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EFFECTS OF FORMATIVE ASSESSMENT PROBES INTEGRATED IN EXTRA-CURRICULAR HANDS-ON SCIENCE: MIDDLE SCHOOL STUDENTS' UNDERSTANDING

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Abstract. *This study had three main purposes, to (a) determine students' understanding of basic physics concepts, (b) analyze the science concepts and their connection to real-life context in science curricula and teaching materials, (c) evaluate effect of formative assessment probes on students' understanding of selected key concepts. Subjects were 197, 8th grade students who had studied five basic physics concepts. To evaluate students' understanding, a questionnaire consisting of formative assessment probes was administered with 4 multiple choice and 4 open-ended questions. Findings indicated that students had poor conceptual understanding of the concepts. Science curriculum, analyzed in terms of application to real-world contexts, indicated that textbooks included few practical explanations. In an intervention, one public school received formative assessment probes integrated with extra-curricular hands-on science instruction. Pre-post data showed significant increases in students' understanding of basic physics concepts. Finding that these students significantly out-performed other groups implies: (a) the need to include students' prior learning in instruction and (b) the need for more learning time to apply understanding of concepts to real-world contexts.*

Key words: *formative assessment, real-world context, hands-on science instruction, science concepts.*

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Introduction

PISA (Programme for International Student Assessment) is an international examination consisting of multiple-choice questions and open-ended questions periodically organized by the Organization for Economic Cooperation and Development to measure the success of secondary education students of member countries in interpreting and applying what they learn at school to real life. Lots of middle school students in different countries don't get high scores on the PISA because PISA is an examination that tries to find out if students are well prepared for future challenges by analyzing, reasoning and communicating effectively, skills that demonstrate the capacity to continue learning in their future lives (Çelen, Çelik, Seferoğlu, 2011). The students` level of problem solving skills and their skills in integrating scientific principles and theories to real life situations, rather than just memorizing, is the main purpose of the PISA. The education systems of many countries, based on just the memorization of facts and principles, do not prepare students to do well on the PISA examination.

Although primary education and secondary education students are exposed to excessively exam- and test-oriented teaching at schools and private teaching institutions in Turkey, the country took almost last place in sciences in the 2009 PISA among 65 countries (PISA, 2009). That indicates that there is something deficient or wrong in educational practices conducted in Turkey. What is wrong with educational practices conducted at schools in Turkey? What is the solution? According to Keeley (2008), even the most interesting activities or lessons may result in little or no conceptual understanding, when the ideas, prior knowledge, and readiness levels of students are ignored. In such cases, teaching may yield no conceptual understanding in science lessons. As a result, some gaps emerge between learning and teaching. These gaps come to light in national (e.g. level determination examinations [placement examination] and transition to higher education examinations) and international (e.g., PISA, TIMMS) examinations aimed at determining the success levels of students. However, when these examinations are taken, it is too late to return and make adaptations in teaching (Keeley, 2008).

According to studies in related literature, the fundamental problem is that assessment practices, which are not integrated into teaching, do not promote students' conceptual understanding (Black, 1993; McConnell, Steer, Owens, 2003; Yin, Shavelson, Ayala, Ruiz-Primo, Brandon, Furtak, 2008; Cliff, Freeman, Hansen, Kibble, Peat, & Wenderoth, 2008; Yin, Tomita, & Shavelson, 2013) End-of-unit or end-of-semester tests involving traditional assessment and evaluation methods, such as true - false questions, matching practices, filling in the blanks, and multiple-choice questions, encourage surface learning and rote learning as they usually cover isolated or detailed information likely to be forgotten by children in a short time (Butler, 1987; Butler & Neuman, 1995). Since these kinds of assessment techniques such as; true-false questions, matching practices, filling in the blanks, and multiple-choice questions which are capable of measuring the acquisitions gained by root learning and low-level acquisitions in general usually focus on grading, learning function stays in the background (Black, 1993; Black & William, 1998; Crooks, 1988). According to Duschl and Gitomer (1997), students take the easy way out by thinking, "it is enough that I pass the course" through evading the teaching activities that wrack their brains and require power of thinking in any education system, where knowledge and skills such as reasoning and critical thinking are not much regarded and assessed. Apart from that, the above-mentioned traditional assessment and measurement approaches have a negative effect on in-class learning climate by inciting competition instead of cooperation among students (Crooks, 1988; Yin, et al., 2008). This is because; the success of a student in the lesson is determined by the grades s/he gets and his/her rank among his/her friends. This being the case, students evaluate their performances through comparison with their friends instead of focusing on and evaluating their individual developments. The negative effects of such a classroom climate on the successes and the motivation of students are reported to be as follows: a) it is believed that students with low achievement levels are incompetent (Siero & Van Oudenhoven, 1995); b) it is accepted that ability and intelligence are innate and unchangeable, which discourages students from learning and improving themselves in the future (Vispoel & Austin, 1995); c) students avoid seeking help from their teachers or friends for fear that the questions they ask may be regarded as evidence of their inability and failure (Blumenfeld, 1992; Crooks, 1988). All these factors cause students to lose confidence in their own learning capacities by diminishing their motivation.

When assessment is mentioned, written and oral examinations, as well as the grades achieved in them, come to mind in general. Thus, *assessment* is mostly used synonymously with written and oral examinations and assignments. According to Atkin, Coffey, Moorthy, Sato, and Thibeault (2005) the use of *assessment* synonymously with the above-mentioned examination types degrades the complex nature, stages, and purpose of assessment. This is because: grading is the smallest piece of assessment. However, assessment is quite a comprehensive word. It is at the top of Bloom's taxonomy (Forehand, 2005) and requires advanced performance. What is important in assessment is to make quantitative and qualitative analyses aimed at determining the points students understand, the points they have deficiencies in, and the sorts of misconceptions they have.

Any assessment that does not pursue the goal of grading, but is made for learning and teaching is a formative assessment (Keeley, 2011, 2012). What is meant by "assessment made for learning" is to determine what students know about the topic taught. The assessment for teaching, on the other hand, refers to adaptation of the coverage of the topic in the light of the information collected from students (Black, 1993; Yin, et al., 2008; Furtak, 2012; Yin et al., 2013). In formative assessment, the prior knowledge and the misconceptions of students guide the manner of covering the lesson. Within the scope of this approach, assessment is made before and during teaching in order to eliminate students' imperfect and inadequate knowledge (Bell & Cowie, 2001; Black & William, 2009). Since formative assessment is also conducted during teaching, it provides both students and teachers with feedback concerning the learning and the teaching of the lesson. If the coverage of the lesson is adapted in accordance with such feedback obtained from students, the new coverage of the lesson may result in improved conceptual learning by students (Black, Harrison, Lee, Marshall, & William, 2004; Ruiz-Primo & Furtak, 2004; Black & William, 2009). Hogan, Nastasi, and Pressley (2000) found that questioning helped students make explanations more complete and phrased in scientific terms. The primary objective of formative assessment is to improve student conceptual understanding during lessons. Thus, an assessment may be considered a formative assessment only if the information collected from students is used in the conduct of lessons (Keeley, 2011:2012). In this regard, it is not a formative assessment unless the information collected from a level determination examination regarding what students know, what students do not know, and what students know imperfectly is used in the teaching of a lesson. It is an integrated circular process that applies student learning data relatively immediately to enhance learning effectiveness.

Many efforts have been made for formative assessment to be carried into effect in science teaching as of

the late 1990s. It has also been highlighted in documents determining national education policies (National Research Council, 2001, 2007, 2011) in the United States of America. Educational directorates and schools in many states of the USA treat formative assessment as a teaching approach (Cizek, 2010). In addition, formative assessment is integrated into many curricula (Lawrence Hall of Science, 2000), and publishing houses develop probes and tests based on formative teaching approaches for schools (Keeley, Eberle, & Farrin, 2005; Keeley & Harrington, 2010; Shepard, 2008). In his book titled "Educational Psychology" (1968), David Asubel said, *"If I had to reduce all of educational psychology to just one principle, I would say this:* The most important single factor influencing learning *is what the learner* already knows. *Ascertain this and teach him accordingly* (p.6.)" The comprehensive literature review conducted by Black and William in 1998 concluded that formative assessment had a very positive effect on the learning and the motivation of students. According to Furtak (2012), formative assessment supports the learning of students, and its importance is gradually increasing in reformation of science lessons taught in classrooms.

Previous studies show that students have different ideas in regard to science concepts. The ideas, which are based on simple observations in the course of time, but are not obtained through research and following a particular method based on real reasons, are called casual knowledge or misconception (Schnotz, Vosniadou, & Carretero, 1999). Such prior knowledge possessed by students that mostly conflicts with scientific knowledge is referred to as "misconception" (NRC, 2001). Misconceptions may result from limited observations and experiences of students in daily life or imperfect knowledge provided by books or hearsay and unsubstantiated tradition (Aşçı, Özkan, & Tekkaya, 2001; Çapa, 2000; Sungur, Tekkaya, & Geban, 2001). According to Keeley (2012), misconceptions are misunderstood or misused by many educators. Perceiving the concepts held by children as misconceptions and treating them as an obstacle before education (Kızılcık & Güneş, 2011) are regarded as the misconceptions of educators concerning teaching. Today, the prior knowledge of students is regarded as a starting point for conceptual understanding. For instance, Larkin (2012) found that while pre-service teachers considered the misconceptions of students an obstacle before science teaching and a mistake to be corrected at the beginning of the semester, they noticed at the end of the semester that the misconceptions of students were important keys for opening the potential for teaching. In consideration of the fact that new learning cannot be achieved through direct transfer in science course, when roots of concepts are very deeply held by students, it is quite difficult to ensure conceptual understanding by students, unless correct knowledge is brought to light and discussed explicitly in the classroom (Posner, Stike, Hewson, & Gertzog, 1982).

The new Turkish National Science Curriculum is designed in a cyclical way, in that each year students study the same concept but at a deeper level to develop more complex understanding through eliminating misconceptions (MEB, 2005). However, recent research studies in Turkey indicate that middle and high school students (Koray & Tatar, 2003; Yumuşak, Türkoğlu, Aycan, & Aycan, 2004; Kocakülah & Açıl, 2011; Ayvacı, Bakıcı, & Yıldız, 2012) and also preservice teachers (Gönen, 2008; Yumuşak, 2008; Tunç, Akçam, & Dökme, 2012) all have difficulty understanding basic physics concepts. For example, Ayvacı et al., (2012) conducted a study on in-service middle school teachers, in-service high school teachers, and pre-service science teachers. They determined that research participants had low levels of understanding of concepts about mass, weight, and gravity, and they had many misconceptions. Likewise, some studies conducted on pre-service teachers alone also showed that they had many misconceptions on the subjects of motion and force (Gönen, 2008; Yumuşak, 2008; Tunç et al., 2012). Carried out on 267 pre-service physics teachers, Gönen (2008) found out that pre-service teachers had grave misconceptions on the subjects of inertia, gravity, gravitational acceleration, gravitational force, mass, and weight. Tunç et al., (2012) conducted a study on 301 pre-service teachers from seven regions of Turkey. They determined that approximately 90% of pre-service teachers were unsuccessful in making predictions and explanations in regard to the question about inertia.

International research on students' basic physics concepts (from primary education to university) found similar results (Stead & Osborne, 1980; Watts & Zylbersztajn, 1981; Watts, 1982; Sequeira & Leite, 1991; Kavanagh & Sneider, 2007; Lair & Cook, 2011). Kavanagh & Sneider (2007) reviewed the body of research on basic physics concept understanding by organizing the nature of the findings, beginning with studies of the youngest children, followed by older students, adults, and teachers. They found a diversity of misconceptions at all age levels. The finding that even college physics students have significant misconceptions about free fall underscores the importance of effective teaching at the middle and high school levels (Sequeira & Leite, 1991; Kavanagh & Sneider, 2007). According to Kavanagh and Sneider (2007) to promote students' understanding of force and motion, science curricula and teaching should be designed to engage students in a variety of challenges involv-

ing the qualitative use of the science concepts before they are expected to solve quantitative problems. They stated that:

> "Students do not have enough opportunities to think about how Newton's laws apply in real-world contexts. The mathematically rich problems in textbooks sometimes mask students' misconceptions because they can find the right equation and plug in numbers to get the right answer. Unless instructors can encourage their students to transport science learning across the boundaries of the classroom into the real world, the entire value of science education will be called into question. To put it differently, science educators succeed when their students carry with them the insights of science into their own world of everyday lived experience. Designing problems that engage students in applying their growing understanding of motion to real-world contexts is challenging but essential if students are to become scientifically literate (Kavanagh & Sneider, 2007, p. 28).

According to Turkish Statistical Institute [TUIK] data, the number of traffic accidents taking place on roads in Turkey in 2012 is 1,296,634. 268,079 people were injured, and 3,750 people were killed as a result of these accidents. In other words, 734 people are injured and 10 people are killed as a result of traffic accidents every day in Turkey. Might there be a relationship between these big traffic accident losses and whether inertia, which is Newton's first law of motion, is understood or not? Bingham (1997, p.19) describes inertia: " It is hard to get things moving, especially if they are heavy, and once they are moving it is hard to make them stop." Inertia is also described as "the magnitude that measures an object's tendency to remain at rest or keep moving with constant velocity." (Biggs, Daniel, Feather, Ortleb, Rillero, Snyder, & Zike, 2005, p. 692)." Based on the examination of the drivers' faults in the traffic accidents that took place on roads in 2012 and involved injuries and deaths in the light of the definitions provided above, it is seen that the violation of right of way at the intersection, wrong direction changing maneuvers, and rear-ending are the leading causes (TUIK, 2012). Analyses of reasons for traffic accidents involving deaths and injuries demonstrate that 88% of accidents result from drivers' faults. Not wearing seatbelts is another fault of drivers and passengers. According to statistical analyses, non-use of seatbelts increases the ratio of accidents resulting in deaths approximately 4.5 times.

This study had four purposes: (a) to determine how well students understood the basic physics concepts, (b) to determine whether public and private school students differed in their understanding of the concepts, (c) to analyze the science concepts and their connection to real-life context included in science curriculum and textbooks, and (d) to evaluate the effect of formative assessment probes integrated with extracurricular hands-on science activities on understanding of these concepts. Research questions:

1. How well do students understood the basic physics concepts?
2. Do public and private school students different in their understanding of the basic physics concepts?
3. What degree the science concepts and their connection to real-life context was included in science curricula and teaching materials?
4. What is the effect of formative assessment probes integrated with extracurricular hands-on science program on students' understanding of the basic physics concepts?

Methodology of Research

Participants

Participants were recruited from three public schools and one private school. The rationale of including students from different schools was to compare students in private and public schools on their understanding of selected, basic physics concepts to determine whether knowledge and misconceptions were consistent across age or influenced by differences in school and related home environments. The one private school in the study has a better educational setting than the public schools in terms of physical environment, budget, library and class size. The private middle school students either have achieved high test scores, winning them scholarships, or come from families able to pay for private schooling. The number of students from public and private schools were. 1) Public school 1: 31, 2) Public school 2: 32, 3) Public school 3: 54, and 4) Private school 80. Total participants included 197, 8th grade students who had completed studying the five basic physics concepts: mass, weight, inertia, air resistance, surface sliding friction and gravity. This study was conducted with the assistance of three science teachers who were master students at a college of education. Two of the science teachers assisted in the study to collect

data from their classrooms to evaluate students' conceptions about basic physics concepts. One teacher (the third author) participated in the study to collect data and implement the instructional intervention.

The Design of the Study and Intervention

This study was conducted in the second half of the spring semester after all students had completed course-work on the basic physics concepts from their textbook. The rationale of conducting the study in the second half of the spring semester was to determine the level of students' understanding of the concepts after they completed study from textbooks. To evaluate students' understanding, eight formative assessment probes were administered to the all students. Evaluation of the pretest data indicated that all students had poor conceptual knowledge / application of the five physics concepts. (The specific activities will be explained in the paragraphs below.) Using these results as a formative assessment, we designed an extracurricular hands-on program by developing and adapting activities from science activity books. These activities integrated real-life context while implementing new teaching techniques in one of the public schools. These hands-on activities utilized various modeling techniques which included videos and simulations involving authentic materials. In order to determine students' reasoning behind prediction, the instructional approach "Prediction-Observation-Explanation" was modified to "Prediction-Explanation-Observation-Explanation", as suggested by Keeley (2008). The extracurricular instructional intervention activities were: 1) which water bottle hits the ground first? 2) the falling orange, 3) can you turn the corner? 4) Video: Zero gravity, 5) which egg (raw or hard boiled) stops spinning first? 6) Video: "No seat belt, no excuse", 7) how to measure mass and weight, 8) the racing copy papers.

The first activity "Which water bottle hits the ground first?" was developed by the authors. In this activity students were told: "two water bottles are dropped from the same height at the same time. Which water bottle hits the ground first? Please make a prediction and explain your answer." Most of the students said that the "heavier bottle will hit the ground first, since it more heavy." After discussion in the class, teacher took two bottles of the same size but one full and the other half full of water. The bottles dropped from the first floor to the ground. All students were surprised that the bottles hit the ground at the same time. They repeated the experiment over and over, but they observed the same result.

The second, "The falling orange" activity was drawn from Bingham (1997). In the falling orange activity a cup, post card, matchbox and an orange were used. A post card was put on top of cup, and then matchbox was placed on post card. Finally, the orange was put on top of all. Students were asked to predict and explain what would happen when the post card was quickly pulled away. Then they observed that on every trial the orange dropped into the cup.

After discussion, the students concluded that heavy objects have greater inertia so once they started to move they do not easily stop and change their direction. In addition to falling orange activity, students participated on the playground in the "can you turn the corner" activity. In this activity, students were asked whether they could turn the corner of the building while running very fast and parallel to the building. They discussed experiencing that while they were running very fast, they were not able turn sharply. Because of their inertia, they were not able to change their direction instantly. After all these experiments to teach inertia, students were asked to explain why over a certain speed limit a driver cannot control the car by using the steering wheel or brakes and usually accidents happen. Several examples of accidents were discussed in the classroom in relation to inertia. The most common faults in traffic accidents were related to difficulty at instant manoeuvres to change direction and instantly stop, while driving over a certain speed limit. In addition to hands-on activities, students also watched the videos about zero gravity in space and in a spaceship (http://www.youtube.com/watch?v=bWyMtJanrts). These videos were taken inside of a spaceship where there is no gravity ad friction. Therefore, students observed inertia easily by watching the actions of the astronauts.

To promote and integrate students' understanding of inertia in a real-world context, the teacher provided an activity called "Which egg (raw or hard boiled) spins?" (Bingham, 1997). Students worked in groups with a hard boiled and a raw egg. They placed the eggs on the tablet to spin. Students were asked to make predictions and explain what would happen if each egg were stopped for an instant by placing a finger on it, then released. After several trials, students observed that the raw egg continued spinning. After their observations with the teacher's help, students decided that a raw egg has yolk in it, so even though the shell stops spinning, the yolk inside the egg continues to spin. This activity integrated with inertia and car crash phenomena, where cars stop quite quickly and passengers in the car need to be kept seated. The sharp changes in direction and stop kill, not so much that a

car keeps going. The car can go in terrible directions and bodies try to go straight. Therefore, if passengers do not fasten their seat belt, their inertia forces them to keep moving in their original direction and they may pop out of the window or hit each other. This activity was followed by watching a video about the use of seat belts called "No seat belt, No excuse" (http://www.youtube.com/watch?v=gYpuPZYrd2M). This video is a good example that demonstrates what really happens in a car crush. In this video, if a person does not fasten their seat belt, s/he is like a billiard ball and has the potential to hit anywhere. After students watched the video, they reflected on their understanding about the importance of fastening seat belts.

In the "how to measure mass and weight" activity, a balance and spring scale were brought to the classroom. By demonstrating how they operate, the teacher facilitated understanding that a spring gets stretched by gravity. An electronic balance measures resistance to gravity when a weight is on it. A balancing scale balances gravitational force on one side with known weights against gravitational force on the side with the unknown weight.

Lastly, students did "the racing copy papers" activity as a whole class activity. In this activity, a student worked a partner, and each partner had two A4 sheet of paper. They crumbled one of the paper into a ball and kept the other as a sheet. The teacher asked them to predict which one would hit the ground first ,when they dropped from the same height at the same time. Then they were asked to explain their own prediction. After their observations, students revised their explanations. With this activity, students were able to experience and develop a simple understanding of air resistance.

Even though students were familiar with surface friction from daily life, they tested the motion of different materials over a ramp made by using their science textbooks. The teacher asked them to make predictions and and to explane the results, when they allowed different materials such as a pencil sharpener, eraser, cloth, sponge, etc. to slide freely. The students were asked to compare and contrast the distances the materials they tested moved on the ramp. Also they explored the effects of height (angle) on the sliding behavior of the materials.

Data Collection

To address the first, second and third research questions, a pretest of scientific concepts was given to three public and one private school. The questionnaire consisting of eight formative assessment probes (4 multiple choice and 4 open-ended questions) was administered (See Appendix A). The first set of four multiple choice type probes was adapted from Lair and Cook (2011). These probes were designed to test students' ability to predict real-events such as free fall and inertia. The second set of open-ended probes was designed to measure students' ability to explain inertia and friction in real-world contexts. The fifth probe adapted from Middle School Physical Science Diagnostic Assessment-Version 2.2, Misconceptions-Oriented Standards-Based Assessment Resource Center for Teachers (MOSART, 2010) measures students' conceptions about inertia. The sixth, seventh, and eighth probes were developed by the authors. The sixth probe measured students' level of understanding of inertia to apply to real-world contexts. The seventh probe was about free fall and air resistance. The final probe measured students' ability to scientificaly explain the use of seat belts. Data validity was verified by using multiple data sources: participants' predictions for the multiple choice questions, written explanations on the open-ended questions, verbally reported explanations to the teacher (the third author) and the third author's observations of her teaching. To check reliability of the categories, the first and second author separately coded the students' explanations to the open-ended questions at the beginning and at the end of the course. The inter-rater reliability coefficients were computed by using SPSS software. Inter-rater agreements for the pre and post probes were 87%, and 91%, respectively. To address the fourth research question the science curricula (Milli Eğitim Bakanlığı [MEB], 2005) and textbooks (Karaarslan, Altuntaş, Zengin, & Tütüncü, 2008; Tunç, Agalday, Akçam, Çeltikli-Altunoğlu, Bağcı, Bakar, Başdağ, İnal, İpek, Keleş, Gürsoy-Köroğlu, & Yörük, 2007) were analyzed qualitatively.

Data Analysis

The data from multiple choice probes was analyzed using descriptive statistics, means and standard deviations. In order to analyze students' explanations to the open-ended questions, a rubric was developed. The coding scale for each concept is presented in Appendix B. Students' answers were coded into three categories (0=represents no answer, wrong, irrelevant answers; 1=represents partially correct answers without elaboration; 2 represents integrated scientific perspective). The frequencies of students' coded answers to the open-ended questions were

computed. To answer the second research question responses, Analysis of Variances (A one-way ANOVAs) were computed by using pretest scores. Also, the Turkish science curricula and science textbooks were analyzed qualitatively in terms of including the application of theory to real-world context. To determine the effect of formative assessment probes integrated with extra-curricular hands-on science activities on students' understanding of the basic physics concepts, paired samples t-tests were computed using pre and posttest mean scores from the public school 1.

Results of Research

Degree to Which Students Understand the Tested Physics Concepts

To determine how well students understood the basic physics concepts (*mass, weight, inertia, air resistance, and gravity)* mean scores were computed on a 100 point scale. Table 1 presents means scores for private and public schools.

Table 1. Means and Standard Deviations of the Students' Understandings of the Concepts.

Schools	N	Mean	SD
Public school 1	31	31.00	10.60
Public school 2	32	29.10	12.90
Public school 3	54	18.10	11.10
Private School	80	33.00	17.20

Findings indicated that all students had poor conceptual understanding of the five basic physics concepts, especially application of their knowledge to real-world contexts. Out of 100 possible points, students in the three public schools scored 31.00, 29.10, and 18.10. Students in the private school scored 33.00.

In order to determine students' misconceptions, frequency analyses for each question were computed. For the first question, out of 197 students, only 9 (6% of them) chose the correct answer "both objects hit the ground at the same time, and their speed is the same." The common misconception was that "heavier balls fall faster than lighter balls". For the second question, 13 (7% of the students) chose the correct answer "neither of them. They have the same acceleration." The common misconception is that heavier objects' acceleration is greater. The third question tested students' understanding of inertia. Compared to the first two questions, students had a better overall understanding of inertia. However, they did not have a strong understanding of inertia, because only 42 (1% of the students) 9 = 6%, 13 = 7%, 42 = 1% chose the correct answer for the 3rd question "spaceship moves in a straight line forever". The fourth question was designed to test students' understanding of the difference between mass and weight. This question got the best overall results with 71 (6 % of the students) choosing the correct answer "traveling to the Moon, my mass remains the same but my weight changes."

Students' explanations to the open-ended real-world context formative assessment probe about inertia and friction were analyzed. The result of the analysis indicated that students' ability to explain real-world integrated probes were much worse than for multiple choice type probes. Students' explanations were coded from zero to two. Based on this coding schema, the percentages of correct explanations ranged from 0,5% to 11,2%. Probe five on had the overall lowest of explanation of all four open-ended probes with only 0,5% of students explaining the probe correctly. This would indicate that students have very little understanding of how to explain Newton's First Law or inertia in a real-world context. Probe six about also had a very low explanation rate; 5,1% of students explained the probe correctly. The general answer to this probe was: when a tire stops, the car stops. The correct explanation of this probe is that a tire can stop, but the entire car can slide or bounce and crash around. Probe seven concerning had the overall highest of explanation rate of all four open-ended probes with 11,2% students explaining the probe correctly. The general misconception or incorrect explanation was that "a paper ball was heavier than a paper sheet." For probe eight about, only 4,1% of the students explained the probe correctly. In general students know the benefits of fastening seat belts but they were not able to relate to inertia.

Comparison of Schools for Student Differences in Physics Concepts Understanding

To determine whether the private school and public schools differed significantly, an Analysis of Variance (A one-way ANOVA) was carried out. The dependent variable was the mean of questions answered correctly about the basic physics concepts. Results indicated that the students' understanding of the concepts across the four schools was significantly different, F (3, 197) = 12.89, $p < .001$. Tukey post-hoc comparisons of the private school with public schools indicated that private school students' understanding of the concepts (M=33.04; SD=17.20) was significantly different only from public school3 (M = 18.05; SD = 17.20). Comparisons of all four schools indicated that public school3 (M=18.05; SD= 11.10) was significantly different from the other three schools (public school1, M= 31.04, SD= 10.64; public school2, M=29.10, SD= 12,85; private school, M= 33.04, SD= 17.20). However, there was a significant difference among students' understanding of the concepts at the public school1 (M=31.04; SD=10.64), public school2 (M=29.10; SD=12.85) and private school (M=33.04; SD=17.20). Therefore, even though there was a difference between schools, all schools still had low conceptual understanding of the science concepts on a 100 point scale.

Analysis of Related Curricula and Teaching Materials

Identify the reason for overall poor understanding of the basic physics concepts, the content of the Turkish science curricula was analyzed in terms of engaging students to apply these concepts in real-world contexts. The Turkish science curriculum does not include any objectives on the laws of force and motion intended to integrate theoretical knowledge into real-life events (MEB, 2005). Students are expected to investigate relationships between force, mass, and the motion of objects and demonstrate the effects of balanced and unbalanced forces on an object in terms of gravity, inertia, and friction (MEB, 2005).

The definitions of basic physics concepts in the textbooks and the images, examples, and activities provided about them, and the end-of-unit assessment questions presented about them were examined in order to analyze the degree to which basic physics concepts were taught through integration with daily life events in those science and physics textbooks. In Turkish, inertia is defined as lack of activity or automation (TDK Sözlük, 2012). Inertia is referred to as balanced forces in science textbooks (Tunç et al., 2007), while it is indicated as the first law of Newton in physics course books (Karaarslan et al., 2008). It is generally described as an object's preserving its state of motion. The review of the images included in the middle school science textbook demonstrated that while 18 of these images were related to the 2nd law of motion of Newton, there were just 2 images about the first law of motion (inertia) of Newton. The textbooks did not give coverage to experiments that could enable students to have some experiences concerning inertia. For instance, there wasn't any activity demonstrating resistance of an object to change in its motion and direction. When the textbook of physics was examined, in order to teach the concept of inertia, the examples were given as: forward and backward movement of the passengers during a sudden braking; outbound aircraft with a constant speed at a certain height; and rain drops falling towards the ground at a constant (Karaarslan et al., 2008). However, textbooks do not link the causes of accidents that generally occur on busy highways and the concept of inertia (Karaarslan et al., 2008; TUIK, 2012; Tunç et al., 2007). Instead of this, the 2nd law of Newton and the various "algorithmic problems" about this law were extensively included in the physics textbooks. An algorithmic problem involves solving science problems by plugging numbers into specific equations to get the right answers. The difference between the concept of weight and mass are extensively included in the textbooks with visual examples from earth, other planets, and space.

Effect of Real-Life Integrated Formative Assessment Probes With Extracurricular Hands-On Science Activities on Students' Understanding of Physics Concepts

To determine whether the public school1 students' understanding of the concepts changed after intervention, paired samples t-tests were computed using pre and posttest mean scores. Table 2 presents the means and standard deviations of the students' understanding of the concepts before and after intervention at the Public school1.

Table 2. Mean Percentages Correct and Standard Deviations before and after Instruction.

Public School1	Pre-test		Post-test		t
N	M	SD	M	SD	
31	31.04	10.60	57.05	22.60	5.90*

*p<0.001

A paired sample t-test analysis indicates that the students understanding of the basic physics concepts at public school was statistically different, t (31) = 5.90, p <0.001.

Discussion

Analysis of the students' understanding of the basic physics concepts indicated that all students had poor conceptual understanding of the five basic physics concepts and lack of ability to explain these phenomena in real-world contexts. We found that those students retained these misconceptions even after having completed the appropriate coursework. For example, the first and the seventh formative assessment probes were aimed to extract the initial knowledge that students had about the effect of mass and volume on the speed of falling to the ground. The proportion of students answering both questions correctly was approximately 10%. This finding was consistent with research studies (Koray & Tatar, 2003; Yumuşak et al., 2004; Kocakülah & Açıl, 2011; Ayvacı et al., 2012). The common misconceptions were "heavier objects fall faster and they have greater acceleration". The proportion of correct answers given by students to the fifth, sixth, and seventh questions measuring their skills to explain real life events by using their knowledge about inertia varied between 0.5% and 11,20%. That is a very clear indicator that students did not understand the concept of inertia. The probe in which the understanding of the difference between mass and weight was measured was the question in which the highest ratio of correct answers was observed (71%). This higher ratio may be attributed to the fact that the difference between the said two concepts is emphasized very much in curriculum acquisitions and is explicitly taught through examples including various images in the science textbook.

When the performances of students from different schools were compared in terms of basic physics concepts, significant differences were found between schools. The most successful performance came from a private school (33.04 %) among the schools included in the present study. Two public schools, displayed performances of 31.04% and 29.10%. Thus, a success difference of approximately 4% was detected between the private and two public schools. The difference of 4% is below expectations since private schools are better than public schools in terms of physical conditions, science course hours, and the number of students in classrooms. Like students in public schools, private school students both form and hold misconceptions, making their ability to explain open-ended probes much poorer than one might pre-suppose. This result is consistent with previous studies (Yumuşak et al., 2004; Kocakülah & Açıl, 2011; Lair & Cook, 2011). For instance, it was found that although classrooms had better conditions, there were more course hours, and courses were more test-solving focused in private schools, students from these schools marked incorrect choices, or made incorrect explanations, or made no explanations in three-fourths of the questions about explaining and applying basic physics concepts to real life. This result reveals that students, regardless of school types, generally have low success in applying basic physics concepts to real life events. This is likely because; conceptual understanding cannot be achieved more drilling/testing. Many studies have demonstrated that these kinds of practices do not bring about any conceptual understanding among students (Stead & Osborne, 1980; Watts & Zylbersztajn, 1981; Watts, 1982).

The authors' review of the Turkish science curriculum revealed that it gives a little coverage to provision concerning the application of basic physics concepts to real- world events. The provision included in the science curriculum determine the content of textbooks. The review of textbooks showed that there are many deficiencies in the integration of the above-mentioned concepts with real life (Tunç et al., 2007; Karaarslan et al., 2008; TUIK, 2012). What is common is the traditional teaching approach that attempts to make students acquire theoretical knowledge through solving various algorithmic problems rather than applying the laws of motion introduced by Newton to real life events (Tunç et al., 2007; Karaarslan et al., 2008). This approach is in conflict with the recommendation that students should first learn how to solve qualitative problems concerning laws of nature, and then

be provided with teaching practices aimed at the solution of quantitative problems (Kavanagh & Sneider, 2007).

A post-test was administered at the end of the extra-curricular program and the results showed a significant increase in the scores of the students who participated. Evidence demonstrated that students who received extra-curricular hands-on science instruction integrated with formative assessment probes significantly outperformed and that result corroborates earlier studies' that found success was related to the method of course delivery (Hogan, Nastasi, & Pressley, 2000; Ruiz-Primo & Furtak, 2004; Yin et al., 2013). Similar to the findings of this, Yin et al., (2013) found that the middle-school students who were in the experimental group that received formative assessment got higher scores on general achievement tests and especially the performance assessment than the students in the control group.

Conclusions

The findings of the study strongly suggest that conceptual understanding cannot be achieved by students through direct transfer unless the prior knowledge and experiences, both valid and invalid, of students concerning basic physics concepts are put in the focus of the lesson. In science teaching practice involving direct transfer from the textbook, students just memorize basic physics concepts and algorithmic problem solutions, but they fail in explaining and applying their knowledge about the concepts to real-life events. The results suggest that current practices of teaching only from science textbooks is not enough for students to gain a working understanding of basic physics concepts. In this sense, it is necessary to generalize the use of formative assessment – a teaching approach where assessment and teaching are integrated into one another – over all science classes.

That schools generally have low success in applying basic physics concepts to real life events indicates that different school types adopt the same traditional teaching approach in which concepts are conveyed to students directly and students are tested via level determining exams rather than offering a learning experience aimed at conceptual understanding. The conceptual understanding cannot be achieved by students through more drilling/testing; the approach to education provided at schools appears far less than optimal.

The findings that science curriculum and textbooks give little coverage to the application of basic physics concepts suggest that science curriculum would be much enhanced by requiring students to learn key concepts by applying them to real-life events. While not an issue originally intended for this study, it is an attention-requiring situation that although there is a direct relationship between traffic accidents and the laws of motion of Newton, it is not included in the science and physics textbooks in Turkey. Many traffic accidents involving injuries and deaths take place both in Turkey (TUIK, 2012) and across the world due to the fact that inertia, one the laws of motion of Newton, cannot be understood or is not taken into consideration in traffic. This practical issue illustrates that science concepts are valuable to every one, not only to scientists. Thus, science and physics textbooks should definitely give coverage to the relationship between the laws of motion and the causes of traffics accidents as well as the rules to be observed in the traffic. In other words, it is of vital importance that the relationship between traffic accidents and the laws of motion of Newton should be made visible to students within the scope of science and physics courses. This is only one of many possible practical appllications of physics concepts that textbook authors and teachers might use for exciting students to learn and to improve their lives as a result. Such applications answer the ever-present question: Why is this boring stuff important to me?

The findings that science curriculum and textbooks gives a little coverage to the application of basic physics concepts suggest that science curriculum would be much enhanced by requiring students to learn key concepts by applying them to real-life events. It is an attention-requiring situation that although there is a direct relationship between traffic accidents and the laws of motion of Newton, it is not included in the science and physics textbooks in Turkey. Many traffic accidents involving injuries and deaths take place both in Turkey (TUIK, 2012) and across the world due to the fact that inertia, one the laws of motion of Newton, cannot be understood or is not taken into consideration in traffic. This practical issue illustrating that science concepts are valuable to every one, not only to scientists. Thus, science and physics textbooks should definitely give coverage to the relationship between the laws of motion and the causes of traffics accidents as well as the rules to be observed in the traffic. In other words, it is of vital importance that the relationship between traffic accidents and the laws of motion of Newton should be made visible to students within the scope of science and physics courses.

A significant increase in the scores of the students who participated in the extra-curricular hands-on science program suggests that academic activities just based on science textbooks are not enough for students to under-

stand the basic physics concepts, and there is need to include a variety of hands-on science activities These hands on activities utilized various modeling techniques which included videos and simulations involving authentic materials. To increase understanding, more time may have been needed for investigation and reflection. In order to improve Turkish students` general scores, changes of approaches in education, more constructivist practices in newly developed curriculum, and the use and diffusion of technology are definitely needed. In addition, Turkish teachers may conduct their own action research that might focus on using formative assessment and related probes to improve their students' conceptual understanding of basic physics concepts. that is not very common among Turkish educators that might also have been needed. Thus, designing formative assessment probes that engage students in applying their understanding of basic physics concepts to real-world contexts is essential to educate them to be scientifically literate.

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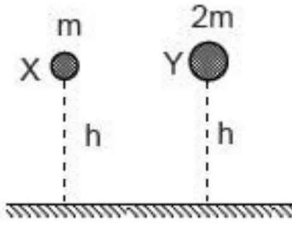
Appendix A: Formative Assessment Probes



Note: First and second questions will be answered the information below:

1. After studying a dynamic unit in school, a group of students got into a discussion about the following question related to free fall. What will happen when the two small objects are dropped at the same time at the same height? Object Y is twice as massive as the object X. This is what they say:

Ali:	Both of them hit the ground at the same time, but object X will be moving faster than the object Y when they hit
Mehmet:	Both balls will hit the ground at the same time, but the object Y will be moving faster than object X when they hit.
Ayşe:	Both objects hit the ground at the same time, and their speed is the same.
Ömer:	Object X hits the ground first, since it is heavier

Circle the name of the student you most agree with. Explain why you think that is the best answer.

---

2. Students also argue which ball has the greater acceleration during this fall. Here is what they say:

Ali:	Object X
Mehmet:	Object Y
Ayşe:	Neither of them. They have the same acceleration
Ömer:	Both of them drop with constant speed to the ground

Circle the name of the student you most agree with. Explain why you think that is the best answer.

---

3. In Earth and Space unit, a student wonders what would happen if a spacecraft left the Solar System and is in empty space where there are no forces.

Circle the answer that best matches your thinking.

A. Move in a straight line forever
B. Coast to stop
C. Move in a circular orbit around the galaxy
D. It is impossible to tell what the spacecraft will do
Explain your thinking. Describe the reasoning you used for your answer

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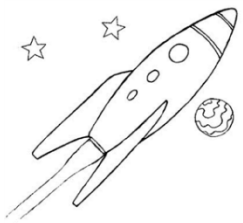
4. You wonder what would happen to your mass and weight while you are traveling to the Moon. Circle the answer that best matches your thinking.



A. My mass remains constant but my weight changes
B. Both my mass and weight remain the same
C. My mass changes but my weight remains the same
D. Both my mass and weight decrease
Explain your thinking. Describe the reasoning you used for your answer

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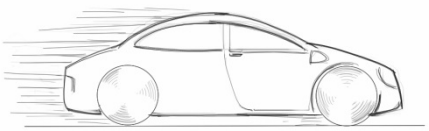
5. When studying force and motion, a group of students points out that a car will stop rolling on a flat surface unless you keep the engine on and in gear so that it continues to provide a force to run the wheels. They cite this situation as a violation of Newton's First Law of Motion (an object in motion continues in motion unless acted on by an outside force).
Do you agree or disagree with this group of students? Please explain your reasoning.



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6. Over a certain speed limit, by pressing the brake pedal, the tires can be stopped but the car will not. By turning the steering wheel, the tires direction can be changed, but the car will not.
Do you agree or disagree with these statements? Explain the reason for your answer.

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7. What will happen if two identical papers (one is a sheet and the other is crumbled) were dropped from the same height at the same time?


Explain the reason for your answer.

The vectors in the figure is not adequate. They should be different

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8. Fastening seat belts is a mandatory rule that we have to obey when we ride in a car. Beyond being a rule, please explain scientifically the reason for fastening the seat belt in the car.

Appendix B: Scoring Rubric for Open-Ended Probes

2: Integrated with scientific perspective (True prediction and explanation)
1: Partially correct or has no elaboration.
0: No response, wrong, or irrelevant answer.

Score	Question 5
2	If s/he can explain the reason that the car stops with two or more friction forces such as air resistance, tires and surface, or any moving parts in the car.
1	Is s/he can explain the reason that the car stops with only one friction force such as tires and surface or air resistance
0	No response, wrong, or irrelevant answer

Score	Question 6
2	Over a certain speed limit, the car's inertia will be bigger so by pushing on brake pedal, the tires will stop turning but the car will not stop instantly and it will slide. Also, by turning the steering wheel the tires will turn but the direction of the car will not change. For instance, in a sharp curve, if a car's speed is very high, it usually skids off the road.
1	If s/he only gives an example about the consequence of using brakes or steering wheel over certain speed limit such as sliding, skidding or turning over
0	No response, wrong, or irrelevant answer.

Score	Question 7
2	If s/he can true predict that a paper ball will hit the ground first. Also s/he can explain that the air resistance acting on a paper ball is smaller because of it has less surface area than a sheet of paper. The net force pulling the papers down is equal to the gravitational force minus air resistance force.
1	Is s/he can make a true prediction that "the paper ball hits the ground first" but they cannot relate their explanation with air resistance as an opposing force to the motion of the paper.
0	No response, wrong, or irrelevant answer.

Score	Question 8
2	If a person is driving a car at a certain speed, s/he has the same speed with the car. In a car crash, the person without a seat belt on will keep moving the same speed and the same direction. This will cause injuries or death in the car accident. However, if the seat belt is on, the seat belt will stop his motion and keep him seated in the car.
1	If s/he can make a true prediction about the consequence of not fastening seat belt in a car but cannot relate it to inertia.
0	No response, wrong, or irrelevant answer.

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