed by ML, followed by C+LAB group, and finally by C group.

A two - way analysis of variance (Table 14) was used to assess the effects of Mastery Learning and laboratory experiments on DEMIT scores. According to this table, Mastery Learning had a very significant effect on DEMIT scores ($F = 16.035$; $p < .000$). That is, by using this instructional method some of the science misconceptions could be eliminated, whereas, laboratory experiments did not have any significant effect on DEMIT scores.

E correlation ratios (Table 15) indicated that while laboratory experiments accounted for only 1.87 % of the variance in DEMIT scores, Mastery Learning method of instruction accounted for 21.06 % of this variance. Mastery Learning explained 11.26 times of the variance in DEMIT than did laboratory experiments.

In order to see the differences between the mean scores of four groups on DEMIT, effect size analyses were also used. According to the results, the difference between ML+LAB and ML (.57 standard deviation) is larger than that of between control groups (.03 standard deviation).

If the effect size between Mastery Learning groups was larger and laboratory experiments had a very weak impact on DEMIT, we can conclude that the impact of laboratory experiments reached its maximum point under Mastery Learning method of instruction.

Limitations and Suggestions for Further Research

One of the main limitations of this study is that students of four groups were not given a pre - test related to density misconception. It could have been that the amount of misconceptions about the concept of density held by students may have been different from each other at the pre-test level as was found at the end of this intervention. Therefore, the analyses conducted to show the effect of instruction type and laboratory experiments may not have reflected the real situation.

The second limitation is that laboratory experiments were standard for each student. If they were designed with respect to needs of students, perhaps, they would have more impact on the achievement and conceptualization levels of students.

One of the strengths of this study was that all four groups were taught by the same teacher. Therefore, teacher effects were well controlled. Despite of using the same teacher for the four groups, Mastery Learning groups achieved better than control groups.

If the limitations are remedied in further research, the results may be more useful.

Conclusions

The findings of this study indicate that Mastery Learning results in mean achievement of 14.5 out of 18 points (80 out of 100 points). This criterion level was reached by 4/5 ths of the students in ML+LAB group and 3/5 ths of the students in ML group.

The achievement level of Mastery Learning groups taken together is 2.56 standard deviations above the achievement level obtained under traditional instruction groups (Table 7). The largest difference between ML+LAB and C groups is 4.05 standard deviations in favor of ML+LAB group, and the smallest difference between ML and C+LAB groups is 1.79 standard deviations favoring ML group.

Mastery Learning has more impact on achievement than laboratory experiments. The effect of Mastery Learning 16.06 times greater than that of laboratory experiments. It is seen that Mastery Learning is a better predictor of achievement than laboratory experiments, but laboratory experiments have more impact on the achievement when they are used with traditional methods. The difference between the two groups, when laboratory experiments are implemented, is .60 standard deviations under Mastery Learning and .96 standard deviation for control conditions, favoring the groups with laboratory experiments (Table 7).

Beyond its effectiveness on summative achievement, Mastery Learning is capable of explaining the amount of misconceptions held by students. The most successful group on summative achievement test, ML+LAB, got the highest mean scores on DEMIT. That is, the most successful students who were taught under ML+LAB had the least amount of misconceptions related to density.

It seems that further research is needed to test whether Mastery Learning can be used as a method to prevent misconceptions related to science, although it is an efficient instructional method. Therefore, we also need to design and conduct many research strategies to investigate and test new methods to treat science misconceptions.

Laboratory experiments in this study were conducted in small groups (3 or 4 students together). They may be more functional to increase students' achievement and conceptualization levels, if each experiment is conducted individually to remediate the initially identified science misconceptions. This study is only a beginning in the area of the impacts of different instructional methods, and " hands-on" experiments on achievement as well as science misconceptions.

References

Abraham,M.R., Gryzbowski,E.B.,Renner,J.W.,Marek,E.A.(1992).Understandings and Misunderstandings of 8th Graders of Five Chemistry Concepts Found in Textbooks. Journal of Research in Science Teaching ,29,2,105-120.

Afreşa,O.(1983).The Effects of Mastery Learning and Traditional Learning Methods on Achievement and Retention of Fifth Grade Turkish Primary School Students in Science. Unpublished Master's Thesis.İstanbul ,Boğaziçi University,Department of Ed ucational Sciences.

Ausebel ,D.P. (1968).Educational Psychology.New York :Holt,Rinehart and Winston.In Hofstein,A. ,Lunetta,N.V.(1982).The Role of the Laboratory in Science Teaching:Neglected Aspects of Research.Review of Educational Research, 52 ,(2) ,201-207.

Block,J.H. (1971).Mastery Learning : Theory and Practice.New York :Holt,Rinehart and Winston.In Yıldıran,G.(1988).1985 Yılı Öğretmenler Günü Konuşması.Boğaziçi University Jounal , 13 , 47-64.

Bloom,B.S.(1968).Learning for Mastery. UCLA-Center for Study Evaluation of Instructional Programs, Evaluation Comment 1, 2.

Bloom,B.S.(1976). Human Characteristics and School Learning .New York:Mc Grow- Hill Book Company.

Bloom,B.S.(1978).New Views of the Learner:Implications for Instruction and Curriculum. Educational Leadership,4,563-576.

Çetin,E.F.(1988).The Effects of University Prepatory Courses and Mastery Learning on Final Achievement Test Scores and University Entrance Examination Scores of Seniors in a Turkish High School.Unpublished master's thesis,İstanbul,Department of Educational Sciences,Boğaziçi University,Turkey.

Dillashow ,F.G.,Okey,J.R.(1983)Effects of Modified Mastery Learning Strategy on Achievement ,Attitudes,and On-task Behavior of High School Chemistry Students.Journal of Research in Science Teaching, 20 ,203-211. In Guskey,T.R.,Pigott,T.D.(1988).Research on Group Based Mastery Learning Programs:A Meta Analysis.Journal of Educational

Research, 81 ,(4),197-196.

Fisher,K.(1985).A Misconception in Biology:Amino Acids and Translation.Journal of Research in Science Teaching,22 ,53-62.

Hammer,D.(1989).Two Approaches to Learning Physics.Physics Teacher,27,9,664-670.

Hancock,C.H.(1940).An Evaluation of Certain Popular Science Misconceptions.Science Education ,208-213.

Hewson , P.W., Hewson,M.G.(1981).Effect of Instruction Using Students' Prior Knowledge and Conceptual Change Strategies on Science Learning.Part II:Analysis of Instruction.Paper presented at the Annual Meeting of the National Research in Science Teaching,New York,April,5-8.

Hewson,M.G.(1986).The Acquisition of Scientific Knowledge :Analysis and Representation of Student Conceptions Concerning Density.Science Education,70,2,159-170.

Hynd,C.R, Alvermoon,D.E.(1989) .Overcoming Misconceptions in Science:An on-line Study of Prior Knowledge Activation.Reading Research and Instruction,28,4,12-26.

İSEM Dershanesi Kılavuzu.(1993).ÖYS Meslekler Tercih Rehberi,İstanbul.

Marek,E.A (1986).They Misunderstand ,But They'll Pass.The Science Teacher, 53 ,(9),32-35

Nwabueze,B.,Yıldıran,G.(1991).The Effects of Mastery Learning and Improved Teaching on Mathematics Achievement of Seventh Grade Turkish Students.Boğaziçi University Journal,14 ,111-121.

Odubunmi,O.,Bologun,T.A.(1991).The Effects of Laboratory and Lecture Teaching Methods on Cognitive Achievement in Integrated Science.Journal of Research in Science Teaching, 28 , (3),213-224.

Osborne,R.J.,Cosgrove,M.M.(1983).Children's' Conceptions of the Changes of State of Water.Journal of Research in Science Teaching, 20 ,(9), 825-838.

Polat,R., Arık,A., Ülker,N., İçbudak,İ.(1992).Physical Science. İstanbul, Oran Yayıncılık.

Saxena,A.B.(1992).An Attempt to Remove Misconceptions Related to Electricity.International Journal of Science Education, 14,(2),157-162.

Sayar, Y.(1986) The effects of Mastery Learning and the Possession of Necessary Prerequisites on Achievement of Turkish Students Studying English as a Second Language .Unpublished master's thesis,Department of Educational Sciences,Boğaziçi University,Turkey.

Shepperd,L.D.& Renner,W.J.(1982).Student Understandings and Misunderstardings of States of Matter and Density Changes.School Science and Mathematics, 82 ,(8),650-655.

Shulman,L.D. & Tamir ,P. (1973).Research on Teaching in the Natural Sciences.In R.M.W Travers(1973) ,Second Handbook of Research on Teaching .Chicago :Rand Mc Nally

Solomon,J.,Longden,K.,Black,p.(1991).Children's Interpretation of Dissolving.International Journal of Science Education, 13,(1),59-68.

Stavy,R.(1991).Using Analogy to Overcome Misconceptions About Conservation of Matter.Journal of Research in Science Teaching, 28 ,(4),305-313.

Tennebaum,G.(1982).A Method of group Instruction Which is as Effective as One-to-one Tutorial Instruction.Unpublished Doctoral Dissertation,University of Chicago. In Guskey,T.R.,Pigott,T.D.(1988).Research on Group Based Mastery Learning Programs:A Meta Analysis.Journal of Educational Research, 81 ,(4),197-216.

Yıldıran,G.(1977). The Effects of Level of Cognitive Achievement on Selected Learning Criteria Under Mastery Learning and Normal Classroom Conditions.Unpublished Ph.D. Dissertation,Chicago,The University of Chicago.

Yontar,A.(1989).The Effect of Grade and Logical Reasoning Ability on Conceptualizations Related to Selected Science Concepts of 5th,8th and 11th Grade Students.Unpublished Ph.D. Dissertation, Ankara,Metu,Department of Science Education.

Yvonne,J.M.(1992).Using the Lab Experiences to Develop the Scientific Literacy.School Science and Mathematics ,92, (8),437-441.

Za'rour,G.I.(1975)Science Misconceptions Among Certain Groups of Students in Lebanon. Journal of Research in Science Teaching,12 , (4),385-391.

Appendices

Appendix I

Objectives

Learning Task 1: Mass

Learning Task 2: Volume

Learning Task 3: Density

Learning Task 1 - MASS

1) The student will be able to define mass.

2) The student will be able to state the relation between units of mass.

3) The student will be able to perform the conversions of mass units.

4) The student will be able to analyze a situation in terms of conservation of mass.

Learning Task 2 - VOLUME

1) The student will be able to explain volume.

2) The student will be able to state the relation between units of volume.

3) The student will be able to perform the conversions of units of volume.

4) The student will be able to identify the formulas of volume of regular solids.

5) The student will be able to calculate the volume of the regular solids.

6) The student will be able to calculate the volume of irregular solids.

Learning Task 3- DENSITY

1) The student will able to define density.

2) The student will be able to calculate the density of a substance with a given mass and volume.

3) The student will be able to compare the densities of substances with the same mass and different volumes.

4) The student will be able to compare the densities of two substances with different masses and same the volume.

5) The student will be able to compare the densities of two substances with different masses and volumes.

6) The student will be able to compare the density of a substance at different temperatures.

7) The student will be able to calculate the density of a mixture.

Appendix II

Tests

Formative Tests

Formative Tests 1A / 1B

Formative Tests 2A / 2B

Formative Tests 3A / 3B

Summative Test

Formative Tests and Summative Test

Formative Test 1 A

1) The student will be able to define mass.

F 1 A 1) The constant quantity of matter in a body is

a) space.

(b) volume.

c) mass.

d) weight.

F 1 A 2) Choose a pair of the following which is dependent on temperature.

a) volume & mass.

b) heat & weight.

(c) weight & mass.

d) heat & volume.

2) The student will be able to state the relation between units of mass.

F 1 A 3) 1000 gram equals to

a) 100 kilogram

b) 10 kilogram

(c) 1 kilogram

d) .1 kilogram

F 1 A 4) 1 miligram equals

a) 1000 kilogram

b) 1000 gram

(c) .001 kilogram

d) .001 gram

3) The student will be able to perform the conversions of mass units.

F 1 A 5) 2356 kgr equals to

a) 235.6 gr.

b) 23.56 gr.

(c) 2.356 gr

d) .2356 gr.

F 1 A 6) 5400 miligram is equal to

(a) 5.4 gr

b) 54 gr

c) 540 gr

d) 5400 gr

4) The student will be able to analyze a situation in terms of conservation of mass.

F 1 A 7) In all changes, total mass before and after the change is

a) constant at the same temperature.

b) different at the same temperature.

(c) constant at all temperatures.

d) different at all temperatures.

F 1 A 8) If a piece of iron burns, the mass of the burned iron will be

a) less than the original mass of iron but different than zero.

b) less than the original mass of iron and equal to zero.

c) more than the original mass of iron.

d) equal to the original mass of iron.

Formative Test 1 B

1) The student will be able to define mass.

F 1 B 1) Mass is the

a) occupied space by matter in a body.

b) quantity of space in a body.

c) quantity of matter in a body.

d) quantity of molecule in a body.

F 1 B 2) The mass of a body is

a) independent of temperature & dependent of matter.

b) dependent of temperature & independent of heat.

c) independent of heat & independent matter.

d) dependent of heat & dependent of temperature.

2) The student will be able to state the relation between units of mass.

F 1 B 3) 1 kilogram equals to

a) 100 gram

b) 100 milligram

c) 1000 gram

d) 1000 milligram

F 1 B 4) 1 gram equals to

a) .01 milligram

b) .001 kilogram

c) 100 milligram

d) 10 kilogram

3) The student will be able to perform the conversions of mass units.

F 1 B 5) 518 milligram equals to

a) .518 gram

b) .518 kilogram

c) 518000 gram

d) 518000 kilogram

F 1 B 6) 1750 gram equals to

a) 4/9 kilogram

b) 4/7 milligram

c) 9/4 milligram

d) 7/4 kilogram

4) The student will be able to analyze a situation in terms of conservation of mass.

F 1 B 7) Which one of the following is always conserved at all temperatures ?

(a) mass

b) volume

c) pressure

d) heat

F 1 B 8) When a piece of aluminum burns, the mass of the burned aluminum will be

a) less than the original mass of aluminum.

(b) more than the original mass of aluminum.

c) equal to original mass of aluminum.

d) approximately equal to zero.

Formative Test 2 A

1) The student will be able to explain volume.

F 2 A 1) Volume is

a) dependent of mass & independent of temperature.

b) independent of mass & independent of temperature

c) dependent of mass & dependent of temperature.

(d) independent of mass & dependent of temperature.

F 2 A 2) Volumes of solids & liquids are

a) definite & independent of heat

b) indefinite & independent of heat

(c) definite & dependent of heat

d) indefinite & dependent of heat

2) The student will be able to state the relation between units of volume.

F 2 A 3) 1000 cm^3 equals to

a) 1 mm^3

(b) 1 dm^3

c) 10 mm^3

d) 10 dm^3

F 2 A 4) 1 mililiter equals to

a) 1000 dlt

b) 1000 dm^3

(c) 1 cm^3

d) 1 Lt

3) The student will be able to perform the conversions of units of volume.

F 2 A 5) 7745 ml equals to

a) 77.45 mm^3

(b) 7745 cm^3

c) 774.5 dm^3

d) .7745 lt

F 2 A 6) 486 dm^3 equals to

(a) 486 lt

b) 486 ml

c) 4.86 cm^3

d) 4.86 mm^3

4) The student will be able to identify the formulas of volume of regular solids.

F 2 A 7) Volumes of a prism and a cube are

a) $V = a^2$ and $V = a.b$ respectively.

b) $V = a^3$ and $V = a.r^2$ respectively.

c) $V = a.b^2$ and $V = a^4$ respectively.

(d) $V = a.b.c$ and $V = a^3$ respectively.

F 2 A 8) Formula of the volume of sphere is

a) $4\Pi r^2$

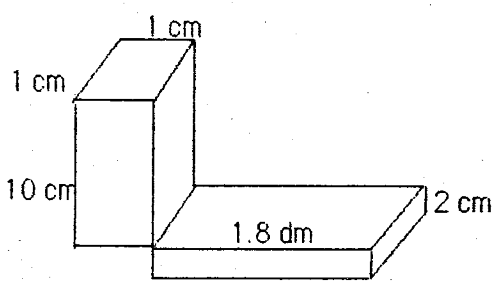
b) $(3/4)\Pi r^3$

c) $3\Pi r^2$

d) $(4/3)\Pi r^3$

5) The student will be able to calculate the volume of the regular solids.

F 2 A 9) What is the volume of the following figure?



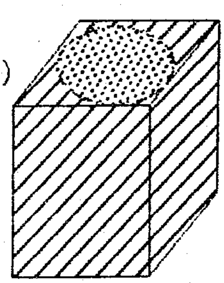
a) 3.6 cm^3

b) 102 cm^3

c) 46 cm^3

d) 75 cm^3

F 2 A 10)



A cylinder is cut from a cube. If one side of the cube is " a " cm , what is the volume of the box shown in the figure in terms of " a " ?

a) $a^2 * (1 - \pi/2)$

b) $a^3 * (2 - \pi)/2$

c) $a^2 * (1 - \pi/4)$

d) $a^3 * (4 - \pi)/4$

6) The student will be able to calculate the volume of irregular solids.

F 2 A 11) When a stone is put in a graduated cylinder water level rises 20 cm. The volume of the stone is

a) 20 cm.

(b) 20 cm^3.

c) 10 cm.

d) 10 cm^3.

F 2 A 12) A volume of 40 cm^3 of dry sand is added to 20 cm^3 of water for a total volume of 50 cm^3. What are the volumes of sand particles alone and of the air spaces between the sand particles?

	sand alone(cm^3)	air(cm^3)
a)	40	-
(b)	30	10
c)	20	20
d)	10	30

Formative Test 2 B

1) The student will be able to explain volume.

F 2 B 1) Which one of the following is dependent on temperature and independent of mass?

(a) volume

b) inertia

c) density

d) solubility

F 2 B 2) Volumes of gases are

a) indefinite & independent of heat

(b) indefinite & dependent of heat

c) definite & independent of heat

d) definite & dependent of heat

2) The student will be able to state the relation between units of volume.

F 2 B 3)10 ml is equal to

a) 100 cm3

b) 1000 mm3

(c) .001 lt

d) .01 dm3

F 2 B 4) 1 liter equals to

a) 100 mm3

b) 100 cm3

c) 1000 mm3

d) 1000 cm3

3) The student will be able to perform the conversions of units of volume.

F 2 B 5) 457 dm3 equals to

a) 457000 mm3

b) 457000 ml

c) 45.7 cm3

d) 45.7 m3

F 2 B 6) 35.88 mm3 is equal to

a) .03588 ml

b) 3.588 cm3

c) 3588 lt

d) .003588 dm3

4) The student will be able to identify the formulas of volume of regular solids.

F 2 B 7) Volumes of a cylinder and a sphere are

a) $V = 4/3.\Pi .r^2$ and $V = \Pi .r^3.h$

b) $V = 3/4.\Pi .r^3$ and $V = \Pi .r^3.h$

c) $V = \Pi .r^2.h$ and $V = 4/3.\Pi .r^3$

d) $V = \Pi .r.h$ and $V = 4/3.\Pi .r^3$

F 2 B 8) What is the volume of a prism?

a) $V=a.b$

b) $V=a.b.c$

c) $V=a.b^2$

d) $V=a^2.b^2$

5) The student will be able to calculate the volume of the regular solids.

F 2 B 9) Outer and inner radii of an iron sphere are 5 cm and 3 cm, respectively. How many cm^3 of iron are there in the sphere? ($\pi = 3$)

a) 500

b) 464

c) 536

d) 392

F 2 B 10) A cylinder with a radius of 5 cm and a height of 10 cm is cut from a cube which has 10-cm sides .What is the volume of the remaining part ?

a) 750

b) 250

c) 650

d) 500

6) The student will be able to calculate the volume of irregular solids.

F 2 B 11) Volume of an irregular solid is 3.5 cm^3 .What will be the change in water level, when it is put in a graduated cylinder?

a) 3.5 cm^3.

b) 7.0 cm^3.

c) 3.5 cm .

d) 7.0 cm .

F 2 B 12) A volume 35 cm^3 dry sand is added to some amount of alcohol to form a total volume of 55 cm^3 .If the volume of air between sand particles is 8 cm^3. What are the volume of sand alone and alcohol ?

	alcohol(cm^3)	sand alone(cm^3)
a)	28	27
b)	27	28
c)	17	38
d)	38	17

Formative Test 3 A

1) The student will able to define density.

F 3 A 1) The density of a substance is

(a) mass / volume

b) volume / mass

c) weight / volume

d) volume /weight

F 3 A 2) The density of a substance

a) increases as temprature rises.

b) increases as the amount of substance increases.

(c) decreases as the temperature rises.

d) decreases as the amount of substance decreases.

2) The student will be able to calculate the density of a substance with a given mass and volume.

F 3 A 3) The volume of an object is 20 cm^3 and it is 210 gram. What is its density ?

a) 1 / 10.5

b) 1 /105

(c) 10.5

d) 105

F 3 A 4) The density of an object is an 2.5 gr/cm^3 .What is the mass of 250 cm^3 of this object?

a) 100

b) 10

c) 625

d) 62.5

3) The student will be able to compare the densities of substances with the same mass and different volumes.

F 3 A 5) At the same temperature,the volume of the object A is half of the volume of the object B. If their masses are equal, then,

a) the density of A = the density of B.

b) the density of A = twice the density of B.

c) twice the density of A = the density of B.

d) information is not eneough to decide.

F 3 A 6) 50 gram of aliminum powder is added to another 50 gram of that powder. If the initial density of the aliminum powder is 2.5 gr/cm^3 after addition the density of aliminum powder will be

a) 5.00

b) 7.50

c) 1.25

d) 2.50

4) The student will be able to compare the densities of two substances with different masses and same the volume.

F 3 A 7) The mass of a liquid is twice the mass of the other one. If the volume of the first one is one-third of the other's , what will be the relation between their densities ?

a) $3d_1 = 2d_2$

(b) $d_1 = 6d_2$

c) $2d_1 = 3d_2$

d) $6d_1 = 3d_2$

5) The student will be able to compare the densities of two substances with different masses and volumes.

F 3 A 8)

$V_1 = 2V$	$V_2 = 3V$	$V_3 = V/4$	$V_4 = 6V$
$m_1 = 6M$	$m_2 = M/4$	$m_3 = 3M$	$m_4 = 2M$

What is the order of densities of these objects?

a) $d_1 < d_2 < d_3 < d_4$

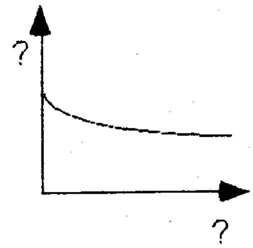
b) $d_2 < d_3 < d_4 < d_1$

(c) $d_2 < d_4 < d_1 < d_2$

d) $d_1 < d_4 < d_2 < d_3$

6) The student will be able to compare the density of a substance at different temperatures.

F 3 A 9) What kind of relationship is indicated in the graph?



(a) density-temperature
b) density-volume
c) temperature-density
d) volume-density

F 3 A 10) Choose the correct statement:

The density of a pure substance...

(a) remains constant for a spesific temperature.

b) increases sharply as .3 the temperature decreases.

c) decreases slightly as the temperature decreases.

d) is unrelated with the temperature.

7) The student will be able to calculate the density of a mixture.

F 3 A 11) Equal volumes of liquids A and B are mixed to obtain the mixture AB. If the densities of liquids A and B 3.4 and 5.0 g/cm^3, respectively, what is the density of the mixture AB?

a) 3.4 g/cm^3

b) 3.8 g/cm^3

(c) 4.2 g/cm^3

d) 4.6 g/cm^3

F 3 A 12) When 8 liters of gas A with a density of 0.5 g/l and gas Z with a density of 2.0 g/l are mixed, the density of the mixture is found to be 1.5 g/l. What is the volume of Z used to prepare the mixture?

a) 2 g/l.

b) 4 g/l.

c) 8 g/l.

(d) 16 g/l.

Formative Test 3 B

1) The student will able to define density.

F 3 B 1) The density of a substance is the ratio of

a) weight to volume.

b) volume to weight.

(c) mass to volume.

d) volume to mass.

F 3 B 2) The density of an object increases as

a) the amount of substance increases.

b) the amount of substance decreases.

c) temperature increases.

(d) temperature decreases.

2) The student will be able to calculate the density of a substance with a given mass and volume.

F 3 B 3) Calculate the density of a 200 gram object which has a volume of $400\ cm^3$.

a) 2 g/cm^3

(b) 0.5 g/cm^3

c) 20 g/cm^3

d) 5 g/cm^3

F 3 B 4) The density of an object is 5 gr/cm3 .What volume of it weighs 300 gr ?

a) 1500

(b) 60

c) 150

d) 6

3) The student will be able to compare the densities of substances with the same mass and different volumes.

F 3 B 5) At the same temperature, the volume of the object A is twice the volume of the object B. If their masses are equal then,

(a) the density of A = half of the density of B.

b) The density of A = the density of B.

c) half of the density of A = the density of B.

d) information is not enough to decide.

F 3 B 6) One of the volumes of two 20-gram liquid samples is equal to 40 ml. If sum of the volumes of the liquids are 120 ml. What is the relationship between their densities?

(density of 40-ml liquid is D1,density of the other one is D2)

a) D1= D2

b) D1= 2D2

c) D1= 3D2

d) D1= 4D2

4) The student will be able to compare the densities of two substances with different masses and same the volume.

F 3 B 7) The volume of an object is four times the volume of the other.If the mass of the first one two-fifth of the mass of the second, what will be the relation between their densities?

a) $8d_1 = 5d_2$

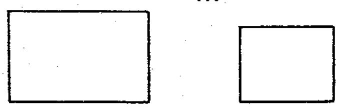
b) $5d_1 = 8d_2$

c) $10d_1 = d_2$

d) $d_1 = 10d_2$

5) The student will be able to compare the densities of two substances with different masses and volumes.

F 3 B 8) I. II.



$m_1 = 2M$ $m_2 = 4M$

$v_1 = 4V$ $v_2 = 2V$

III. IV.

$m_3 = M/4$ $m_4 = M/2$

$v_3 = V/2$ $v_4 = V/4$

Compare the densities of these objects.

a) d1 < d2 < d3 < d4

b) d1 > d2 > d3 > d4

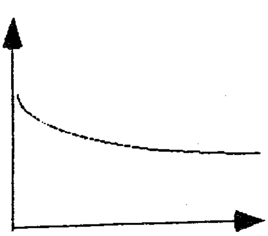
c) d1 = d2 < d3 = d4

d) d1 = d3 < d2 = d4

6) The student will be able to compare the density of a substance at different temperatures.

F 3 B 9) What kind of relationship is shown in the graph?

a) d-T
b) d-V
c) T-d
d) V-d



F 3 B 10) The density of a pure substance...

a) increases slightly as the temperature increases.

(b) increases slightly as the temperature decreases.

c) decreases slightly when the temperature is constant.

d) remains constant for all temperatures.

7) The student will be able to calculate the density of a mixture.

F 3 B 11) Equal volumes of the liquids X and Y are mixed to prepare the mixture XY. If the densities of the liquids are 2.6 and 3.2 gr/cm^3, respectively, the density of the mixture XY is

a) 2.8 g/cm^3

(b) 2.9 g/cm^3

c) 3.0 g/cm^3

d) 3.1 g/cm^3

F 3 B 12)Of 400 gr of alcohol is mixed with 300 gr of an unknown liquid,the density of the mixture is 1.0 gr/cm3.What is the density of the unknown liquid? (density of alcohol is 0.8 gr/cm3)

a) 1.5 gr/cm^3

(b) 3.5 gr/cm^3

c) 0.5 gr/cm^3

d) 2.5 gr/cm^3

Summative Test

F II Objective 1) The student will be able to explain volume.

1) (Taken from F II B 1)

Which one of the following is dependent on temperature and independent of mass?

a) volume

b) inertia

c) density

d) solubility

F II Objective 1) The student will be able to explain volume.

2) (Taken from F II B 2)

Volumes of gases are

a) indefinite & independent of heat

b) indefinite & dependent of heat

c) definite & independent of heat

d) definite & dependent of heat

F II Objective 3) The student will be able to perform the conversions of units of volume.

3) (Taken from F II A 5)

7745 ml equals to

a) 77.45 mm3

(b) 7745 cm3

c) 774.5 dm3

d) .7745 lt

F II Objective 3) The student will be able to perform the conversions of units of volume.

4) (Taken from F II B 6)

35.88 mm3 is equal to

(a) .03588 ml

b) 3.588 cm3

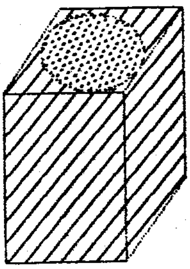
c) 3588 lt

d) .003588 dm3

F II Objective 5) The student will be able to calculate the volume of the regular solids.

5) (Taken from F II A 10)

F 2 A 10)



A cylinder is cut from a cube. If one side of the cube is " a " cm , what is the volume of the box shown in the figure in terms of " a " ?

a) $a^2 * (1 - \pi/2)$
b) $a^3 * (2 - \pi) /2$
c) $a^2 * (1 - \pi/4)$
(d) $a^3 * (4 - \pi) /4$

F II Objective 6) The student will be able to calculate the volume of irregular solids.

6) (Taken from F II B 12)

A volume 35 cm^3 dry sand is added to some amount of alcohol to form a total volume of 55 cm^3 .If the volume of air between sand particles is 8 cm^3. What are the volume of sand alone and alcohol ?

	alcohol(cm^3)	sand alone(cm^3)
(a)	28	27
b)	27	28
c)	17	38
d)	38	17

F I Objective 1) The student will be able to define mass.

7) (Taken from F I B 1)

Mass is the

a) occupied space by matter in a body.

b) quantity of space in a body.

c) quantity of matter in a body.

d) quantity of molecule in a body.

F I Objective 1) The student will be able to define mass.

8) (Taken from F I B 2)

The mass of a body is

a) independent of temperature & dependent of matter.

b) dependent of temperature & independent of heat.

c) independent of heat & independent matter.

d) dependent of heat & dependent of temperature.

F III Objective 3) The student will be able to perform the conversions of mass. units.

9) (Taken from F I B 6)

1750 gram equals to

a) 4/9 kilogram

b) 4/7 milligram

c) 9/4 milligram

d) 7/4 kilogram

F I Objective 4) The student will be able to analyze a situation in terms of conservation of mass.

10) (Taken from F I A 8)

If a piece of iron burns,the mass of he burned iron will be

a) less than the original mass of iron but different than zero.

b) less than the original mass of iron and equal to zero.

c) more than the original mass of iron.

d) equal to the original mass of iron.

F III Objective 1) The student will able to define density.

11) (Taken from F III A 2)

The density of a substance

a) increases as temprature rises.

b) increases as the amount of substance increases.

c) decreases as the temperature rises.

d) decreases as the amount of substance decreases.

F III Objective 2) The student will be able to calculate the density of a substance with a given mass and volume.

12) (Taken from F III B 4)

The density of an object is an 2.5 gr/cm^3 ·What is the mass of 250 cm^3 of this object?

a) 100

b) 10

c) 625

d) 62.5

F III Objective 3) The student will be able to compare the densities of substances with the same mass and different volumes.

13) (Taken from F III A 5)

At the same temperature,the volume of the object A is half of the volume of the object B. If their masses are equal, then,

a) the density of A = the density of B.

b) the density of A = twice the density of B.

c) twice the density of A = the density of B.

d) information is not eneough to decide.

F III Objective 4) The student will be able to compare the densities of two substances with different masses and same the volume.

14) (Taken from F III B 11)

Equal volumes of the liquids X and Y are mixed to prepare the mixture XY. If the densities of the liquids are 2.6 and 3.2 gr/cm^3, respectively. So, the density of the mixture XY is

a) 2.8 g/cm^3

b) 2.9 g/cm^3

c) 3.0 g/cm^3

d) 3.1 g/cm^3

F III Objective 7) The student will be able to calculate the density of a mixture.

15) (Taken from F III B 12)

Of 400 gr of alcohol is mixed with 300 gr of an unknown liquid,the density of the mixture is 1.0 gr/cm3.What is the density of the unknown liquid?

(density of alcohol is 0.8 gr/cm3)

a) 1.5 gr/cm^3

b) 3.5 gr/cm^3

c) 0.5 gr/cm^3

d) 2.5 gr/cm^3

F III Objective 2) The student will be able to calculate the density of a substance with a given mass and volume.

16) (Taken from F III B 4)

The density of an object is 5 gr/cm^3 .What volume of it weighs 300 gr ?

a) 1500

b) 60

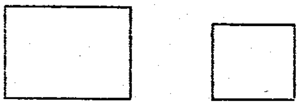
c) 150

d) 6

F III Objective 5) The student will be able to compare the densities of two substances with different masses and volumes.

17) (Taken from F III B 8)

I. II.



$m_1 = 2M$ $m_2 = 4M$

$v_1 = 4V$ $v_2 = 2V$

III. IV.

$m_3 = M/4$ $m_4 = M/2$

$v_3 = V/2$ $v_4 = V/4$

Compare the densities of these objects.

a) d1 < d2 < d3 < d4

b) d1 > d2 > d3 > d4

c) d1 = d2 < d3 = d4

d) d1 = d3 < d2 = d4

F III Objective 3) The student will be able to compare the densities of substances with the same mass and different volumes.

18) (Taken from F III A 6)

50 gram of auiminum powder is added to another 50 gram of that powder. If the initial density of the aluminum powder is 2.5 gr/cm^3 after addition the density of aluminum powder will be

a) 5.00

b) 7.50

c) 1.25

d) 2.50

Appendix III

DEMIT

Density Misconception Test

1)

(1) 10-gram-milk | (2) 30-gram-milk | (3) 20-gram-milk | (4) 40-gram-milk

(5) mixture of (1) and (2) | (6) mixture of (3) and (4)

Compare the densities of milk samples in these six beakers.

a) $d_1 < d_2 < d_3 < d_4 < d_5 < d_6$

b) $d_1 > d_2 > d_3 > d_4 > d_5 > d_6$

c) $d_1 = d_2 = d_3 = d_4 = d_5 = d_6$

d) $d_1 = d_2 = d_3 = d_4 < d_5 = d_6$

2) **If 1-liter of a liquid is added to 1-liter of the same liquid, its density will be**

a) twice the original density.

b) same with the original density.

c) half of the original density.

d) four times the original density.

3) A 20-cm^3 of an acid solution is added to 40-cm^3 of the same acid solution. If the density of the mixture is 1.8, what are the densities of 20-cm^3 and 40-cm^3 acid solutions?

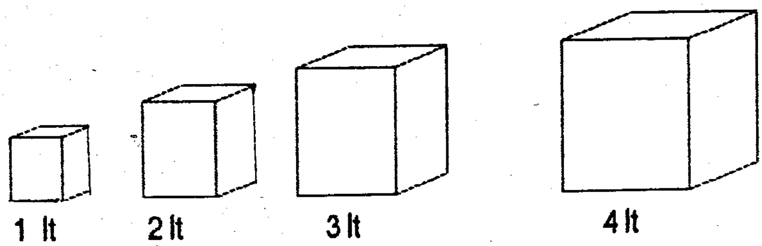
	20-cm^3 acid solution	40-cm^3 acid solution
a)	0.9	0.9
b)	0.6	1.2
c)	1.8	1.8
d)	1.2	2.4

4)

100 cm^3 vinegar is divided into 20,30, and 50 cm^3 beakers. If the density of 100 cm^3 vinegar is 0.5 gr/cm^3, what will be densities of the vinegar in 20,30 and 50 cm^3 beakers?

	20 cm^3	30 cm^3	50 cm^3
a)	0.10	0.15	0.25
b)	0.20	0.30	0.50
c)	0.25	0.25	0.25
d)	0.50	0.50	0.50

5)



Four boxes of equal masses, with volumes 1liter, 2 liters, 3 liters, 4 liters,respectively. Put their densities in order.

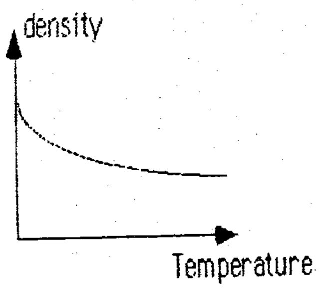
a) $d_1 < d_2 < d_3 < d_4$

b) $d_2 < d_1 < d_4 < d_3$

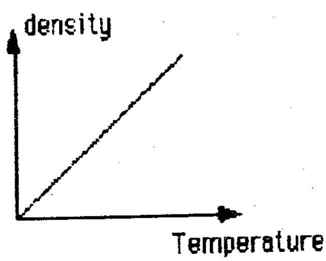
ⓒ $d_1 > d_2 > d_3 > d_4$

d) $d_1 = d_2 = d_3 = d_4$

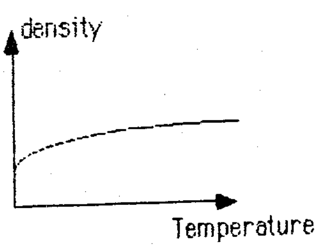
6) **Which of the following graphs shows density-temperature relationship of a liquid? (Between the freezing and boiling points.)**



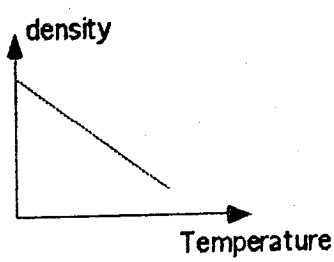
ⓐ



b)

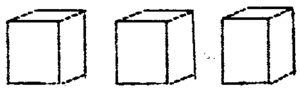


c)



d)

7)



V, T_1 V, T_2 V, T_3

There are three different liquids in the same volume of boxes. Compare their densities ($T_1 > T_2 > T_3$).

a) $d_1 = d_2 = d_3$

b) $d_1 > d_2 > d_3$

c) $d_1 < d_2 < d_3$

(d) there is not enough information.

8) **Ice floats in water, because water**

a) is heavier than ice.

b) has less volume than ice.

c) is hotter than ice.

(d) is more dense than ice.

9) **Equal volumes of two different solids are put into two beakers which are full of water. Compare the amount of displaced water in these beakers(Solids are not soluble in water.)**

(a) $V_1 = V_2$

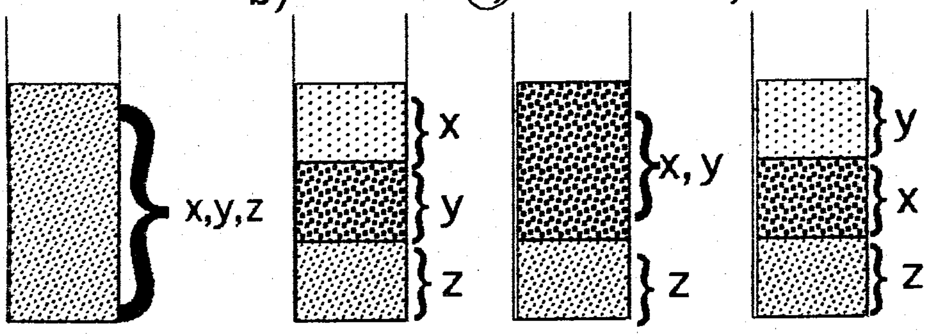
b) $V_1 > V_2$

c) $V_1 < V_2$

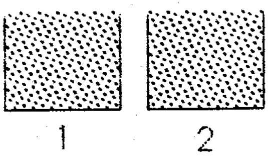
d) can not be compared.

10) Three liquids x,y,z with densities $d_x = d_y < d_z$ are put into a test tube. The test tube is shaked strongly and it is left aside for a moment. What will be the place of each liquid in the test tube?

a) b) c) d)



11) Two beakers are full of water. Objects A and B with equal masses are put into beakers (1) and (2),



respectively. Object A displaces more water than object B. Because

a) A is heavier than B.

b) A has more volume than B.

c) A is more dense than B.

d) A contains more air than B.

12) **A sheet of aluminum and an aluminum bead with equal volumes are put into water. Which one/s will sink?**

a) Only the bead will sink, because it is heavier than the sheet.

b) Only the bead will sink, because it is more dense than the sheet.

c) Both will sink, because both of them are heavier than water.

d) Both will sink, because both of them are more dense than water.

13) **You will sink more in a swimming pool than being in the sea while you are swimming. Because**

a) there are more water in the sea than the pool.

b) attractive force of water is greater than of the salty water.

c) density of salty water is larger than that of water.

d) swimmer is heavier in the swimming pool.

14) **Lakes and seas begin to freeze from the surface, because**

a) there is no pressure at the top.

b) bottoms of lakes and seas are hotter.

c) water at the surface of lakes and seas contacts with air.

d) there are more water than ice in unit volume.