World Applied Sciences Journal 2 (S): 770-778, 2007
ISSN 1818-4952

Revelation of General Knowledge and Misconceptions about Newton's Laws of Motion by Drawing Method

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Abstract: The aim of this study is to reveal what basic knowledge and misconceptions students have about Newton's Laws of Motion by use of a drawing method. The sample consisted of 54 first grade students attending the Candidate of Elementary School Teacher at Pamukkale University. No pattern of drawing was suggested in order to allow students to state their knowledge of this topic freely and it was explained that any kind of drawing pattern and explanation could be used. As a result, it was found that drawing method was an effective way to source the basic knowledge and misconceptions shown by students. Whilst students had difficulty in expressing their knowledge in writing, it was seen that they expressed their knowledge easily by drawing.

Key words: Drawing Method · Newton's Laws of Motion · Misconceptions

INTRODUCTION

There are many ways of gathering information about students' understandings of scientific phenomena [1]. The open-ended questions Eisen and Stavy [2], two-tier diagnostic test Haslam and Treagust [3], concept mapping Hazel and Prosser [4], prediction-observation-explanation Liew andTreagust [5], interviews about instances and events Osborne and Cosgrove [6], interviews about concepts Abdullah and Scaife [7], drawings Martlew and Connolly [8], Prokop *et al.* [9], Bowker, R. [10] and word association Bahar *et al.* [11], Maskill and Cachapuz [12] can be given as the example of these methods. Each of these approaches has its own particular advantages and disadvantages and a useful distinction has been made between phenomenological and conceptually based approaches [13].

Behrendt and Dahncke [14] reported on student's understandings of their own internal structures with drawing method. discusses Also, Drawings have been considered as a simple research instrument that enables easy comparisons at the international level [9]. While many children dislike answering questions, drawings can be completed quickly, easily and in an enjoyable way. Children's drawings provide a 'window' into their thoughts and feelings, mainly because they reflect an image of his/her mind [15]. As a technique for exploring ideas, drawing taps holistic understanding and prevents children from feeling constrained by trying to match their knowledge with that of the researcher [1]. It is also a useful alternative form of expression for children who have difficulty expressing their thoughts verbally [16].

Where drawings have been used to probe understanding in science, they have been used in a variety of ways. Drawing activities in conjunction with interviews have been successfully used to explore children's ideas about abstract concepts, e.g. 'technology' [16] and more specific ideas, e.g. 'evaporation' [17]. In other studies, drawing content has been quantified, as e.g. in research into children's drawings of a forest[18]. In another study was used the children were asked to draw a person without being given any opportunity to practice beforehand [8]. Dove *et al.* [19], investigated children's drawings of a river basin, a concept linked to the water cycle. In other previous study McNair and Stei [20] fifth, eighth and eleventh grade students were asked to draw a plant and include plants part, functions and information about what plants need to grow in their drawing. Reiss and Tunnicliffe [21], Reiss, Tunnicliffe and Andersen *et al.* [22], Prokop and Fančovičová [9] used children's drawings to provide a reliable projection of what children know about the human body. Prokop *et al.* [23], used drawings to examine children's understanding about animal internal structure can be affected by several factors which are poorly understood by teachers.

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Johnstone and Mughol [24] reported that there are three main reasons for common misconceptions in Physics. Namely, education and the use of language on daily basis and everyday life experiences. In researches which were done in order to reveal the misconceptions in physics courses among secondary school students in Nigeria and South Africa, they showed teachers and course books (textbooks) as the main reason for misconceptions [25, 26]. Newton's Laws of motion are the most basic topic of classical physics. The complete learning of these topics by students is important to their understanding future physics subjects correctly.

Newton's Laws of Motion deal with the concepts of mass, movement and force. The first law, which is also known as Inertia Law, states that objects tend to keep its state of motion if there is no net force applied on them. This law is important, in a way, in terms of constituting the substructure of whole classical physics topics. Other law is the equality of $F=m.a$, which is known as basic principle of dynamics. This law is studying the relationship among the concepts of force, mass and acceleration is better known and applied more easily than the other laws by students [27, 28]. It is conspicuous as the law which is mostly dealt with and explained correctly even in this study. Action-reaction law which is the third law deals with application of a reaction force which is equal in size and opposite in direction to the force applied on this mass. It is observed that students have the most numbered misconceptions in this law among three laws.

One of the most frequently used methods used to determine the misconceptions in physics is multiple choice tests [26, 29-31]. Using these types of studies, it is difficult to determine how the students made their choice. Therefore, a drawing method was used in order to determine the students' present level and misconceptions.

This study reveals the present situations and misconceptions of students who have not yet taken General Physics course. General Physics course is given at second grade at Pamukkale University, this study was made with the first grade students who hadn't taken that course.

MATERIALS AND METHODS

This study was administrated to with 54 freshman students of Candidate of Elementary School Teacher at Pamukkale University. Knowledge levels of the students participated in the research was supposed to equals be equal because they registered in the faculty according to University Entrance Exam results. General Physics research group consisted of 31 girl and 23 boy students. They were asked to express Newton's Laws of Motion theoretically by drawing. In order to allow students to express their knowledge about the topic freely, no pattern of drawing was suggested and it was stated that any every kind of drawing pattern and explanation could be used. 30 minutes was given to each student to complete this study. A six level evaluation table was formed in order to evaluate theoretical knowledge and drawing with regard to Newton's Laws of Motion (Table 1). In this table which was applied to each law separately, theoretical knowledge and drawings were dealt with separately. Students' theoretical knowledge for each law and their drawings which were expressing that law were scaled from level 1 to level 6. For these levels, a points scale of 1 to 6 were given. Each law was evaluated separately according to this scale frame.

Table 1: A six level Evaluation Table which was formed to evaluate theoretical knowledge about Newton's Laws of Motion

Level 1	no theoretical knowledge
Level 2	wrong theoretical knowledge
Level 3	partly wrong or inadequate knowledge
Level 4	theoretical knowledge with misconception
Level 5	accurate but missing theoretical knowledge
Level 6	completely accurate and perfect theoretical knowledge

Table 2: A six level Evaluation Table which was formed to evaluate drawings about Newton's Laws of Motion

Level 1	no drawing
Level 2	irrelevant wrong drawing (Figure 2)
Level 3	partly wrong or inadequate drawing (Figure 3)
Level 4	drawing with misconception (Figure 4-5-6)
Level 5	accurate but missing drawing (figure 7-8)
Level 6	completely accurate and perfect drawing (figure 9)

In scaling, it was grouped as Level 1 for no theoretical information and drawing; Level 2 for wrong information and irrelevant drawing; Level 3 for partially wrong and inadequate information and drawing; Level 4 for information and drawing including misconception; Level 5 for right but inadequate information and drawing; Level 6 for completely accurate information and drawing. Sum of level 5 and level 6 were taken as an acceptable information and drawing level.

RESULTS AND DISCUSSION

Misconceptions about Newton's Laws of Motion resulted from this study were given in Table 3.

Table 3: Misconceptions regarding Newton's Laws of Motion observed in drawings

Misconceptions	Frequency	Ratio (%)
Inertia is a situation having no force	15	28.80
Inertia is related to the movement	20	38.40
The object will stop slowly If you remove the influencing force	18	34.60
Two stopping objects have the same inertia	13	25.00
The normal force affecting the object is every time equal to the objects weight	35	67.30
Friction Force is always opposite to the force applied to object	9	17.30
Friction force depends on the interaction surface	12	23.07
Action force applied to a small object by a big object is bigger than reaction force applied to big object by a small one	15	28.80
There may not be reaction force in responce to action force	14	26.92

Table 4: Evaluation Results of Theoretical Knowledge regarding Newton's Laws of Motion

		1.LAW		2.LAW		3. LAW	
		N	%	N	%	N	%
Level 1	no theoretical knowledge	8	14.81	4	7.40	9	16.66
Level 2	wrong theoretical knowledge	12	22.22	12	22.22	8	14.81
Level 3	partly wrong and inadequate theoretical knowledge	11	20.37	10	18.51	7	12.96
Level 4	theoretical knowledge with misconceptions	15	27.77	9	16.66	21	38.88
Level 5	accurate but incomplete theoretical knowledge	6	11.11	15	27.77	5	9.25
Level 6	completly accurate and perfect theoretical knowledge	2	3.70	4	7.40	4	7.40

Table 5: Evaluation Results of drawings regarding Newton's Laws of Motion

		1.LAW		2.LAW		3. LAW	
		N	%	N	%	N	%
Level 1	no drawing	3	5.55	3	5.55	4	7.40
Level 2	irrelevant wrong drawing	11	20.37	9	16.66	10	18.51
Level 3	partly wrong and inadequate drawing	18	33.33	12	22.22	8	14.81
Level 4	drawing with misconceptions	10	18.51	9	16.66	22	40.74
Level 5	accurate but inadequate drawing	8	14.81	17	31.48	8	14.81
Level 6	completely accurate and perfect drawing	4	7.40	4	7.40	2	3.70

Only 14,80% of the theoretical knowledge given about first law is in acceptable level. It shows that they didn't have enough information about this topic (Table 4). Inertia law which was perceived only to "If object is stopping, it tends to stop" by students is a difficult topic to explain. A common misconception of students about this law is that inertia is valid only for stopping systems.

Acceptable level of theoretical knowledge about second law is 35.17%. For the second law, becoming known better or becoming more lasting can be bound to basic mathematical equality expressing this law. The equality of $F=m.a$ shows the relationship among the related concepts clearly. But still partially or completely wrong answers' ratio (40.73%) is quite high. The least misconception ratio (16.66%) is also found for this law. Misconception is an expression of "friction force is always opposite to the force influencing the object", whereas a force in the direction of friction force can be applicable. For example, on a horizontal and frictional ground, the force influencing oppositely the movement is in the same direction with the friction force of a slowing object.

isconception level of third law is 38.88% for theoretical knowledge and 40.74% for drawings. That gives a clue as to how big the present misconceptions are. The clearest misconceptions for this law are: a)There may not be a reaction force for each action force, b) Action and reaction forces may not be the same every time.

According to the applications, although there aren't any mathematical equations or explanative expressions, drawings were encountered even if they are very simple. For example, in spite of 38.87% ratio for theoretical knowledge for level 1, we see a 18.5% drawing ratio. So, it can be said that they don't like theoretical knowledge only by writing, but in the contrary they can express themselves more freely by drawings. So quality of knowledge can be determined more clearly.

Table 6: Drawings used in expressing Newton's Laws of Motion and their numbers

Topic	Type of the object used	Frequency
1. Law	Stopping Object	25
	Falling of an apple from a tree	12
	Force applied ball	9
	Object set free from a building	2
	Passengers in a vehicle	1
2. Law	Object on an inclined plane	3
	Falling of an apple from a tree	24
	Moving car	8
	Force applied car	11
	A pendulum in a moving vehicle	2
	Objects hanging on fixed bobbin	1
3. Law	A ball kicked by a footballer	11
	A stationary object on the table	19
	Falling of an apple from a tree	6
	Colliding cars	6
	Man applying force on the wall	7

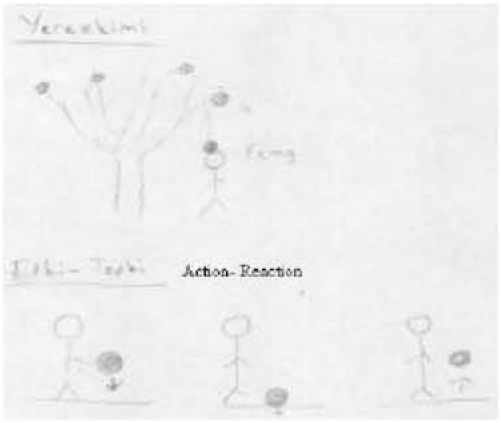


Fig. 1: Two drawings mostly used for expressing Newton's Laws by students

As it is seen on Table 4 and Table 5, the ratio of theoretical answering is higher than drawing one at level 1. That is, students can express their knowledge by drawing more easily. It is clear that students gave up expressing by writing when they had difficulty in writing. Beside, try to express by drawing. High drawing ratio level at level 5 is a result of this. While they had difficulties with expressing what they knew true by writing, they expressed it more easily by writing. In the same way, it is seen at the comparisons at level 2 and level 3 that they express their knowledge more clearly and easily by drawing method.

Generally for each law, while there is a definite image shaped in students' mind, we see a few number of

Fig. 2: Wrong drawings which are examples of level 2

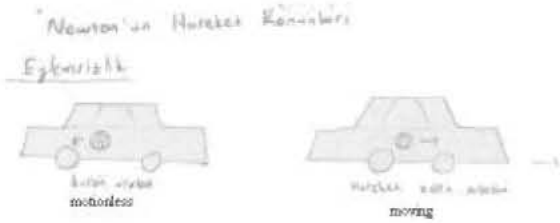


Fig. 3: An example of partly wrong and inadequate drawings

students choosing the way of expressing their knowledge by peculiar drawings. Eg, when Newton's laws of motion is mentioned, the ratio of drawings of man with a apple falling from a tree onto his head cannot be ignored. 42% of all the students used that figure in order to explain any of the laws of motion (Figure 1). That image which is rather popular in daily life became the symbol of gravitational force. The same way the image of a stopping vehicle with passengers on a horizontal surface is used to explain the inertia law. Also, the image of a motionless book on the table and colliding cars for action and reaction are used quite frequently.

At level 2, there are irrelevant or wrong drawings. 20.37% of drawing about Newton's First Law, 16.66% of drawings about second law and 18.51% of drawings about third law are included in that way. We see that students who have insufficient knowledge about topic is reflected in their drawings.

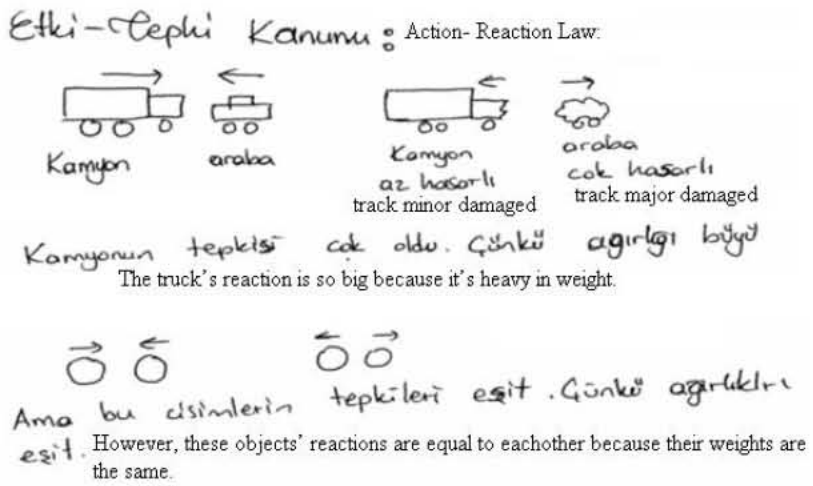


Fig. 4: A drawing having determined a misconception about Newton's Third Law

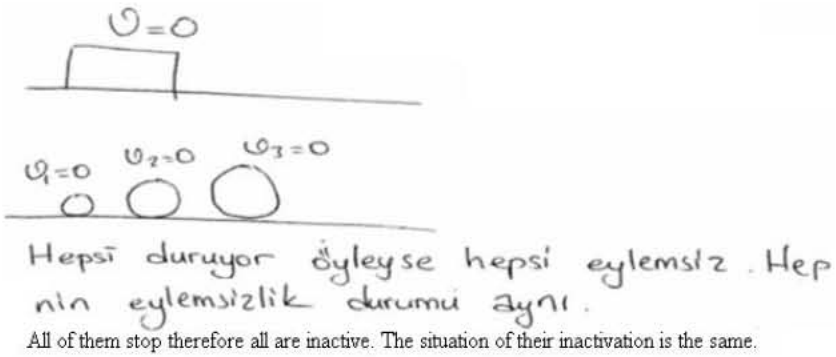


Fig. 5: A drawing having determined a misconception about Newton's First Law

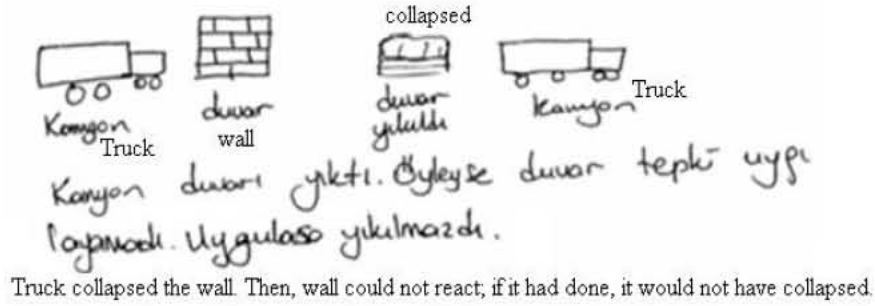
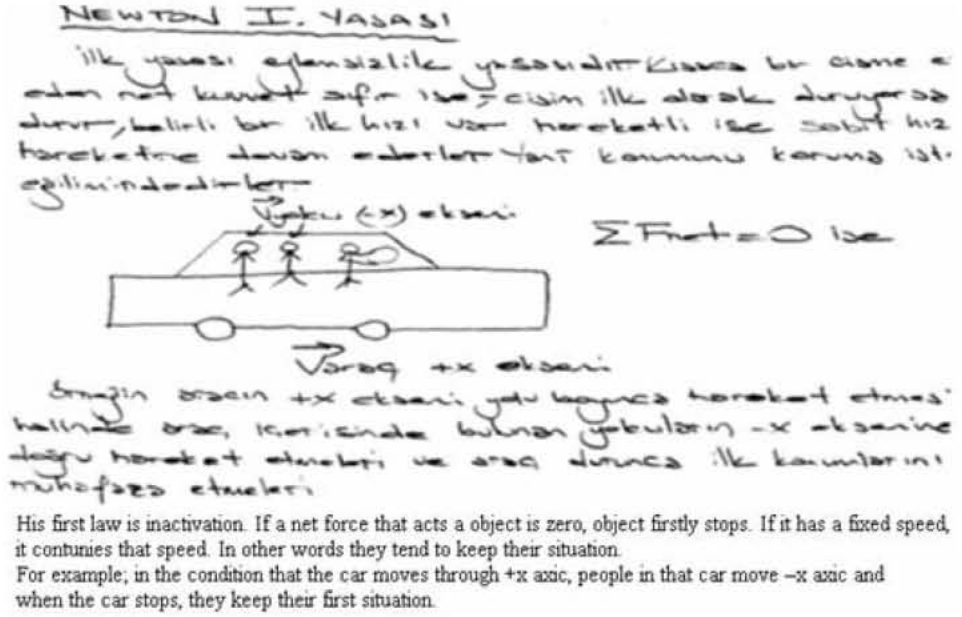


Fig. 6: Another drawing having determined a misconception about Newton's Third Law

There are misconceptions at level 4. At this level, excessive generalization can be stated as the most important reason of encountered misconceptions. Students reached a general judgment by emphasizing a unique set of criteria as applicable for every situation. Students stated physical concepts wrongly by misinterpreting a mass of every day events and generalizing their interpretations.

Drawings for level 5 are generally true drawings but they have some deficiencies. An image of an object at balance on a horizontal surface is not enough to express third law of motion. Explanation of the properties of action-reaction force pair is more important for less frequent situations. Especially it must be considered that students having a misconception of "normal force affecting the object always equals

(a)



His first law is inactivation. If a net force that acts a object is zero, object firstly stops. If it has a fixed speed, it contunies that speed. In other words they tend to keep their situation.
For example; in the condition that the car moves through +x axic, people in that car move –x axic and when the car stops, they keep their first situation.

(b)

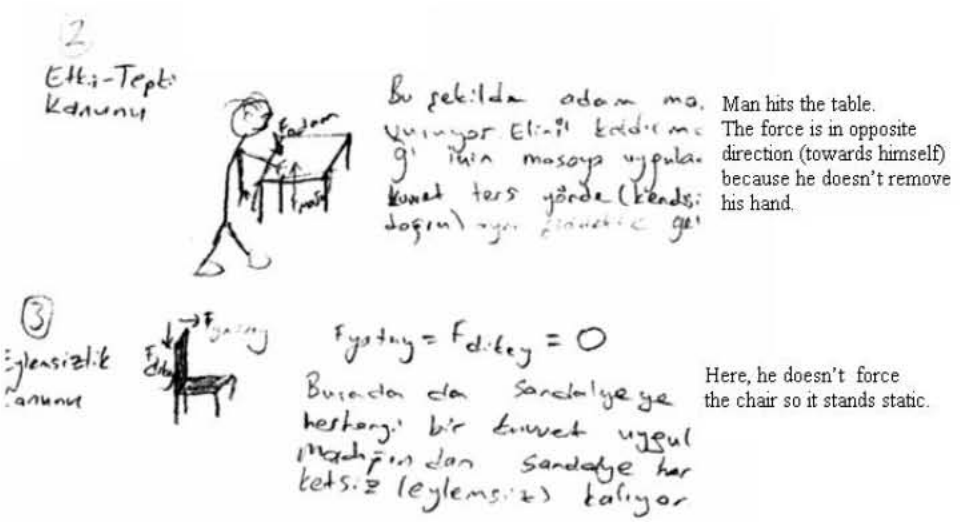


Fig. 7: Two drawings (a, b) of level 5 expressing First and Third laws of motion

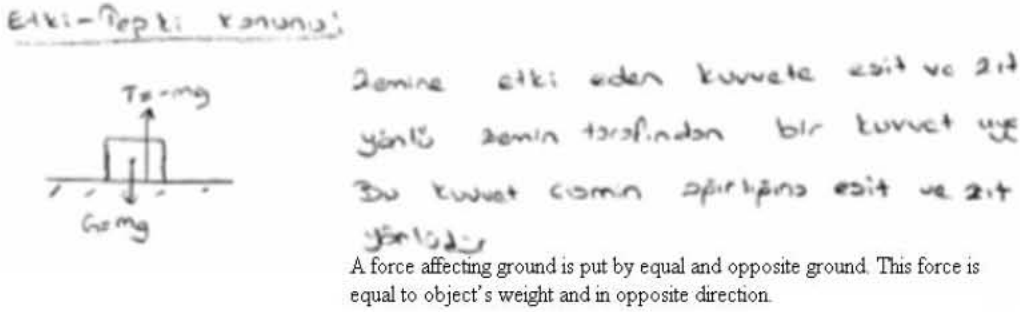


Fig. 8: A drawing expressing action-reaction law

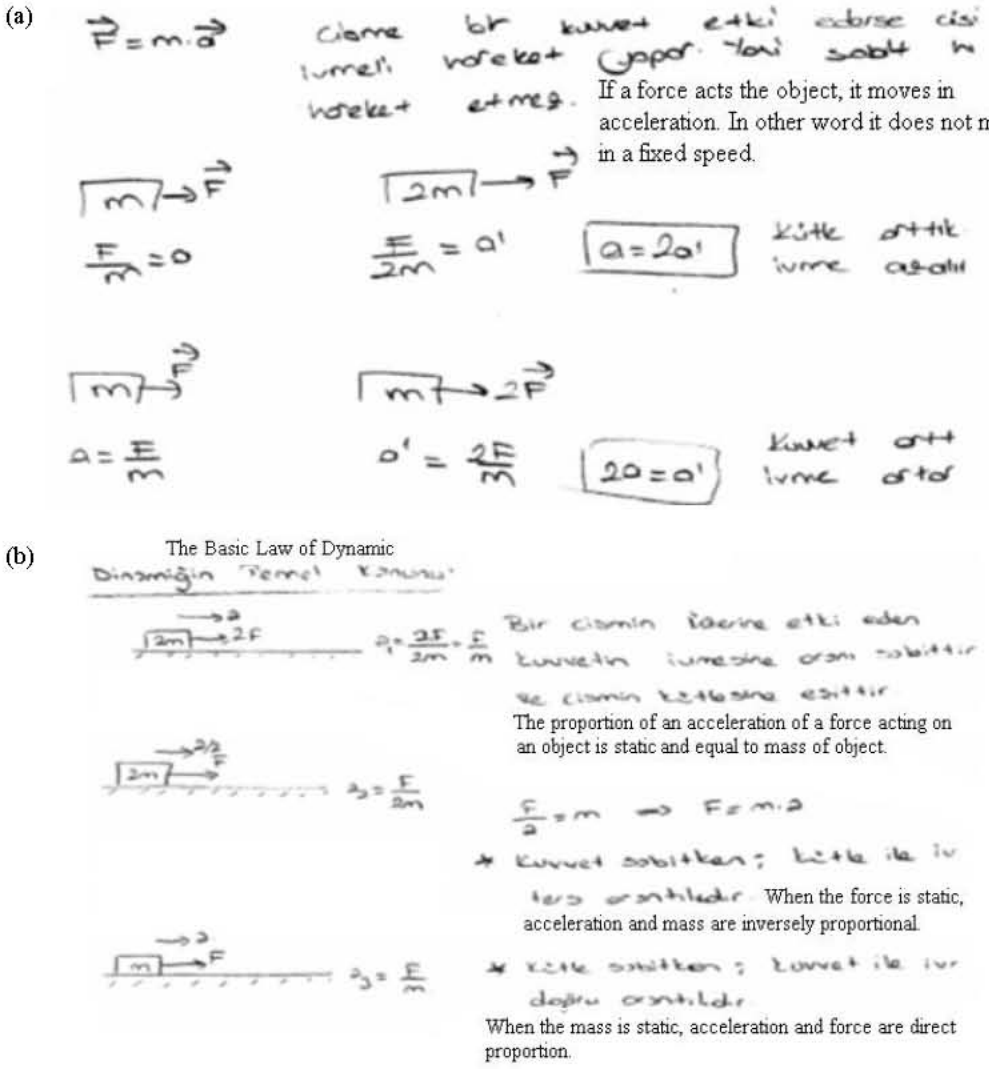


Fig. 9: Examples of completely accurate and complete drawings category (a, b)

the weight of the object" can also have the same drawing.

Drawings of level 6 show complete and true drawings. Drawings supported by necessary equalities express integrity and gives the idea that students have enough knowledge about the topic.

RESULT

Drawing method is used in order to reveal the present level and misconceptions of students who didn't take General Physics course. When we look at the results, we see that using writing alone, students have difficulty expressing theoretical knowledge. Using the same criteria it was seen that they express themselves more freely by drawings. Therefore, drawing method as used is capable of showing the quality and quantity of knowledge understood by students more clearly.

REFERENCES

1. White, R. and R. Gunstone, 2000. Probing understanding, London, Falmer Press.
2. Eisen, Y. and R. Stavy, 1988. Students' understanding of photosynthesis. The American Biology Teacher, 50(4): 208-212.
3. Haslam, F. and D.F. Treagust, 1987. Diagnosing secondary students' misconceptions of photosynthesis and respiration in plants using a two-tier multiple-choice instrument. Journal of Biological Education, 21(3): 203-211.

4. Hazel, E. and M. Prosser, 1994. First-year university students' understanding of photosynthesis, their study strategies and learning context. The American Biology Teacher, 56(5): 274-279.
5. Liew, C.W. and D.F. Treagust, 1995. A predict-observe-explain teaching sequence for learning about students' understanding of heat and expansion of liquids. Australian Science Teachers' Journal, 41(1): 68-71.
6. Osborne, R.J. and M.M. Cosgrove, 1983. Children's conceptions of the changes of state of water. Journal of Research in Science Teaching, 20(9): 825-838.
7. Abdullah, A. and J. Scaife, 1997. Using inteviews to assess children's understanding of science concepts. School Science Review, 78(285): 79-84.
8. Martlew, M. and K. Connolly, 1996. Human figure drawings by schooled and unschooled children in Papua New Guinea. Children Development, 67: 2743-2762.
9. Prokop, P. and J. Fančovičová, 2006. Students' ideas about the human body: Do they really draw what they know? Journal of Baltic Science Education, 2(10): 86-95.
10. Bowker, R., 2007. Children's perceptions and learning about tropical rainforests: an analysis of their drawings, Environmental Education Research, 13(1): 75-96.
11. Bahar, M., A.H. Johnstone and R.G. Sutcliffe, 1999. Investigation of students cognitive structure in elementary genetics through word association tests. Journal of Biological Education, 33(3): 134-142.
12. Maskill, R. and A.F.C. Cachapuz, 1989. Learning about the chemistry topic of equilibrium: The use of word association tests to detect developing conceptualizations. International Journal of Science Education, 11(1): 57-69.
13. Driver, R. and G. Erickson, 1983. Theories-in-action: some theoretical and empirical issues in the study of students' conceptual frameworks in science. Studies in Science Education, 10: 37-60.
14. Behrendt, H. and H. Dahncke 2002. Research in Science Education past, present and future, Kluwer Academic Publishers, New York, Boston, Dordrecht, London, Moscow.
15. Thomas, G.V. and A.M.J. Silk, 1990. An introduction to the psychology of children's drawings. Hemel Hempstead: Harvester Wheat sheaf.
16. Rennie, L.J. and T. Jarvis, 1995. Children's choice of drawings to communicate their ideas about technology. Research in Science Education, 25: 239-252.
17. Schilling, M., L. McGuigan and A. Qualter, 1993. The primary science and concept exploration (SPACE) project. Investigating, 9: 27-29.
18. Strommen, E., 1995. Lions and tigers and bears, Oh my! Children's conceptions of forests and their inhabitants. Journal of Research in Science Teaching, 32: 683-698.
19. Dove, J.E., L.A. Everett and P.F.W. Preece, 1999. Exploring a hydrological concept through children's drawings. International Journal of Science Education, 21(5): 485-497.
20. McNair, S. and M. Stein, 2001. Drawing on their understandings: Using illustrations to invoke deeper thinking about plants. Proceedings of the 2001 Annual International Conference of the Association for the Education of Teachers in Science. Costa Mesa, CA: Association for the Education of Teachers in Science.
21. Tunnicliffe, S.D. and M.J. Reiss, 1999. Student's understanding about animal skeletons. International Journal of Science Education, 21(11): 1187-1200.
22. Reiss, M.J., S.D. Tunnicliffe, A.M. Andersen, A. Bartoszeck, G.S. Carvalho, S.Y. Chen, R. Jarman, S. Jónsson, V. Manokore, N.Marchenko, J. Mulemwa, T. Novikova, J. Otuka, S. Teppa and W.V. Rooy, 2002. An international study of young peoples' drawings of what is inside themselves. Journal of Biological Education, 36: 58-64.
23. Prokop, P., M. Prokop, S.D. Tunnicliffe and C. Diran, 2007. Children's ideas of animals' internal structures. Journal of Biological Education, 41(2): 62-67.
24. Johnstone, A.H. and A.R. Mughol, 1976. Concepts of physics at secondary level, Phys. Educ,. 11(7): 466-469
26. Ivowi, U.M.O., 1984, Misconceptions in physics amongst Nigerian secondary school students. Phys. Educ., 19: 279-285.
27. Helm, H., 1980, Misconceptions in physics amongst South Africa students, Phys. Educ., 15: 92-105.
28. Mazur Eric, 1997. Peer Instruction: A User's Manual, Prentice Hall, Upper Saddle River, NJ.
29. Yakar, H. and I. Kara, 2007. Effects of Computer Supported Education on the Success of Students on Teaching of Newton's Laws of Motion. World Applied Sciences Journal, 2(6): in press.
30. Atasoy, Ş. and A.R. Akdeniz, 2007. The development and application of a test intended for determine to misconceptions on subject the Newton's Laws of Motion, Journal of Turkish Science Education, 4(1): 45-59.

31. Savinainen, A. and P. Scott, 2002. The Force Concept Inventory: A Tool for Monitoring Student Learning. Physics Education, 37(1): 45-52.
32. Jimoyiannis, A. and V. Komis, 2003. Investigating Greek Students' Ideas about Forces and Motion. Research in Science Education, 33: 375-392.
33. Trumper, R., 2003, The Need for Change in Elementary School Teacher Training a Cross-College Age Study of Future Teachers' Conceptions of Basic Astronomy Concepts. Teaching and Teacher Education, 19: 309-323.