# Free Falling Eggs Reaching Different Types of Ground

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## Introduction

During a science class 15-16 year-old students worked on an unstructured problem to study the connection between the change of momentum and force within the topic of mechanics. The aim of the activity is to help the students recognize and identify the factors that influence the force emerging during the collision, and develop a hypothesis and design an experiment. The heterogeneous class consists of 26 students, 9 girls and 17 boys, of whom 5 boys have special educational needs. The activity was preceded by a discussion of the theoretical background knowledge and the adoption of a common scientific terminology.

*The plan of the team*

Working in groups of 4 the students tried to find an answer to the question of what factors influence the safe landing of the egg and how?

## The aim of the study

During the preparation of the lesson the teacher selected some criteria according to which the groups' work would be assessed, mainly focusing on the planning of the experiment.
The identification of dependent and independent variables, and the developing of the hypothesis became the two main aspects. Assessment took place on group level.

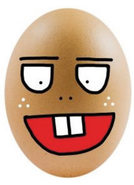
*Planning together*

During planning, using the table below as a guide, possible helping questions and assessment criteria were formulated in line with the three-level scale.

| Raising questions | | | |
|---|---|---|---|
| **Helping questions:** | | | |
| • How would you like to get an answer to your question?<br>• How would you like to observe the phenomenon?<br>• What would you like to find out during the observation?<br>• What variables would you like to observe during the experiment? | The student does not recognize the connection between the question and the experiment, the question does not help their work. | The student recognizes the connection between the question and the experiment, but the question does not help their work. | The student recognizes the connection between the question and the experiment, they systematically build the answers into their work. |
| **Developing hypothesis** | | | |
| **Helping questions:** | | | |
| • What do you think will happen?<br>• Why does this phenomenon occur?<br>• Based on what you have learnt can you explain your hypothesis? | The student formulates their hypothesis, but is not able to explain it. | The student formulates their hypothesis and is able to explain it with some help. | The student formulates their hypothesis and supports it with scientific explanation. |
| **Planning the experiment** | | | |
| **General helping questions** | | | |
| • How can the phenomenon be investigated?<br>• What physical quantities do you have to investigate?<br>•How can you observe the connection between the variables?<br>• What can you do in order to record the most precise observations possible?<br>• More specific question can be found in the teacher's manual. | The student proposes an investigation of the phenomenon, but does not see it in its details. | The student proposes an investigation of the phenomenon, sees the process in its details, but is not able to think it through on their own. | The student is able to plan the experiment, and to identify the dependent and independent variables. The student recognizes the connections between the variables and is able to identify the principles. |

**In order to facilitate their work a student worksheet was prepared**

WHAT FACTORS INFLUENCE FORCES DURING COLLISION?



*In our everyday life, safe travel is of high priority. When travelling by various vehicles the most important consideration is the safety of passengers. When developing safety equipment, it is important to understand the forces affecting the body during collisions.*

To understand the interactions during collisions, we recommend studying the effects of impact on an egg.

**I. What factors make it possible for the egg to land safely?**

1. As a team, collect the factors that affect the egg during collision.
2. Design an experiment in groups of 3-4 to study the factors of collision.

Equipment available: tray, rag, bucket, deep bowl, tape measure, ruler, stopwatch, box of eggs, digital balance, water, semolina, flour, sand, balloon.

**Check with your teacher** if you need additional equipment/materials.

Don't forget to identify variables: an independent variable (that changes), a dependent variable (that you measure or observe) and the constant variable (that you choose to be constant).

**II. From how high can you drop an egg into a bucket of flour without breaking it?**

2.1. The group should consult with the teacher before going ahead with the experiment
2.2. Plan the procedures and record the expected outcomes
2.3. Perform the experiment and write down your observations
3.1. According to the previous experiment, estimate the height from which an egg can be dropped into a bucket of flour without it breaking.

3.2. Compare the estimates of various groups, select the most probable one.
3.3. Proceed with the experiment.
4. Consult with your group on how the observations correspond to the mechanisms of safety equipment in vehicles.

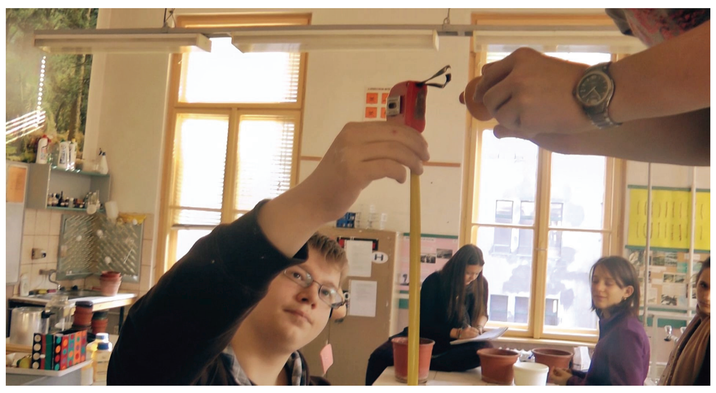
## Results

During the presentation of the results we also rely on the video recordings made during the sessions.

**As the first step** the students collected the factors that influence the force acting upon the egg at the moment of collision.
Observed inquiry skill: recognition of variables
Helping question: What physical quantities influence the force acting upon the object? What does an object's momentum depend on? How does the change of momentum influence the strength of the force? What variable can be assigned to the quality of the ground?
Some observations: Group no. 1: Teacher: 'How can you keep the speed of the egg constant?'
Student: 'I always drop it from the same height.'

**As the second step** the group presents the plan: 'We will see how the egg reacts to the different materials and we will drop it from the same height.'
Conclusion: The students summed up using the already available pieces of information with deductive thinking. By identifying the variables they selected the dependent and independent variables and applied the recognition of regularities.

*The presentation of the plan*



*Setting the independent variable*

**As the third step** the students planned an experiment in small groups with the help of which they examined the force acting upon the egg at the moment of collision.
Inquiry skills: handling variables, recognizing relationships, developing hypotheses.

Helping questions: Which variable can be kept constant during the observation? How can you ascertain connection among the variables? How can the momentum of an object be changed? What does the landing speed depend on? How does the height from which the egg was dropped influence the collision? What variable can be changed with the quality of the ground?
Observation: Group no.4: Student presents their plan to the teacher: 'We drop the egg from 50cm, from 1meter and from 2meters. With the help of the questions we examine the connections between the different heights and the material it falls on dropped. We recorded the forces acting upon the egg: gravity, mass force, drag and the counter force put up by the ground.'

*Student presents their plan to the teacher*

Conclusion, assessment: The students recognized the connection between the variables, separated the dependent and independent variables. When determining the heights they did not have any hypotheses, they could not explain the height data. During the planning of the experiment they endeavored to recognize the learnt regularities and to ascertain connections.

After the implementation of the experiment the students worked in groups to decide under what conditions they could keep the egg intact if it is dropped from the school's 14-meter high staircase.

Observation: Group no.1: Student plans with peers: 'If the egg falls onto the paper hankie, it sags and lessens the force.'
The group presents the result of the experiment: 'We planned to put a hankie into the bottom of the box, then flour, then semolina, then flour again, since when it was dropped from a 2m height the egg did not break.'
Conclusion: The students developed a hypothesis, they used the analogies appropriately during the planning, but they did not have enough observations to determine the rule.

*The trial*

*Out of the six groups only two dared to drop the egg into flour only*

## Conclusions

All six groups identified the variables, four groups recognized how the speed of the egg when landing can be changed and when and when the different variables had to be kept constant during the experiments. None of the groups could explain why they had chosen the given height. None of the groups calculated the speed of the egg that had been dropped from 14 m, and only two groups took into account the observations of the previous task when developing their hypothesis.
The three-level scale does not always allow a sufficiently fine-grained evaluation but it is a suitable starting point.

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This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 289085