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UNIVERSITY STUDENTS' DIFFICULTIES AND MISCONCEPTIONS ON ROLLING, ROTATIONAL MOTION AND TORQUE CONCEPTS

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ABSTRACT

Rolling, rotational motion and torque is one of the main subjects of physics that the students have difficulties to comprehend. The aim of this study is to determine university students' difficulties and misconceptions about rolling, rotational motion and torque. The sample of the study consists of 100 students majoring mathematics education at Balıkesir University, Necatibey Faculty of Education, in the academic year of 2013-2014. The descriptive survey method was carried out in the study. There was one instrument, the Rolling, Rotational Motion and Torque Concept Test, consisted of 20 multiple-choice questions related to subject areas, in the study. The reliability coefficient of the test was found as r=0.66. After analyzing data obtained from the study, it was found out that university students have many difficulties understanding, applying and interpreting many fundamental concepts related to rolling, rotational motion and torque. It was also found that students' achievement levels were very low and they have many misconceptions about the subjects.

Key Words: University students, difficulties and misconceptions on rolling, rotational motion, torque concepts.

INTRODUCTION

Students come to the classroom before formal instruction with various ideas that mostly reflect their life or depend on their experiences (Widodo, Duit & Müller, 2002). These ideas developed by the students are generally intuitive and/or naive ideas that contradict scientifically accepted knowledge (Lautrey & Mazens, 2004). Students' naïve ideas about their environment are important because those kinds of ideas shape and affect their future learning. According to Ausubel's learning theories, the most important factor affecting learning is student's prior knowledge (Özmen, 2005). Ausubel (1963) and Gagne (1965) had highlighted the importance of those kinds of prior knowledge in learning science and some other core concepts in education. The student's prior knowledge gives us some information about their scientific beliefs and also their pre-conceived ideas. (Hewson & Hewson, 1983). Clement, Brown and Zeitsman (1989) indicated that students' prior knowledge might or might not conform to the scientifically accepted ideas. Although, it is very difficult to identify and reveal, misconceptions or alternative conceptions are necessary to confront them and also to improve teaching activity in a classroom setting (Brown and Clement, 1987; Hewson and Hewson, 1991; Terry, Jones & Hurford, 1985).

There is a little study of the literature related to concepts of rolling, rotational motion and torque. For example; Pol, Harskamp, Suhre, & Goedhart (2008) studied on high school and undergraduate students' ideas about torque concept. Rimoldini and Singh (2005) designed to reveal 669 undergraduate students' ideas about rolling and rotational motion and torque concepts. In their study, they concluded that students have difficulties to understand the torque concept and they generally confused about force and torque concepts. Furthermore, according to their conclusion, some of the misconceptions that encountered among students were: 'torque is force's angular state' and 'constant torque produce constant angular velocity'. Also they reported that some students confused about the role of torque on velocity or acceleration change. Another study related to torque was done by Klammer (1998). He identified from his study these misconceptions about torque concept: Students think that "every force acting on an object produces a torque" and "torque is the same as force and also has the same direction''.

Bostan-Sarıoğlan and Küçüközer (2013) aimed to reveal the prior knowledge of 133 tenth grade students about torque, conservation of angular momentum and Kepler's second law of motion. In their study, they asked the students three open-ended questions related to torque, angular momentum and Kepler's second law of motion concepts. Students' prior knowledge about torque and angular momentum was conflicting with scientific ideas about torque and angular momentum and students had misconceptions about given all of the subject area as indicated before.

Palmieri and Strauch (1963), Williamson, Torres-Isea and Kletzing (2000) carried out about conservation of angular momentum. Palmieri and Strauch (1963) had been demonstrated from their experiment that students had many misconceptions about angular momentum. Some of were: "objects that move through the line do not have angular momentum" and "angular momentum is not a vector quantity.''

Determining university undergraduate students' difficulties and misconceptions about rolling rotational motion and torque is very important to shape future physics classes to confront their difficulties and to eliminate their misconceptions.

PURPOSE

The purpose of this study is to determine university students' difficulties and misconceptions about rolling, rotational motion and torque concepts. To fulfill this purpose the following questions are posed:

Research Questions

1. What are the university students' difficulties and misconceptions about rolling, rotational motion and torque concepts?
2. Is there any significant difference between male and female students' rolling, rotational motion and torque conceptual test scores?
3. Is there any significant difference between two sections students' rolling, rotational motion and torque conceptual test scores?

Limitations

This research is limited to, the following;

1. Academic year of 2013-2014.
2. Total 100 students at Balıkesir University, Necatibey Faculty of Education
3. The subject of rolling, rotational motion and torque and related to conceptual test.

METHOD

Sample

The sample of the study has been chosen from 100 prospective mathematics teachers who take a general physics course at Balıkesir University, Necatibey Faculty of Education during the academic year of 2013-2014. The distribution of the sample according to branches is given in Table 1.

Table 1: The distribution of students according to the branches

Branch	Girl	Boy	Number of students (N)
2A	29	8	37
2B	9	7	16
3A	15	3	18
3B	22	7	29
Total	75	25	100

Instrumentation

In the study, there was only one instrument, related to Rotational Motion, Angular Momentum and Tork concepts. The test, consists of 30 multiple choice questions, was first introduced by Lorenzo, Rimoldini and Singh (2005). It is design to cover subject areas torque, moment of inertia, and rotational kinetics energy, angular acceleration, rolling, rolling with friction and sliding on incline plane. The detail distribution of questions related to concept area is given in Table 2.

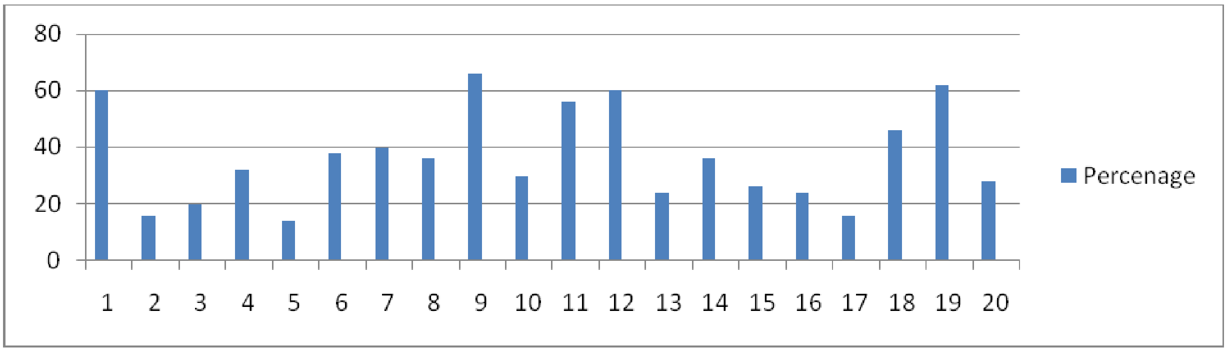
Table 2: The distribution of questions related to concept area in the test

Concepts	**Questions regarding concepts**
Torque	5, 8, 9, 10, 11, 17, 18, 19, 20,
Moment of inertia	4,15
Rotational kinetic energy	1, 2, 3, 16
Angular speed/velocity	5, 17
Angular acceleration	5, 10, 11
Rolling (relative motion)	6, 7, 16
Rolling (role of friction)	12, 13
Sliding on inclined plane	14

Procedures

After translating conceptual test into Turkish, the test controlled and checked by some physics instructors and then applied to 50 undergraduate students as a pilot study. According to students' responses reducing the 10 questions the final conceptual test, consisted of 20 multiple questions, was finalized to use in the study. And then this test was applied to 100 prospective mathematics teacher students. Applying and analyzing this test to students, the reliability of the final version of the test was calculated as r=0,636.

Difficulty coefficient is a measure of the degree of difficulty of the questions that make up a test. Difficulty factor has a value ranging from 0 to 1. When difficulty factor approaches 1 test question thought as easy, then it approaches 0, it is thought difficult (Demirci & Çirkinoğlu, 2004). According to Rolling, Rotational Motion and Torque conceptual test, obtained from this study, difficulty coefficient was ranged between 0.16 and 0.66 and average difficulty level of 0,37 (see, Picture 1).



Graphic 1: The Difficulty coefficient (in %) of rolling, rotational motion and torque concept test

Statistical Analysis

The analysis of the test was done using the SPSS 19 programme. To compare significant difference between male and female students' rolling, rotational motion and torque conceptual test scores, an independent t-test was used. Also to determine if there is any statistical difference between students' branches from test scores obtained from conceptual test one Way Anova Test and LSD (Fisher's Least Significant Differences) were used.

RESULTS

After analyzing data, students' average rolling, rotational motion and torque conceptual test score was found as 36,4%. Distribution of students' answer according to each question is given in the Table 3.

Table 3: The answers are given by students and their rates

Q	A (%)	B (%)	C (%)	D(%)	E(%)	C.A (%)
1	24	4	**65**	6	0	**65**
2	42	**22**	19	12	5	22
3	10	**13**	72	1	4	13
4	16	17	**35**	18	6	35
5	22	15	23	22	**9**	**9**
6	15	**34**	37	8	5	34
7	41	13	2	4	**36**	36
8	12	11	**39**	27	9	39
9	3	27	10	**55**	4	55
10	10	3	6	**33**	34	33
11	14	10	**55**	5	13	55
12	12	11	15	2	**51**	51
13	23	14	**19**	26	10	19
14	**48**	17	12	3	13	48
15	5	14	**25**	31	20	25
16	28	14	22	**24**	9	24
17	7	**25**	19	36	7	25
18	12	14	13	13	**44**	44
19	**59**	17	10	6	5	59
20	**35**	12	19	3	28	35

As shown in Table 3, in general, all of the correct answer percentage was below the 50%. The most correct answer is given in question 1 with 65% while at least correct answer is given in question 5 with 9%. This question is related to concept of torque. The test results reveal that students lack a coherent understanding of torque concept and have difficulty applying it in different physical situations. Some detail results according to concept by concept are given the following part.

Torque (Question 5,7,8,9,10,11,17,18,19,20)

The least correct answer rate was given in 5th question with 9%. It can be inferred that the definition or meaning of torque were unclear to many students. Repeatedly concept of torque is replaced by the concept of force and many considered torque and force are equivalent concepts. According to this, it can be said that students could not understand relationship among the concepts of angular velocity, angular momentum and angular acceleration. The following were typical explanations from students that could be seen as misconceptions: "constant torque forms constant angular velocity'', "constant torque responsible for rotational balance'' and "constant torque forms constant angular momentum''. The rate of correct answers for other questions in this group are: 36% for item 7, 39% for item 8, 55% for item 9, 33% for item 10, 55% for 11th questions, 25% for 17th questions, 25% for 18th questions, 44% for 19th questions, 59% for 20th questions. 9, 11 and 19th

Moment of Inertia (Question 4,15)

The correct answer rate for 4th question was 35% and for 15th question was 25%. Student responses to the questions concerning moment of inertia reviled that most students were uncertain about this idea. For instance, many did not know that moment of inertia is a function of the mass distribution about an axis, and that the rotational kinetic energy depends on moment of inertia and not just on the total mass of the system. Student responses to questions related to rotational kinetic energy showed that students had great difficulty with the exact reliance of the kinetic energy on the moment of inertia and the angular speed of the object. The following were typical explanations from students that could be seen as misconceptions: “The larger the mass of a wheel is, the greater the rotational energy is.”, “The lighter wheel has more rotational kinetic energy…because it’s moving faster”, ′′moment of inertia depends on rollers’ angular acceleration′′ and ′′moment of inertia does not depend on rollers’ mass′′.

Rotational Kinetic Energy (Question 1,2,3,16)

The correct answer rate for the 1st question was 65%; 2nd question was %22; 3rd question was 13% and 16th question was 24%. Student responses to questions related to rotational kinetic energy showed that students had great difficulty with the exact reliance of the kinetic energy on the moment of inertia and the angular speed of the object. The following were typical explanations from students that could be seen as misconceptions: “The larger the mass of a wheel is, the greater the rotational energy is.”, “The lighter wheel has more rotational kinetic energy…because it’s moving faster”, ′′moment of inertia depends on rollers’ angular acceleration′′ and ′′moment of inertia does not depend on rollers’ mass′′.

Angular Speed/Velocity and Angular Acceleration (Question 5,10,11,17)

Students also shared common difficulties on questions related to torque, angular acceleration and angular speed/velocity. It is clearly seen that students have misconceptions about angular velocity and angular acceleration. The lower rate of correct answer from 5th question supports this idea. The following were typical explanations from students that could be seen as misconception: ′′ a constant torque forms constant angular velocity and angular acceleration′′.

Rolling, Sliding (Question 6,7,12,13,14,16)

Many questions associated with rolling motion investigate student understanding of relative motion concepts. Students had great difficulty distinguishing between the speeds of different points on a rigid wheel with respect to the center of the wheel or ground. Most students did not recognize that the bottom point of a rolling wheel was at rest with respect to the ground. The following were typical explanations from students that could be seen as misconceptions: “The instantaneous velocity with respect to the ground is always tangent to the rolling circle.” and “The speed of all points should be the same with respect to ground because they are all on the same wheel which is rolling.”. Many rolling motion questions also related to the condition for rolling and the roles of friction and other parameters on the rolling motion. A large fraction of students had difficulty with these questions and they believed that friction must slow any kind of motion. The rates of correct answer for other questions are: 34% for item 6; 36% for item 7; 51% for item 12; 19% for question 13; 48% for item 14; 24% for item 16.

In order to determine difference between the male and female students’ rolling, rotational motion and torque conceptual test scores the independent sample t-test was used. Male and female students’ average test scores and standard deviations are given in table 4 and the summary of independent t-test results are given in Table 5.

Table 4: Male and female students’ average test scores and standard deviations

	N	Average	Std. Deviation	%
Female	75	6.96	2.704	34.8
Male	25	8.24	3.455	41.2

Table 5: The summary of independent sample t-test results by gender

		Levene's Test for Equality of Variances		t-test for Equality of Means				
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Top	Equal variances assumed	2.125	.148	-1.907	98	**.059**	-1.280	.671
	Equal variances not assumed			-1.688	34.330	.100	-1.280	.758

p>0.05

According to the independent t-test results shown in Table 5 it can be concluded that there was not statistical significant difference between male and female students rolling, rotational motion and torque conceptual test.

Also, in order to determine if is there any significant difference among students' test scores in different branches on rolling, rotational motion and torque conceptual test scores one way ANOVA test was conducted. The summary table from this result is given in Table 6.

Table 6: The one way Anova test results between groups

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	110.483	3	36.828	4.729	**.004**
Within Groups	747.677	96	7.788		
Total	858.160	99			

*p< 0.05

According to one-way ANOVA Test results based on students branches on rolling, rotational energy and torque test score, there was a statistical significant difference among branches. In order to determine statistical differences between branches the LSD "post hoc" test was performed. The summary of LSD test results is given in Table 7.

Table 7: The LSD test results between groups

(I) 3	(J) 3	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
2A	2B	-1.424	.835	.091	-3.08	.23
	3A	.458	.802	.569	-1.13	2.05
	4B	-2.142*	.692	.003	-3.52	-.77
2B	2A	1.424	.835	.091	-.23	3.08
	3A	1.882	.959	.053	-.02	3.79
	4B	-.718	.869	.411	-2.44	1.01
3A	2A	-.458	.802	.569	-2.05	1.13
	2B	-1.882	.959	.053	-3.79	.02
	4B	-2.600*	.837	.003	-4.26	-.94
3B	2A	2.142*	.692	.003	.77	3.52
	2B	.718	.869	.411	-1.01	2.44
	3A	2.600*	.837	.003	.94	4.26

*. The mean difference is significant at the 0.05 level.

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According to ANOVA and LSD Test results, there is a significant difference between 3A and 2B and 4B and 3A about rolling, rotational motion and torque conceptual test scores.

CONCLUSION

Rolling, rotational motion and torque is one of the main subjects of physics that the students have difficulties to understand. The current study is designed to determine university students' difficulties and misconceptions about rolling, rotational motion and torque concepts. The sample of this study was chosen from department of mathematics education at Balıkesir University, Necatibey Faculty of Education during the academic year of 2013-2014. The Rolling, Rotational Motion and Torque Concept Test, consisted of 20 multiple-choice questions was conducted to 100 prospective mathematics teachers. The reliability coefficient of the test was found as r=0.66. In general, all of the correct answer percentage from the test was below the 50%.

In order to determine difference between the male and female students' rolling, rotational motion and torque conceptual test scores the independent sample t-test was used. According to the independent t-test results there was not any statistical significant difference between male and female students rolling, rotational motion and torque conceptual test.

Also, in order to determine if is there any significant difference among students' test scores in different branches on rolling, rotational motion and torque conceptual test scores one way ANOVA test was conducted. According to one-way ANOVA Test results based on students branches on rolling, rotational energy and torque test scores, there was a statistical significant difference among branches. In order to determine statistical differences between branches the LSD "post hoc" test was performed. According to ANOVA and LSD Test results, there is a significant difference between 3A and 2B and 4B and 3A about rolling, rotational motion and torque conceptual test scores.

Overall, students have some difficulties and misconceptions about fundamental concepts such as rolling, moment of inertia, rotational energy and torque concepts.

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REFERENCES

Bostan-Sarıoğlan, A., & Küçüközer, H. (2013). Determination of Conceptions of Secondary 10th Grade Students About Torque, Angular Momentum and Kepler's 2nd Law. *Necatibey Faculty of Education Electronic Journal of Science and Mathematics Education*, 7(1), 121-141.

Brown, D. E., & Clement, J. (1987). Misconceptions concerning Newton's law of action and reaction: The underestimated importance of the Third Law. In *Proceedings of the Second International Seminar: A Misconceptions and Educational Strategies in Science and Mechanics* (Vol. 3, pp. 39-53).

Clement, J. Brown D.E. & Zeitsman, A. (1989). Not all preconceptions are misconceptions: finding anchoring conceptions' for grounding instruction on students' intuitions. International Journal of Science Education, 11 (special issue), 554-565.

Demirci, N., & Çirkinoğlu, A. (2004). Öğrencilerin elektrik ve manyetizma konularında sahip oldukları ön bilgi ve kavram yanılgılarının belirlenmesi. *Türk Fen Eğitimi Dergisi, 1(*2), 116-138.

Hewson, P.W., & Hewson, M.A.B. (1983). Effect of instruction using students' prior knowledge and conceptual change strategies on science learning. Journal of Research in Science Teaching, 20(8), 731-743.

Hewson, P., & Hewson, M. (1991). The Status of students' conceptions Research in Physics Learning: theoretical Issues and Empirical Studies. Institute for Science Education at the University of Kiel. 59-73.

Klammer, J. (1998). An overview of techniques for identifying, acknowledging and overcoming alternative conceptions in physics education, alternate conceptions in physics. 39s, 1997-98 Klingenstein Project Paper, Teachers Collage, Columbia University.

Lautrey, J.,& Mazens, K. (2004). Is children' naive knowledge consistent? A comprising of the concepts of sound and heat. *Learning and Instruction*, 14 (4), 399-423.

Özmen, H. (2005). *Öğrenme kuramları ve fen bilimleri öğretimindeki uygulamaları*. In Çepni, S. (Ed.), Kuramdan uygulamaya fen ve teknoloji öğretimi. Ankara: PegemA Yayıncılık.

Palmieri, J.N., & Strauch, K. (1963). An experiment on angular momentum for the introductory laboratory. American Journal of Physics, 31 (91), 91-95.

Pol, H.J.,Harskamp, E.G., Suhre, C.J.M., & Goedhart, M.J. (2008). The effect of hint sand model answers in a student-controlled problem-solving program for secondary physics education. *Journal of Science Education and Technology,* 17 (4), 410-425.

Rimoldini, L.G.,& Singh, C. (2005). Student understanding of rotational and rolling motion concepts, the American physical society. *Physical Review Special Topics - Physics Education Research*, 1, 1-9.

Terry, C. Jones, G. & Hurford W. (1985). Children's conceptual understanding of forces and equilibrium. *Physics Education.* 20, 162 – 165

Widodo, A, Duit, R.,& Müler, C. (2002). Constructivist views of teaching and learning in practice: teachers' views and classroom behaviour. *Annual Meeting of the National Association for Research in Science Teaching*, New Orleans: April 2002, (DRAFT).

Williamson, J.C., Torres-Isea, R.O., & Kletzing, C.A. (2000). Analyzing linear and angular momentum conservation in digital videos of puck collision. American Association of Physics Teachers, 68 (9), 841-847.