Student teachers' levels of understanding and model of understanding about Newton's laws of motion

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Abstract

This study was conducted to determine the level of student teachers' understandings of Newton's laws of motion and relating these levels to identify student teachers' models of understanding. An achievement test composed of two parts comprising 12 open ended questions was constructed and given to 45 pre-service classroom teachers. The first part of the test included 3 open-ended questions for each law asking students to explain a case, determine the physics law related to the case and write a case suitable for the related law. The second part was composed of three questions about defining Newton's laws of motion.

The data analysis was carried out in two stages. In the first stage, the analysis of understanding level showed that pre-service teachers were relatively successful at explaining a case about Newton's law of motion. However, their achievement in defining these laws was low. In the second stage, the analysis of the understanding model revealed that students developed different understanding models such as Optimum Model (OM), Uncreative Model (UM), Theoretical Model (TM), Practical Model (PM), Memorizing Model (MM) and Inappropriate Model (IM). As a result of the data analysis it was determined that only a few students had a scientific understanding model.

The results showed that the student teachers' have significant weaknesses in understanding the terms of fundamental knowledge of Newton's Laws of Motion. This may stem from the lack of student teachers to relate scientific knowledge with real life phenomena and experiences. Another result of this study is that defining the level of understanding and model of understanding students can help educators to prepare and implement teaching activities more effectively to promote students' thinking, discussing and interpreting skills.

Keywords: level of understanding, model of understanding, Newton's laws of motion

Introduction and Related Works

Effective learning of concepts and laws, constituting the basis of physics, is essential for understanding and explaining natural phenomena. This learning process has attracted many researchers' attention. Studies have shown that students have learning difficulties on basic physics concepts like; "force, acceleration, movement, gravitational acceleration and so on" (Atasoy, 2008; Aycan and Yumuşak, 2002; Bayraktar, 2006; Boeha, 1990; Clement, 1982; Eryılmaz and Tatlı, 1999; Kuru and Güneş, 2005; Legendre, 1997; Nuhoğlu, 2008; Osborne and Wittrock, 1983) and that these concepts have been referred to as abstract concepts which are difficult to learn by students ranging from primary school to university (Atasoy and Akdeniz, 2007; Bodner, 1990; Gilbert et al., 1982; Gilbert and Watts, 1983; Helm, 1980; Kuru and Güneş, 2005; Martinez et al., 2001;Osborne and Freeman, 1989; Watts and Zylbersztajn, 1981). It is asserted that students have not learnt the most basic Newtonian concepts and they have failed to comprehend most of the material taught in science courses.

Force is the central concept of Newtonian mechanics. Studies show that physics students have an alternative concept of force. Clement (1982) stated that when the concept of force is misunderstood at the qualitative level it is called a "conceptual primitive". Clement (1982) states that the source of this qualitative misunderstanding can be traced to a deep-seated preconception that makes a full understanding of Newton's first and second laws very difficult. Robertson, Gallagher and Miller (2004) argued that one of the most basic concepts related to force and motion is Newton's first law. They investigated student understandings of Newton's first law across a range of ages. They used a set of inquiry-based activities designed to help students understand the reasoning behind Newton's first law.

Studies have also been conducted to determine the difficulties students have with Newton's laws (Bayraktar, 2009; Galili and Tzeitlin, 2003; Smith and Wittman, 2007). Newton's laws are important because they have easily visible applications in the daily lives of students. McCarthy (2005) demonstrated how Newton's first law of motion applied to the everyday lives of students. He developed a learning cycle consisting of a series of activities to teach the concept of inertia. O'Shea (2004) demonstrated the action of Newton's second law by describing the forces involved during snowboard jumping, while Smith and Wittman (2007) developed three tutorials designed to improve student understandings of Newton's third law.

Hestenes, Wells and Swackhamer (1992) designed an instrument to probe student beliefs about force and how their beliefs compare with the many dimensions of the Newtonian concept. The Force Concept Inventory (FCI) is an instrument used to assess students' beliefs about force. It is based on the fundamental issues and concepts inherent in Newtonian mechanics. The Force Inventory Concept is composed of 29 multiple choices items to probe student understandings of basic concepts in mechanics. Newton's laws of motion are especially important when viewed in conjunction with other fundamental concepts in physics. The majority of research about force is designed to detect student misconceptions or alternative conceptions. These studies show that there are a considerable number of alternative conceptions related to Newton's laws among primary, secondary and university students (Bayraktar, 2006; Brown, 1989; Jimoyiannis and Komis, 2003; Kurt and Akdeniz, 2004; Maloney, 1984; Montanero et al., 1995). Some research has also demonstrated that such misconceptions also existed among pre-service teachers (Atasoy and Akdeniz, 2005; Kurt and Akdeniz, 2004; Trumper and Gorsky, 1996) as well as teachers (Kikas, 2004; Trumper, 2003). Interestingly, there has been limited number of studies about how to replace these misconceptions. Consequently, studies that attempt to replace such misconceptions have become increasingly important (Atasoy, 2008).

Conducting studies to detect and replace misconceptions is necessary, but they are not sufficient by themselves. In other words, effective learning is facilitated not only by investigating misconceptions, but also by investigating how to correct them, identify learning difficulties and remedy learners' mistakes. Determining learners' perceptions and developing learning environments that promote effective learning about forces, Newton's Laws and related topics can achieve this goal.

The aim of the present study is to determine student teacher levels of understandings about Newton's Laws of Motion and to identify student teacher models that underlie and inform those understandings.

Method

Sample

The sample for this study consisted of 45 elementary student teachers in an education faculty in the Black Sea Region of Turkey. The sample was randomly selected from second year student teachers undertaking an introductory physics course. A few parts of these students have already studied Newton's Laws of Motion in physics lessons in high school; but the other students took this subject for the first time in their physics courses at university.

Instrument and Data Collection Process

An achievement test, developed by the researchers, about Newton's Laws of Motion composed of 12 open-ended questions or items, was used as a data-gathering instrument. In the first part of the test, an everyday example or sample case was presented to students. They were asked questions about the 'sample case' that probed their ability to explain the sample case (*Item A*), determine the physics law explaining the sample case (*Item B*) and provide an additional sample case about related law (*Item C*). Overall, three questions were asked about Newton's three laws of motion, totaling nine questions in all. In the second part of the test, participants were asked three questions about defining Newton's laws of motion *(Item D)*. We introduce the test items below:

Problem (1)

a. Please describe the movement of a child on a scooter while the scooter is bumping against a barrier.
b. Which laws of physics can explain the movement of the child?
c. There are many more applications of this law that you have explained. Could you give one more example?
d. Please explain this law.

Problem (2)

a. Please consider your experiences about pushing a car that has a dead engine and explain the relation between the cars' acceleration according to the forces applied as $|F1|>|F2|>|F3|$.

b. Which physics' law can be used to explain the variance of acceleration values of the car pushed?
c. Please give an example referring to this law.
d. How can we explain this law?

Problem (3)

a. Please describe the movement of a person who has fired a rifle.
b. Which law of physics can explain this fact?
c. Please give another example confirming the presence of this law.
d. Define this law.

One researcher completed the data collection during introductory physics courses. Students were given 40 minute to complete the test and they were encouraged to freely express their thoughts. They were assured that it was not an examination and their answers were not to be used in order to evaluate their academic levels.

Pilot Study

In order to test the data collection instrument, a pilot study was conducted with 30 student teachers enrolled in an introductory physics course. The data provided by the pilot study was not included in the actual study. The students' papers showed that the items introduced above were understood by participants and provided data that could be analysed to answer the research question. Furthermore, the research questions and the achievement test were discussed by a group of researchers to confirm the validity of the test.

Data analysis

Student responses were analyzed in two ways. The first identified the student level of understanding and the second identified the student model of understanding. The analysis of understanding level is a suitable analysis method, which gives a general view of the academic level of participants about each question on an achievement test. On the other hand, the student model of understanding helps to analyze a student' answers to all questions about a subject, in other words, helps to analyze students' answers individually. In that way, one can find a link between the student's knowledge about a subject. In other words, one can reach some clues about student's mental model. Because mental models are used to construct new knowledge (Vosniadou and Brewer, 1992), it is important to reach some understanding about them. As there are mental models composed by the students behind the meaningful learning (Duit and Glynn, 1996 in Ünal and Ergin, 2006), putting forward the participants' general achievement about any subject is not only enough for arranging the instruction and education activities.

Student Level of Understanding

Data obtained from the instrument was analyzed to understand levels of understanding as suggested by Abraham et al. (1992) and adapted by Coştu (2002) (see Table 1).

Table 1 ***Categories Used to Determine Student Level of Understanding and Their Characteristics***

Level of Understanding	Criteria for Scoring
[0] No response (NR)	• Leaving blank • Answering "I don't know" • Answering "I don't understand"
[1] No Understanding (NU)	• Complete repetition • Irrelevant answer • Vague answer
[2] Incorrect Understanding (IU)	• Insensible information • Incorrect information
[3] Partial Understanding (PU)	• Answers that include only one aspect but not all aspects of a valid answer • Answers that include some aspects of a valid answer and some misunderstandings
[4] Sound Understanding (SU)	• Answers that include all aspects of a valid answer

Student Model of Understanding

In the second stage of the study, student answers were analyzed according to the models shown below in Table 2. These models were adapted from the Students' Model of Understanding in Typology of Perceived Knowledge as suggested by Saglam (2004).

Table 2. ***Understanding Models and their Characteristics***

Model of Understanding	Characteristics
OM (Optimum Model)	Student properly defines, utilizes, applies and exemplifies any piece of theoretical knowledge.
UM (Uncreative Model)	Student properly defines, utilizes and applies any piece of theoretical knowledge but fails in exemplifying it.
TM (Theoretical Model)	Student properly determines and defines any piece of theoretical knowledge but fails in applying and exemplifying it.
PM (Practical Model)	Student properly applies and exemplifies any piece of theoretical knowledge but fails in determining and defining it.
MM (Memorizing Model)	Student properly defines any piece of theoretical knowledge as the books do but fails in utilizing, applying and exemplifying.
IM (Inappropriate Model)	Student fails defining, utilizing, applying and exemplifying any piece of theoretical knowledge.

Student answers to the four questions about each law of motion were analyzed collectively to determine the characteristics of each individual's model of understanding. To achieve this, the characteristics of each Model of Understanding shown in Table 2 were applied to the items put to students and associated with the Level of Understanding described in Table 1. The relationships between students' model of understanding and students' level of understanding are shown in Table 3.

Table 3 ***The Relationship between Students' Model of Understanding and Students' Level of Understanding***

Model of Understanding	Characteristics	Levels for Items (A, B, C, D)
Optimum Model (OM)	Answers to each of the 4 questions requiring explaining the sample case, determining the law, exemplifying the law and defining the law about any of Newton's Laws of Motion are at level 3 [PU] or level 4 [SU].	$\begin{pmatrix} 3 & 3 & 3 & 3 \\ 4 & 4 & 4 & 4 \end{pmatrix}$
Uncreative Model (UM)	Answers to each of the 3 questions requiring explaining the sample case, determining the law and defining the law about any of Newton's Laws of Motion are at level 3 [PU] or level 4 [SU]. However, the answer for exemplifying the law question is at level 0 [NR], level 1 [NU] or level 2 [IU].	$\begin{pmatrix} 3 & 3 & 0 & 3 \\ 4 & 4 & \substack{1\\2} & 4 \end{pmatrix}$
Theoretical Model (TM)	Answers to the questions requiring determining the law and defining the law about any of Newton's Laws of Motion are at level 3 [PU] or level 4 [SU]. However, the answers for explaining the sample case and exemplifying the law questions are at level 0 [NR], level 1 [NU] or level 2 [IU].	$\begin{pmatrix} 0 & 3 & 0 & 3 \\ \substack{1\\2} & 4 & \substack{1\\2} & 4 \end{pmatrix}$
Practical Model (PM)	Answers to the questions requiring explaining the sample case and exemplifying the law about any of Newton's Laws of Motion are at level 3 [PU] or level 4 [SU]. However, the answers for determining the law and defining the law questions are at level 0 [NR], level 1 [NU] or level 2 [IU].	$\begin{pmatrix} 3 & 0 & 3 & 0 \\ 4 & \substack{1\\2} & 4 & \substack{1\\2} \end{pmatrix}$
Memorizing Model (MM)	Answers to the question requiring defining the law about any of Newton's Laws of Motion are at level 3 [PU] or level 4 [SU]. However, the answers for explaining the sample case, determining the law and exemplifying the law questions are at level 0 [NR], level 1 [NU] or level 2 [IU].	$\begin{pmatrix} 0 & 0 & 0 & 3 \\ 1 & 1 & 1 & \\ 2 & 2 & 2 & 4 \end{pmatrix}$
Inappropriate Model (IM)	The answers to all 4 questions requiring defining the law, explaining the sample case, determining the law and exemplifying the law about any of Newton's Laws of Motion are at 0 [NR], level 1 [NU] or 2 [IU].	$\begin{pmatrix} 0 & 0 & 0 & 0 \\ 1 & 1 & 1 & 1 \\ 2 & 2 & 2 & 2 \end{pmatrix}$

Levels of Understanding: [0]: No response; [1]: No Understanding; [2]: Incorrect Understanding; [3]: Partial Understanding; [4]: Sound Understanding

To determine the model of understanding for any given student about one of Newton's laws of motion, their levels of understanding for each item related to that particular law of motion were examined. For example, the levels of understanding for Student A for each of the four items about Newton's First Law of Motion were as follows: level 1 for item A; level 0 for item B; level 1 for item C and level 3 for item D. Using the matrices shown in the third column of Table 3, the model of understanding for Student A is the Memorizing Model.

Results

The findings from the achievement test are presented using the headings students' level of understanding and students' model of understanding.

A. Students' level of understanding

The findings from the achievement test are presented below after analysing each item about Newton's Laws of Motion.

Table 4 ***Percentages of Responses to Questions – Level of Understanding***

	First Law of Motion				*Second Law of Motion*				*Third Law of Motion*			
Levels	*A*	*B*	*C*	*D*	*A*	*B*	*C*	*D*	*A*	*B*	*C*	*D*
[0] NR	-	18	2	38	2	47	49	42	9	13	11	16
[1] NU	2	4	-	6	-	6	6	6	9	11	20	2
[2] IU	16	29	33	6	24	6	11	-	11	2	16	-
[3] PU	-	4	4	23	4	4	4	36	6	2	2	42
[4] SU	82	44	60	27	69	36	29	16	64	71	51	40

Levels of Understanding: [0] No response; [1] No Understanding; [2] Incorrect Understanding; [3] Partial Understanding; [4] Sound Understanding

Students' level of understanding about Newton's First Law of Motion (Law of Inertia)

Table 4 shows that all students answered the "explaining the sample case" question. Most of the answers (82%) were classified at the sound understanding level. The remaining responses were classified as incorrect understanding (16%) and no understanding (2%). However, only 44% of student responses about the question asking with "which law the sample case could be explained" were classified as sound understanding (level 4), while there were also significant numbers of incorrect understanding (29%) and partial understanding (18%) responses. The analysis of the levels in the first two questions showed that although the students knew that the car's matter had the tendency to move forward in the result of a car's sudden brake, they were not aware that this situation could be theoretically explained with the law of inertia.

Table 4 also shows that responses to the third question, requiring students to write a sample case about the Law of Inertia, were mainly classified as sound understanding (60%) and incorrect understanding (33%). There were no responses at the no understanding level and only a few responses at the partial understanding (4%) and no response (2%) levels. The percents of the levels for this question show that most of the students could give a similar event as an example by analyzing the sample event given in the first question. Sample answers given below show clearly the students' implication:

> Suppose that we are running down a slope. Even we try to stop immediately we cannot (Student 8).
>
> Water spills forward when we immediately stop while we are walking with a glass of in our hands (Student 25).
>
> An eraser on a book tries to keep its position when we draw the book away fast (Student 41).
>
> Victims in cars collided head-on rush forward (Student 31).

These answers were classified at the sound understanding level. However, a student answer classified at the incorrect understanding level was: *A flying bird hits against the wall (Student 44).*

Half the responses to the final question asking for a definition of the Law of Inertia were classified at the no response (38%), no understanding (6%) and incorrect understanding (6%) levels. However, 23% of responses were classified as partial understanding and 27% were classified as sound understanding. The percentage range among levels and the decline in the students' achievement can be correlated with the levels of achievements in item B. Because an important number of the students can't state correctly the law of physics expected in item B, the general achievement in this question has fallen according to the other questions. Thus it can be said that only a small part of the students that could state the related law couldn't correctly explain the law of inertia. Below are examples of some of the responses that were classified as insufficient and incorrect understanding:

> The law of inertia is defined as the product of all the forces applied on an object body (Student 8).
>
> Inertia is that stable objects (trees, traffic lamps etc.) seem as if they were moving, while we are traveling on a bus (Student 14).

Students' level of understanding about Newton's Second Law

Table 4 shows that 69% of students gave sound understanding level responses for explaining the sample case question about Newton's Second Law of Motion. However, this percentage was much lower for the other three questions (36%, 29% and 16% respectively). The students' achievement in the first question probably results from the fact that they have been expected to reason about the given situation rather than to make an explanation about the theoretical knowledge. This also explains that the students' general achievement has fallen progressively. Accordingly, whereas the students succeeded in the question related to procedural learning, they couldn't reach to the same success in the questions related to the conceptual learning.

When the responses to the first question about the second law were examined in detail, it was found that 69% of students gave scientific explanations and were classified at the sound understanding level (see Table 4). Most of the other responses for this question were classified at the incorrect understanding level (24%), with very few classified at the partial understanding level (4%) and no response level (2%).

The question that asked students to determine the physics law explaining the sample case shows that 47% of student responses were classified at the no response level. Answers classified at the sound understanding level (36%) were higher at than the remaining levels of no understanding (6%), incorrect understanding (6%) and partial understanding (4%).

Responses for the question requiring students to write a sample case that could be used to explain the second law of motion were classified as insufficient to a large extent. The responses to this question were mostly placed in the first three categories (no response, 49%; no understanding, 6%; and incorrect understanding, 11%). Examples of the no understanding responses were:

> The reaction of a dropped pen when it hits the floor (Student 10).

Cars stopping at different velocities (Student 30).

The remaining 29% of responses were classified at the sound understanding level, while 4% were classified at the partial understanding level.

Forty two percent of responses to the final question about Newton's Second Law of Motion were classified at the no response level. The remaining responses were classified at the partial understanding (36%), sound understanding (16%) and no understanding (6%) levels.

Students' level of understanding about Newton's Third Law

Responses to the four questions about Newton's Third Law of Motion were better than those for the other laws of motion. They were mainly at the sound understanding level (item A, 64%; item B, 71%; item C, 51%; and item D 40%). Students' achievement can be related to the simplicity of remembering the related law; because according to Newton's third law 'for every action, there is an equal and opposite reaction'. Besides, events explained by this law can be experienced in real life (for example, when we hit the wall, etc.), and these events increase the achievements level of understanding in the questions related to this law.

Table 4 shows that most of the responses explaining a sample case question about the Third Law of Motion were classified as sound understanding (64%) and partial understanding (6%) levels. However, there were 9% for no response, 9% for no understanding and 11% for incorrect understanding categories.

Seventy-one percent of responses to the question about determining the physics law explaining the sample case in the first question were at the sound understanding level. Nevertheless, there were 13% at the no response level and 11% at the no understanding level, while 2% were classified as incorrect understandings and 2% were classified as partial understandings.

Additionally, half the responses to writing a sample case for Newton's Third Law were classified at the sound understanding level. The no understanding level was 20%, the incorrect understanding level was 16% and the no response level was 11%, with 2% of responses classified at the partial understanding level. Examples of responses classified at the sound understanding and partial understanding levels were:

The backward movement of the body when someone kicks the wall (Student 1).

The backward reaction movement of arms when we hit sledgehammer on a stone (Student 23).

Backward shake when someone is putting the shot (Student 4).

A student's pulling his hand as soon as the teacher hits his hand with a stick (Student 9).

Forty two percent of responses asking for a definition of Newton's Third Law of Motion were classified as partial understanding with forty percent classified at the sound understanding level. Sixteen percent of the remaining responses were classified as no response and 2% as no understanding.

B. Students' model of understanding

To determine the Model of Understanding students used the main characteristics of responses were matched to the characteristics shown in Table 3. The resulting classifications are shown in Table 5.

Table 5 ***Percentage of Responses to Questions- Models of Understanding***

Model of Understanding	First Law of Motion	Second Law of Motion	Third Law of Motion
Optimum Model	31	22	40
Uncreative Model	7	16	16
Theoretical Model	-	4	9
Practical Model	31	11	11
Memorizing Model	2	2	13
Inappropriate Model	18	34	7
Others	11	11	4

Table 5 shows that the students' achievement changes according to the understanding models. According to that, Optimum Model appears more in the Third Law of Motion and appears less in the second Law of Motion. That is, an important part of the participants don't have the expected scientific knowledge related to the second Law of Motion. This situation is supported with the percentage observed in the inappropriate model in the second Law of Motion.

Recall that optimum model includes the knowledge nearest to the scientific knowledge, while inappropriate model includes the farthest knowledge.

Determining the model of understanding proved difficult for some students. Consequently, they were placed in the "others category". When responses from students placed in the others category were investigated, it was found that the majority of them answered the first two questions about one of Newton's laws then did not answer the remaining questions about that law.

Students' Model of Understanding about Newton's First Law of Motion (Law of Inertia)

When responses for each of the four questions about Newton's First Law of Motion were analyzed, it was found that 31% of the students used the optimum model while a further 31% used the practical model. This means that one-third of students gave acceptable answers for all questions, and another one third could apply knowledge effectively, but could not explain the theoretical bases of this knowledge. When optimum model is correlated with conceptual learning and practical model with procedural learning, it can be said that all students having optimum model have succeeded in all questions and the students having practical model have succeeded only in the questions involving practical using of knowledge as in the procedural learning. However, 18% of students were classified as using an inappropriate model, while 7% used the uncreative model and 2% used the memorizing model. No student used the theoretical model.

Students' Model of Understanding about Newton's Second Law of Motion

When responses for each of the four questions about Newton's Second Law of Motion were analyzed, the inappropriate model dominated. Thirty-four percent of students could not provide appropriate responses to any of the questions asked about this law. The situation related with this law, which is also known as the basic principle of dynamics, is very interesting. The fact that inappropriate model is the most appearing one is due in particular to the fact that Newton's Second Law of Motion is generally related to theoretical knowledge rather than to applications in daily life. Although this law is used to explain many physical phenomena, it doesn't enter the students' life like other laws, and it is not correlated with the interesting events.

However, 22% of students used the optimum model and were able to respond appropriately to all questions asked about this law. It was also found that 16% of students could not write a sample case for this law and were classified in the uncreative model category, while 11% of students used the practical model. Only one student, (2%) used the memorizing model and 4% used the theoretical model.

Students' Model of Understanding about Newton's Third Law of Motion

When responses for each of the four questions about Newton's Third Law of Motion were analyzed, it was found that more students gave appropriate answers to questions about this law than for the other two laws, with 40% of students classified in the Optimum Model category. Sixteen percent of students gave appropriate answers to the other questions except the one asking them to writing a sample case explained by the Third Law and so were classified in the uncreative model category. The proportion of students using the memorizing model was 13%, the practical model was 11% and the theoretical model was 9%. Additionally, the number of the students using an inappropriate model for Newton's Third Law was relatively low at 7%.

Results and Discussion

Student teachers' levels of understanding of Newton's Laws of Motion showed significant weaknesses in fundamental knowledge, particularly in providing scientific explanations. This result is consistent with previous research (Atasoy and Akdeniz, 2007) focusing on student misconceptions about Newton's Laws of Motion. This lack of understanding can be attributed to the inability of students to relate scientific knowledge with real life phenomena and experiences (Altınok et al., 2005; Akyaz et al., 2005; Devecioğlu and Akdeniz, 2006; Yağbasan and Gülçiçek, 2003). It suggests that the lack of real life examples in curricula experienced by students could be a significant factor contributing to their lack of understanding (Devecioğlu and Akdeniz, 2006; Gürses et al., 2003; Yüzbaşıoğlu and Atav, 2004).

This study also showed that student teachers developed alternative models of understanding about Newton's Laws of Motion, with only a small number using scientifically acceptable models of understanding. This result supports Atasoy and Akdeniz (2007) conclusion that student teachers have a tendency to learn concepts and complete topics in a superficial and somewhat meaningless way.

Newton's Laws of Motion have been included in primary, secondary and university curricula and play a fundamental role in explaining real life physical phenomena. The existence of alternative models to explain Newton's Law of Motion is attributed to weaknesses in teaching processes. Consequently, such weaknesses will be perpetuated and therefore play an important role in preparing and implementing future teaching activities, and will adversely affect the learning of future generations of students.

Consequently, using instructional materials that employ cognitive activities that promote student thinking, discussing and interpreting (Atasoy, 2008; Çepni and Kurt, 2004; Dekkers and Thijs, 1998; Devecioğlu and Akdeniz, 2006; Eryılmaz, 2002) and providing concrete real life examples (Ayvacı and Devecioğlu, 2008; Driver and Bell, 1986; Legendre, 1997; Posner et al., 1982; Tobin and Gallagher, 1987; White and Gunstone, 1992; Yiğit et al., 2002) are recommended when teaching fundamental physics concepts and topics related to Newton's Laws of Motion.

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