# Effects of Prior Conceptualization of Force and Kinematics on Later Instruction in Newtonian Mechanics

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**Abstract:** Repeated analysis by the Kenya National Examination Council (KNEC) after release of results of National Examinations has consistently shown that performance of physics is low and so is enrolment. This paper presents research finding of a study that was undertaken to find out what ideas about Newtonian Mechanics learners had prior to instruction and how they influenced the conceptual acquisition of the same after instruction and subsequently affect performance in the subject. The specific objective was: To investigate learner conceptualization of Force and Kinematics before instruction. The theoretical framework for the study was based on the constructivist learning theory of Jerome Bruner. The theory lays emphasis on guiding learners as they build on and modify their existing mental models. The two-tailed t-test was used to test the hypothesis.

**Key words:** Commonsense beliefs: beliefs held by one due to experience. Kinematics: The study of motion of an object in which the mass of the moving particle is considered. Misconception: Commonsense alternative to a concept**.** Newtonian mechanics: These are mechanics in which the central concept is force.



## 1. Introduction

Physics is an international enterprise which plays a key role in the future progress of mankind. Physics is the most basic of the physical sciences. From chemistry and geology to biology and cosmology, we understand science in terms of the concepts developed in physics. Also many of the tools on which the advance of science and technology depend are direct products of physics.

Physics generates fundamental knowledge needed for the future technological advances that will continue to drive the economic engine of the world; it contributes to the technological infrastructure and provides trained personnel needed to take advantage of scientific advances and discoveries.

But as a community or nation we must ask the basic question, "How successful are we educating our students in physics". This concern is supported by observation made by physics teachers, many of whom have come away from teaching physics, even introductory physics, deeply dismayed with how little the majority of their students have learned [1]. One of the reasons for this low level of achievement by learners is the fact that every student begins physics with a well-established system of common sense beliefs about how the physical world works, derived from years of personal experiences. Research has established that these beliefs play a dominant role in introductory physics and any instruction that does not take them into consideration is almost totally ineffective for the majority of students [2]. In fact research from a few selected universities in the United States of America show that students fail to acquire a sound conceptual grasp of basic principles; they do not use the same physical models as physicists as they answer the simplest conceptual question.

The same students were able to solve many traditional problems involving the solution of algebraic equations or even those requiring the methods of calculus. Even so, they enter and leave the course with the basic misunderstandings about the physical world essentially intact [3].

## 2. Description of Research

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The design of the study was experimental and it involved seventy eight form three students from four purposely sampled schools in Uasin Gishu County, Kenya.

## 3. Existence of preconceptions and common sense beliefs on force and Kinematics

The existence of preconceptions and common sense beliefs on force and kinematics was investigated by using hypothesis $HO_1$ that stated: *Learners do not have prior conceptualization of force and kinematics and common sense beliefs before instruction*. An independent t-test was carried out to test hypothesis $HO_1$. The t-test analysis is presented on table 1.

Table 1: Independent t-test for hypothesis HO1

| | | **Equal Variances assumed** | **Equal variances not assumed** |
|---|---|---|---|
| Levene's Test for Equality of variances | F | 0.210 | |
| t-test for equality of means | Sig | 0.65 | |
| | t | -5.324 | -5.161 |
| | df | 32 | 21 |
| | sig (2-tailed) | 0.00 | 0.00 |
| | mean difference | -0.6969 | -0.6969 |
| | std. error difference | 0.13090 | 0.13503 |
| | 95% lower | -0.96361 | -0.43033 |
| | Confidence Level upper | -0.97796 | -0.41598 |

From table 1p=(0.00,0.00)<0.05. Since the p-value associated with the ratio is less than the level of significance the null hypothesis $HO_1$ was rejected; a significant number of learners had prior knowledge on force and kinematics.

## 4. Persistent and specific students preconception

The study also investigated the persistence of preconceptions and common beliefs after instruction. This was done by advancing hypothesis Ho2: There are no prevalence of misconceptions after instructions $HO_2$. An independent t-test for hypothesis $HO_2$, the result of which is given in table 2 below:

| | | **Equal Variances assumed** | **Equal variances not assumed** |
|---|---|---|---|
| Levene's Test for Equality of variances | F | 20.832 | |
| t-test for equality of means | Sig | 0.000 | |
| | t | 2.095 | 2.144 |
| | df | 34 | 31 |
| | sig (2-tailed) | 0.044 | 0.040 |
| | mean difference | 0.30341 | 0.30341 |
| | std. error difference | 0.14480 | 0.13503 |
| | 95% lower | -0.00913 | 0.59768 |
| | Confidence Level upper | -0.01487 | 0.59195 |

P=(0.044,0.040),therefore hypothesis $HO_2$ was rejected. There are prevalence and persistence of misconceptions of some aspects of force and kinematics after instructions

## 5. Discussion of findings

The study has shown that a number of learners had prior knowledge on force and kinematics. The existence of preconceptions is consistent with the findings of Adrian and Fuller [4] who found out phenomenon in the process of teaching electric field to college students. The existence of a preconception can present a challenge to instructions because if the conceptualization is wrong it becomes an obstacle in the process of learning since they are more pervasive than we realize and they often persist strongly in spite of later instructional attempts to correct it [5]. These preconceived notions are popular conceptions rooted in everyday experiences and they usually interfere with the learners conceptualization in topics of heat energy and force of gravity [4,6].The study supported this claim and the reason why some misconceptions persist strongly in spite of later instruction is because students misconceptions are never challenged by an exam experiment or homework problem [5,7]. So long as a misconception seems to work "or at least doesn't fail" It will persist; the principle of positive and negative reinforcement. They are often preferred by the learners because they seem more reasonable and perhaps are more useful for the learners' purpose. Misconceptions are often deeply held largely unexplained and sometimes strongly defended.

Mc Dermott [8] and other physics education researchers have documented that even after studying physics students understanding of fundamental concepts is often weak. They studied university students who were able to answer standard problems on the photo electricity or the Compton Effect, the way they think about the proton inhibited the way they makes sense of the nature of light. Hestenes et al [2, 9] stated that the impetus concept of motion and the dominance principle or the conflict concept of interaction were the most difficult misconceptions to be overcome and that unless they are dealt with they may persist in the minds of students for a long time even into graduate school.

## 6. RECOMMENDATIONS

To be effective in Newtonian mechanics instruction physics teachers should not under estimate the significance and the persistence of misconceptions and how they act as a barrier to realistic understanding of concepts. An effective instructional strategy should be developed so that it helps students overcome their misconceptions thus leading to proper conceptual understanding. The salient aspects of such a strategy is to ensure that learners are constructing and reconstructing a correct frame work and creating concept maps as they continue to make sense of the concept(s) being studied. With such interactive techniques students learn to visualize a group of concepts and their interrelationships. Such strategy would intellectually engage learners and are actively involved in the learning of concepts. Its only when students directly observe that their understanding do not explain their observations will they begin to alter those common sense beliefs.

## 7. REFERENCES

[1] Redish ,E. F and Steinberg N.R(1999).teaching physics :figuring out what works university of Maryland college park

[2] Hestenes, D et al (1992) Force Concept Inventory the physics teacher 30,1414-158

[3] Laws, P.et al (2006) Promoting active learning using the resulted of physics education research.

[4] Adrian, B.W and Fuller, R.G(1997) A qualitative investigation of college students conception of electric field. University of Nebraska, Nebraska 68,588 undergraduate science education Cambridge U.K

[5] Simanek, E.D(2014)Physics misconceptions.

[6] Adrian, B.W and Fuller, R.G(1997) A qualitative investigation of college students conception of electric field. University of Nebraska, Nebraska 68,588 undergraduate science education Cambridge U.K

[7] Simanek, E.D(2014)Physics misconceptions.

[8] M c Dermott, L.C (1991) What we teach and what is learnt-closing the gap American journal of physics 59,301-315.

[9] Hestenes, D et al (1992) Force Concept Inventory the physics teacher 30,1414-158