Seventh Grade Students' Qualitative Understanding of the Concept of Mass Influenced by Real Experiments and Virtual Experiments

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Abstract
This research is conducted among 65 seventh graders (12-14 years old) who attend introductory course on physics. Tests and interviews are used to trace the roots of the students' misconceptions about mass. Results from the research reveal serious weaknesses in students' understanding of concept of mass, and its confusion with concepts of density and weight. Pre-conceptions about dependence of volume and mass of physical body and concept of heavy materials have deep impact on students understanding of mass and its measurement. Also, poor understanding of inertia signals that it might be more natural way for students to present mass as property of matter that comprises the body. Sources of misconceptions are found in the prior students' experience in informal, as well as in formal education. Later include students' vocabulary development, physics curriculum structure, and physics textbook. Weaknesses are detected in the non-physics teachers' competences who teach physics concepts. All of the research findings are supported by similar findings in other researches, which confirm that detected misconceptions are generic. In order to minimize the existence of detected misconceptions, directions for revision of the curriculum and textbook are proposed. Also, directions for methodological approach are given.
Keywords: Physics education, mass, weight, misconceptions.

Introduction

Introducing basic physics concepts to students in lower secondary school is not an easy task as one might think. Teachers use everyday life experiences to bring the idea of those concepts closer to students understanding, yet those experiences often don't explain the concept themselves. As Gönen (2008) points out, "many physical interactions are difficult to perceive (friction, inertia, gravitation…), and may induce students to assign these phenomena an inferior status or simply to ignore them as a possible cause of natural events". Teachers often take time, space, mass and density as concepts, which are well understood by their students, since they use them to explain different phenomena in everyday life. This assumption is the worst possible starting point of the teacher, since it's activities should bring to understanding one of the most demanding concepts of today's physics, which are still not well defined and understood. Smith et al, (1997) suggested, "teachers should strive to be sensitive to students' starting conceptions about space and matter and should not assume that its basic properties are obvious to them".

Students come to physics course with their own well-developed preconceptions with explanatory power, which are inconsistent with the accepted scientific concepts. These pre-concepts are usually product of students' interactions with their natural and social environment, and are usually the basis of the future misconceptions, which are highly resistant to change, strongly influence new learning, and even cause students to misperceive laboratory events and classroom demonstrations (Stylos et al, 2008; Wenning, 2008; Gönen, 2008). Surprisingly, some of students' misconceptions are supported and reinforced by physics textbooks and teachers who have no physics education background, but teach basic physics concepts in some other subjects (Gönen, 2008). For example, in the fourth grade mathematics, general teachers teach measuring time, distance, mass and volume of liquids. Also in the fourth grade, in the frame of the subject called Nature, same teachers teach heat, temperature, sound and using scales for measuring mass. In the sixth grade, math teachers again teach measuring distance, mass, time, temperature, area and volume and their units.

Teaching is not efficient if it's based on simple transfer of knowledge from teacher to student. Instead, it should be directed towards detection and replacement of students' misconceptions with a set of "precise concepts appropriate for mathematical applications" (Biener & Smeenk, 2004). Today's teachers tend to achieve these goals by implementing different teaching techniques, and to make students understand the basic physics concepts, not just memorize it, because basic understanding of scientific concepts determines the success in students' future learning. "Both qualitative and quantitative reasoning skills are important and contribute to students' mastery of scientific reasoning. An exciting challenge for *physics* curriculum planners is to provide sustained opportunities for students to develop both kind of reasoning and understanding (Smith et al, 1997)".

This text reflects students' understanding of mass. Results are derived from research conducted in lower secondary school that was intended to measure the outcomes from implementation of different approaches in teaching density. Since density depends on mass and volume, the research also measured students' understanding of those quantities.

Difficulties in defining mass

"The unitary Newtonian concept of mass has now fragmented into various 'masses', including inertial mass, active gravitational mass, passive gravitational mass and so on" (Roche, 2004). Dominant view of the concept of mass through history, and one of few which stands today, is that mass is measure of the amount of matter that comprises physical body. We will not discuss the correctness of this view. But, how do we measure the quantity of the particles? Isaac Newton (1999) stated, "*Quantity of matter is a measure of matter that arises from its density and volume jointly*". This suggests that mass can be determined as product of density and volume, but since density can only be defined as mass of unit volume, then the circle is obvious (Newton, 1934). As a consequence of Newton's second law of motion, mass of an object can be determined by applying a force to an object, and measure the resulting acceleration. The ratio of force and acceleration gives the mass of the object. This concept of mass is called *inertial mass*. So, according to the concept of inertial mass, mass is a measure of object's resistance to change its state of motion or rest.

Oversimplification of presented "definitions" of mass is obvious, but the general idea of both approaches in defining mass is presented. That is enough for us, since our goal is not to give new definition of mass, neither to improve the existent ones. Presented two definitions are most widespread approaches to explain the nature of mass to students. Both of them treat mass as constant, conserved quantity. But if we take relativity in consideration, then these two concepts reveal serious flaw, because relativistic mass is not necessarily conserved quantity (Hecht, 2006). If we take in consideration that there are few more approaches in defining mass, then it becomes clear that there is no unique and clear definition of mass, but few of them defining it in different context. This is serious problem for education, because the concept of mass is a basis for many physical phenomena, which students should learn about in school.

We do not expect from students to understand all these definitions and to "juggle" with all these concepts and situations, but we do expect them to know and understand the difference between mass and weight, to know what mass is not, to know the units of mass, how to measure it and to use all that knowledge in order to explain in its words what mass is.

The aim of the research

For many years, the physics teaching in Macedonia was based on a "chalk and talk approach". Only few teachers used experiments in a form of demonstrations, which, again, did not engage students actively in the experimenting processes and procedures. Teachers' demonstrations were expected to keep the students with minds on. Last six years there are efforts to incorporate computers into teaching and to use their features as a substitute for real experiments. This process faces new problems: students' and teachers' capabilities for using computers, compatibility of the software with the curriculum and organization and management of the class. Having in mind all these problems, primary goal of the research was set to determine:

- Whether or not an approach that includes computer simulations produce significant difference in students' understanding of density and their levels of motivation when compared with the one that includes real experiments.

- The difficulties in understanding the concept of mass.

How students learn mass

Curriculums of several subjects contain activities in which students are introduced with the term "mass". These activities are not pointed toward explanation of the concept of mass, but towards explanation and presentation of different procedures of measuring mass and relations between its various units. By the time students reach seventh grade, both informal and formal education have given their contribution in creation of one of students' most stubborn misconceptions, one of them creating it, the other one confirming it, respectively.

Seventh grade physics curriculum is dealing with basic physical quantities and their units, such as time, length, area, volume, mass and density, and at this point students for the first time learn about the concept of "mass". In physics textbook (Geshoski & Nonkulovski, 2009), concept of *inertial mass* is presented. At the beginning of the lesson on mass, authors are directly referring to students, posting a question:

"*Have you ever heard about "mass"? If you have, does that word mean anything to you?*"

After this question, three different situations are presented in the textbook, which imply on inertia. First situation involves toy car placed on piece of paper. Student should try to pull out the paper beneath the toy car very fast, and to observe the behavior of the toy. In second situation student should imagine that she/he has to push a car. The question is, is it easy to do it? Also, if the car is moving, is it easy to stop it? Following these two situations, authors of the textbook are presenting a definition of "inertia" as "*property of (physical) bodies to preserve their state of rest or uniform rectilinear motion*".

Following the definition of inertia, the famous tablecloth magician trick is presented, so students should apply their gained knowledge of inertia to explain the phenomenon.

Authors in the textbook state that "*Physicists describe the inertia of a physical body with the physical quantity called "mass". Measure of inertia of one physical body is called mass of physical body*".

About the sample and the students' activities

The research (Stamenkovski, 2013) was conducted among 65 seventh graders (12-14 years old). Participants were divided into two groups. The participants in the first group, called RE group used real experiments, while the participants in the second one, called ICT group, used computer simulations.

During the class, when students in RE group learned density, they were divided into few smaller groups consisted of four to five students. Every group was provided with necessary apparatus to measure mass and volume of given objects. Apparatus included digital kitchen scale for measuring mass. Students in RE group had to measure mass of several objects, made from various materials, with various shapes and volumes. Distinct differences of objects, which masses were measured during the class, should have provided the students with necessary means to infer conclusion that bigger objects are not necessarily heavier, and that object made from *"heavier"* materials, are not necessarily heavier.

Students in ICT group were divided into few sub-groups consisted of four or five students equipped with computer, running PhET simulation "Density" (Olson & Reid, 2011). This simulation involves swimming pool filled with water, in which students should submerge cubic objects made from various materials in order to measure their volumes. Virtual scale is used in order to measure the mass of objects. Various volumes and masses of objects, as well as data about materials from which measured objects are made of are presented in the simulation, and provide the students with enough information to conclude that bigger objects are not necessarily heavier, and that objects made from "*heavier*" materials are not necessarily heavier.

The test

Data on the students' acquired knowledge were provided by pretest and posttest, which students took before and after they learned about volume, mass and density, respectively. To successfully understand density, one must certainly understand the concepts of mass and volume, so tests contained questions that reflected students' understanding of mass and volume. The first question about mass was straightforward:

"Try to explain what is mass of a physical body, and write down the unit of mass."

This question was asked because its results could be used to give insight into the situation with the obtained declarative knowledge about concept of mass. However, it does not give insight into students' true understanding of it. To overcome this problem, test contains open-ended questions which treat students understanding of concept of mass from different aspects.

Next question related to mass was:

"What do you think, what has greater mass, 1 tonne of iron or 1 tonne of feathers?"

Answers to this question can reveal presence of students pre-conceptions of "heaviness of materials" and comparison of masses of different objects by comparison of its volumes. It can also reveal whether or not students have in depth understanding of the concept behind which double pan balance operates.

Presence of students' misconception on connection of sinking or floating of an object and its mass was tested with the following question:

“Heavy objects sink, while light objects float in water. What do you think, is this statement true or false?”

Students’ ability to solve tasks that include quantitative calculation of mass using modified formula for density was also included in the test. The task was:

“Room with volume of 80 m^3 is filled with air. What is the mass of the air in the room if its density is 1.28 kg/m^3?”.

Results

As for the first goal of the research, it did not reveal any significant difference in understanding the concept of the mass between the students in the two groups. Both, real experiments and computer simulations were very similar, which enabled the students to perform very similar activities. The biggest difference was that the students in the RE group had more technical and hands-on activities, while the students in the ICT group had just to click the mouse button and to drag-and-drop the virtual objects, which obviously, did not produce almost any difference in understanding the concept of mass. Therefore, when it comes to understanding of concept of mass, students from both groups will be considered as one group. Presented results are inferred from students’ answers to questions posted on both pretest and posttest, and represent quantitative reflection on students understanding of concept of mass.

The relative distribution of the answers to the first question on test: *“Try to explain what is mass of a physical body, and write down the unit of mass”* is presented in Table 1.

Try to explain what is mass of a physical body, and write down the unit of mass		
	Relative number of students (%)	
Answers	**Pretest**	**Posttest**
Mass is same as weight	58	32
Mass means to measure something	26	5
I don’t know	16	30
Mass is measure of inertia	0	28
Mass is derived from density	0	5

Table 1: Relative distribution of answers on pretest and posttest - question 1

The answers given at the pretest can be categorized in three categories. The misconception that mass is the same as weight is relatively wide accepted. Besides of mass, students also expressed their opinion about the unit of mass. On pretest, 63% of students answered that kilograms and grams are units of mass, and the rest 37% of students did not answer this question. From students, who answered that mass is the same as weight, 72% also stated that kilogram and gram are units of mass.

Posttest results reveal additional two categories of answers. Although the situation is changed, still most answers state that mass is the same as weight. Encouraging fact is that percentage of this answer is significantly reduced, and the biggest part of this reduction is due to correct answer. However, one cannot be satisfied with the results, which shows that little about quarter of the students gave the correct answer. Even more, correct answer does not necessarily mean that students really understand what mass is. Another interesting result is that the number of students who stated that they do not know what mass is has doubled. These results will be discussed in details in the next section of this text.

On posttest, 61.5% of students answered that kilograms and grams are units of mass, while 33.5% of students answered either that they do not know what the unit of mass is or they did not wrote it on the test. The rest 5% of the students answered that unit of mass is kg/m^3.

From the students who answered that mass is the same as weight, 78.5% also answered that kilogram and gram are units of mass, while from students who answered that mass is measure on inertia, 91.5% also answered that kilogram and gram are units of mass.

Answers to other questions will not be presented in this section, but will be used in the discussion to additionally explain some of the misconceptions and consequences.

Discussion

From presented results it is obvious that students have modest knowledge of the concept of mass and in most cases they identify it as weight. This finding is not new at all. Everyone who teaches introductory physics is aware of the tremendous problems in explanation of concept of mass and its distinction from weight, and is used to deal with the confusion that students will encounter when they will be confronted with the difference of mass and weight (Morrison, 1999). In case of this research, by the time when students learn about mass, they still have not learned about weight, nor was the term "weight" used in the textbook or in the classroom in any occasion. Yet, on posttest, nearly one third of students are identifying mass as weight. This brings us to conclusion that this confusion comes from outside the physics classroom, and its origins partially lie in informal education. It is inevitable that students will form part of their perceptions through interaction with their natural and social environment (Stylos et al. 2008), but those perceptions are not necessarily correct, although they fit well in students' common-sense-world. One of the students that on the test answered that *mass is actually a weight*, during the interview was asked that *if mass and weight are the same thing, then, why are there two words to explain the same thing*? Student answered that mass and weight are the same thing, only the words are different because they originate from different dialect. It is obvious that teachers should not take account only on students' conceptual development, but their vocabulary development as well (Littleton et al. 2011).

It is not only students' informal education that leads students to construct faulty concepts, but their previous formal education also takes significant part in it. For example, fifth grade textbook on *Science* (Trajkova & Miladinova, 2010) puts the following task to students:

Construct a hypothesis: matter has both mass and volume.

1. *You can measure the mass of matter (tennis ball), with a scale, and you can express it in grams.*
2. *Write down the* ***weight*** *of the tennis ball.*

It is clear that there is not distinction between mass and weight in this textbook. Teachers must insist on scientific discourse so that the students won't have to "unlearn" something they learned in lower grades. Teachers should step in and make a correction, "*write down the mass of the tennis ball*", and not "*write down the weight of the tennis ball*" (Littleton et al, 2011).

Most of the students which on pretest or posttest answered that *mass means to measure something*, used their everyday life experience to explain what mass was. Few of the answers are as following:

"*Mass is actually a body weight*",

"*Mass is a weight of solid bodies and liquids*", "*Mass is to measure something on a scale, like when we go to a store and ask for 2 kg of tomatoes*".

Particularly interesting is the statement that solid bodies and liquids have mass. The very absence of *gases* in the sentence loudly speaks and indicates another preconception, in which students' state that gases have no mass, or even more, they exclude gases as matter (Smith et al, 1997). This preconception is probably a product of "Seeing is believing" principle of construction of concepts, but since most of the gases are invisible, this principle could not be successfully applied (Azizoglu & Geban, O., 2004). Hence, students' perception does not correctly describe real phenomenon. This preconception can be challenged by a simple experiment, to actually measure the mass of the ball, both when it is flat and pumped up, on a sensitive scale, and compare the values (Kind, 2004).

Amy MacDonald (2010) in her *Heavy thinking* presents an idea that children tend to believe that the bigger an object is, the heavier it is. This students' preconception can sometimes be true, it is a reasonable assumption but not necessarily correct. It has to do with density. However, it is true that students often tend to present bigger objects as heavier, and smaller objects as lighter (Smith et al, 1997). This misconception led some students to answer that 1 tonne of feathers will certainly have larger mass then 1 tonne of iron since we need larger volume of feathers then iron to make 1 tonne of them. Seventh grade physics textbook is subtly reinforcing this students' preconception by presenting a picture of several objects with different sizes and mass (Figure 1).

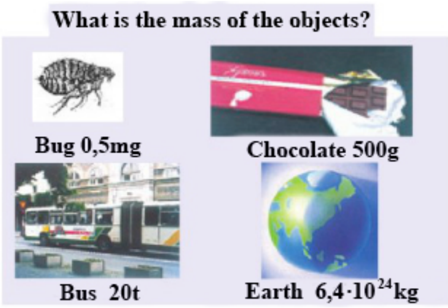

Figure 1: Extract from seventh grade physics textbook

It is easy to conclude from the picture that the bigger an object is, the grater mass it has. Pictures in books are not just decorative elements; they are intended to project certain messages, which correct understanding depends on students' existent knowledge. In cases where students do not have sufficient existing knowledge, there is a great possibility for students to "read" the image message incorrectly, which as consequence will lead to erroneous conclusions (Stylos et al, 2008).

The fact that textbook instructions lead students to express weight in grams, or to determine objects mass by their volume, is simple proof that materials used in formal education are misleading the students and reinforcing their already developed preconceptions.

Throughout their education, students meet the term "mass" several times before they learn this concept in physics class. By then, it is explained by teachers that are not competent in the field of physics, and have no sufficient knowledge of its concepts. Even prospective physics and science teachers have many misconceptions concerning the concepts of mass (Gönen, 2008). These kinds of teachers actually reinforce students misconceptions developed through their informal education.

Another interesting conclusion derived from the results of posttest is that the number of students that answered that they do not know what mass is, is actually doubled. If we jump into conclusion, we may say that studying in school is actually worsening the situation. Fortunately, this conclusion will be false. The interview reveals that many students have learned that mass is not the same thing as weight. According to Piaget, this is the moment when cognitive conflict appears, the moment when one begins to learn. This is important shift in the students' system of knowledge, because their previous misconception is seriously challenged. These students have made place for new concept of mass, it is teachers' duty to lead the way in which they will find the suited concept and build it in their system of knowledge. In most cases, this positive change will never occur because teachers, pushed by curricula schedule, do not have enough time to lead the students all the way. Time is essential. If alternative concept is not accepted by the students in short period of time, they will simply get back to their previous beliefs. Gönen (2008) points out that physics students have better understanding of different concepts of mass then science students do, simply because they take physics courses concerning mass and gravity concepts more detailed then science students do.

Little more than quarter of students accepted the proposed concept that *mass is measure of inertia*. We cannot deny that these students gave correct answers on test, but do they really understand what inertia is? The question "*What is inertia?*" was posted to these students during the interview, and the results are more than worrying. Nearly half of these students did not know what inertia was. They have memorized the definition, but they cannot give additional explanation whatsoever. "Students tend to answer quickly, with rote learned response and what most readily comes to mind, rather than thinking deeply and carefully about each item" (Smith et al, 1997). Most common answer about the nature of inertia was that "*Inertia is a force needed to stop moving object or to put it in motion"*. At the interview, a student that has answered that mass is a measure of inertia, was asked to explain what inertia is. He answered that "*inertia is when objects detect their state of rest or uniform rectilinear motion"*. When the student was asked to explain how nonliving objects can detect its state of rest or any kind of motion, student corrected himself and answered that *"physical objects are not actually detecting their state, but they are somehow aware of it"*. It was also detected that student does not know the difference between *uniform rectilinear motion* and *rectilinear motion*. Students have not learned about their difference by the time the term *uniform rectilinear motion* is mentioned in this definition in their textbook, which again reveals the problem with the textbook, and curriculum in general. Besides the fact that lectures schedule is inadequate, more disturbing is the fact that student was comfortable to say something that he obviously did not understand. This shows that students are pursuing correct answer and good mark, not sophisticated knowledge whatsoever, and therefore misperceives the primary role of education. Curriculums of different subjects don't help to resolve this problem. For example, students learn two similar definitions about the concept of measurement, one in physics class and one in chemistry class. But when it comes to put them in practice, they almost totally fail. When students were asked to compare masses of 1 tonne of feather and 1 tonne of iron, their reasoning was not driven from knowledge of the concept of measurement, but from widespread *"heavy material"* misconception. This is why most of the students answered that 1 tonne of iron has greater mass than 1 tonne of feathers.

Few students on posttest answered that mass is actually density of the physical body. These answers could be connected with two misconceptions. First one is that physical bodies that have more mass also have greater density, hence the equivalence. This misconception is displaying students' inability to operate with two dependent unknown quantities simultaneously. The other one is product of students' reasoning of causality. Since gases have no mass, than gases have no density, too. These answers are more of implication rather than equivalence, since there are students, which answered that mass, is the same thing as density, but there are none who stated the opposite, that density is the same thing as mass. If we first post the question "What is density?", students will point to viscosity of liquids rather than mass of an object. On pretest, nearly 85% of the students answered that the proposed assumption that heavy objects sink while light objects float in water is correct. On posttest, number of students that answered that this assumption is true is predominantly consisted of students, which stated that not mass, but density is the property, which should be taken into account to answer this question correctly. Anyway, they explain further, this assumption is true because heavier objects also have greater density then lighter objects. This result is, in general, outcome of students shocking finding that oil, since it floats in water, has less density than water. Students always tend to answer that oil is denser than water, but if we insist from them to answer why, they often point to viscosity. Also, students that know that oil has less density than water, also state that two identical bottles, one filled with oil and the other with water, will have equal masses. Again, students' inability to simultaneously operate with two related quantities is obvious. In these answers there is certain distinction of concepts of mass and density, but they also present students inconsistent concepts.

From all of the above it might be more natural way for students to present mass as property of matter that comprises the body, then to present it as measure of inertia. "Construction of explicit visual (atomistic) packing model of density can contribute to the process of differentiation of mass and density as such model provides a highly memorable visual image that helps students to consolidate their differentiation of mass and density" (Smith et al, 1997). It is obvious for a student that mass is related to the material from which body is made of and its volume, but not with its "motion properties". After all, when we measure mass, we do not move the body in any way. This is not suggestion that concept of inertial mass should be abandoned in introductory physics course. However, wider approach, which will present the concepts of mass from different points of view, as measure of matter that comprises a physical body, concepts of inertial and gravitational mass which will be presented on appropriate time schedule, should be considered. This approach will reveal to students the true nature and complexity of mass and might be great exercise for their causal reasoning skills.

On the other hand, understanding the concept of mass and the ability to calculate it as product of density and volume of a body has nearly nothing in common. The results also reveal that some students do not understand the need to precisely define basic physics concepts. They do not see the difference in expressing a precise definition of mass and written formula ($m=\rho\cdot V$) of how mass could be measured. For them, both are correct answers to the question "*What is mass?*". There are students that clearly are not able to explain the concept of mass, but are able to calculate it with nearly no effort at all which is in accordance with the findings of other authors (Mazur, 1996a). This finding goes in favor of those of Smith et al. (1997) that "students with poor definitions often went on to make appropriate calculations". They are also in compliance with the finding that many students resort to memorization of equations and algorithms copied in their notebooks (Mazur, 1996b). In our research, only quarter of students were able to calculate mass of air in the task that is presented to them. This is not a bad result because this is the first time for students to be asked to calculate any quantity, although pretest results show that students were aware that they should use mathematical calculations in order to solve the task. Furthermore, students were not shown how to use density formula to calculate mass. These results also suggest that students have poor mathematical skills; therefore physics teachers should work with students and try to improve them. In this case, students' difficulties lie in bad correlation between mathematics and physics curriculums.

Conclusion

Real experiments and computer simulations i.e. virtual experiments that we used in our research, did not give significantly different contribution in understanding the concept of mass.

Although it is known for a long time that there is a common misconception mass to be confused, or to be referred to as weight, results from this research convince us that this misconception still prevails today, despite the continuous reform of education system and curriculums. Roots of this misconception are traced not only in students' informal education, but in their formal education as well.

It is unlikely that physics education can have so big cultural impact to overthrow linguistic based misconception that has been transferred from generations to generations. Teachers should put more effort in distinguishing mass from weight, not only by emphasizing their conceptual differences but also on insisting of usage of scientific discourse in physics class. Precise expression and need to understand the ideas behind basic physical concepts, not just memorizing it, should be primary goal of physics education. Mathematical interpretation of relations between different physical quantities in order to explain some of the basic physics concepts should be discouraged.

Teachers should take more active role in evaluation of learning materials that students use to learn physics, and to point out any information that could lead to ambiguity. Curricular guidelines should be altered because one class is not enough to challenge and overcome misconception that has been built for years. Instead, carefully planned approach is needed. When students learn about physical quantities and measurement units, maybe mass should be introduced as quantity of matter that comprises physical body. Of course, teacher should present the dependence of mass from the attributes of molecules and atoms that comprise physical body. This approach could later be very useful in presenting the concept of density, and distinguish it from concept of mass, which some students identify, in most cases due to the proportional relation of mass and density. Concept of inertial mass should be introduced when presenting inertia as a property of physical bodies, and may be used as an introduction to dynamics, after needed concepts from kinematics are well understood. By this approach, students may become aware of the complexity of concept of mass, but it should be stressed that besides several concepts of mass, weight certainly is not one of them.

References

Azizoglu, N., Geban, O. (2004). Students' Preconceptions and Misconceptions about Gases. *Balikesir Journal of University of Science and Technology Institute, 6*. Retrieved from: http://fbe.balikesir.edu.tr/dergi/2004-6-1.php

Biener, Z., & Smeenk, C. (2004). Pendulums, Pedagogy, and Matter: Lessons from the Editing of Newton's Principia. *Science & Education, 13,* 309-320.

Geshoski, S., & Nonkulovski, F. (2009). *Physics – Textbook for 7th grade.* Skopje: Prosvetno delo (in Macedonian)

Gönen, S. (2008). A Study on Student Teachers' Misconceptions and Scientifically Acceptable Conceptions About Mass and Gravity. *Journal of Science Education and Technology, 17,* 70-81

Hecht, E. (2006). There Is No Really Good Definition of Mass. *The Physics Teacher, 44,* 40-45.

Kind, V. (2004). *Beyond appearances: Students' misconceptions about basic chemical ideas* (2nd ed.). London: Royal Society of Chemistry. Retrieved from: http://www.rsc.org/images/Misconceptions_update_tcm18-188603.pdf

Littleton, P., Riggs, B., & Jackson, A. R. (2011). Proceedings from CAMT 2011 Presentation: *"Fruity" Math (with a Few Veggies!)*. Stephenville, TX: Tarleton State University.

MacDonald. A. (2010). Heavy Thinking: Young Children's Theorizing about Mass. *Australian Primary Mathematics Classroom, 15,* 4-8.

Mazur, E. (1996a). *Peer Instruction: A User Manual*. Upper Saddle River, NJ: Prentice Hall.

Mazur, E. (1996b). Are Science Lectures a Relic of the Past?, *Physics World, 9,* 13-14, Retrieved form: http://mazur.harvard.edu/

Morrison, R. (1999). Weight and Gravity - The Need for Consistent Definitions, *The Physics Teacher, 37,* 51-52.

Newton, I. (1934). *The Principia: Mathematical Principles of Natural Philosophy.* (F. Cajori, Ed. & A. Motte, Trans.). Berkley, California: University of California Press. (Original work published 1687)

Newton, I. (1999). *The Principia: Mathematical Principles of Natural Philosophy.* (B. I. Cohen & A. Whitman, Trans.). Berkley, California: University of California Press. (Original work published 1687)

Olson, J., & Reid, S. (2011). PhET Interactive Simulations: Density (1.05) [Software]. Available from http://phet.colorado.edu

Roche, J. (2004). What is Mass?, *European Journal of Physics, 26,* 225–242.

Stamenkovski, S. (2013). *Introduction to action research: expected and real outcomes of the physics teaching and learning in seventh grade.* (Master thesis). Ss. Cyril and Methodius University, Faculty of Natural Sciences and Mathematics, Skopje, Macedonia (in Macedonian)

Smith, C., Maclin, D., Grosslight, L., & Davis, H. (1997). Teaching for Understanding: A Study of Students' Preinstruction Theories of Matter and a Comparison of the Effectiveness of Two Approaches to Teaching About Matter and Density. *Cognition and Instruction, 15,* 317-393.

Stylos, G. (2008). Misconceptions on Classical Mechanics by Freshman University Students: A case study in a Physics Department in Greece. *Themes in Science and Technology Education, 1,* 157-177.

Trajkova, B., & Miladinova, V. (2010). *Science – Textbook for 5th grade.* Skopje: Graficki centar (in Macedonian)

Wenning, J. C. (2008). Dealing More Effectively With Alternative Conceptions in Science. *Journal of Physics Teacher Education Online, 5,* 11-19, retrieved from: http://www.phy.ilstu.edu/jpteo/