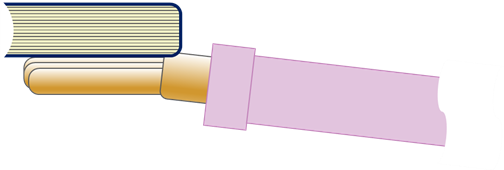
**Holding a book**

Kevin has picked up a heavy book.

His friends are talking about the forces needed to hold it steady.



**Olivia:**

Kevin’s hand pushes up with a force that is the same size as the weight of the book.

**Noah:**

There are no forces on the book when it is not moving.

**Mia:**

Kevin’s hand pushes up with a force but the weight of the book is bigger.

**Parker:**

Kevin’s hand does not push up on the book. It gets in the way to stop it falling.

To answer:

1. Who is right about the forces Kevin uses to keep the weight steady?

*Explain your answer.*

1. What mistakes do you think the other three students made?

*What would you say to them to help them to understand?*

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| --- | --- |
| Cards for  **Holding a book** |  |
| **Mia:**  Kevin’s hand pushes up with a force but the weight of the book is bigger. | **Noah:**  There are no forces on the book when it is not moving. |
| **Olivia:**  Kevin’s hand pushes up with a force that is the same size as the weight of the book. | **Parker:**  Kevin’s hand does not push up on the book. It gets in the way to stop it falling. |

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| Cards for  **Holding a book** |  |
| **Mia:**  Kevin’s hand pushes up with a force but the weight of the book is bigger. | **Noah:**  There are no forces on the book when it is not moving. |
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*Physics > Big idea PFM: Forces and motion > Topic PFM3: More about forces > Key concept PFM3.2: Hidden forces*

|  |
| --- |
| **Response activity** |
| **Holding a book** |

**Overview**

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| --- | --- |
| Learning focus: | An object resting on the floor squashes it a little and, because at a microscopic level the floor is springy, it pushes back on the object with an equal sized force in the opposite direction to the object’s weight. |
| Observable learning outcome: | Describe how a person’s hand uses force to support different sized weights. |
| Activity type: | Talking heads |
| Key words: | force, gravity, weight |

This activity can help develop students’ understanding by addressing the sticking-points revealed by the following diagnostic question:

* Diagnostic question: A big weight

**What does the research say?**

Research by Terry *et al (1985)* has shown that expressing Newton’s third law in the form: “for every action (force) there is an equal and opposite reaction” is confusing for students aged 11-16. It is far clearer to describe in full: the force of object A on object B is equal in size, and opposite in direction to the force of object B pushing on object A.

When thinking about one object resting on a surface, students typically apply a concept of force that is different to the one they use for objects in motion. In a study of 1000 Norwegian upper secondary students, Sjoberg and Lie (1981) found that just 50% of the young people recognised ‘passive’ forces acting when there was no movement.

When Minstrell (1982) asked two US high school physics classes (aged 14+) about forces on an object resting on a table, most of the students understood that gravity was exerting a downwards force on the object, but only about half described the table exerting an upwards force. Students who did not identify an upwards force mostly described the table as ‘getting in the way’ (Driver et al., 1994). Typically those who recognised an upwards force from the table described the downwards force as bigger. In a further study, Montanero et al. (2002) found that only a very small minority of 11- to 16-year-olds (n=240) consistently applied the correct scientific understanding that the upwards force of a surface is the same size (and in the opposite direction) to the weight of an object that it supports.

Bridging analogies gradually take the learner through a series of easily understood ‘base analogies’, in order to lead them to an understanding of a challenging ‘target concept’, which is outside the realm of their usual experience or understanding. Holding a weight on an outstretched hand and feeling the upwards force necessary to hold it still appears to help learners understand that an upwards force is necessary to keep an object at rest on a table (Bryce and MacMillan, 2005).

This question investigates students’ ideas about what their own hand is doing when it is holding a weight, which is a starting point for developing an understanding of the forces involved in supporting an object resting on a surface.

**Ways to use this activity**

This activity is largely the same as the response activity *PFM1.2: Holding a we*ight that was used in an earlier key concept.

Students should complete this activity in pairs or small groups, and the focus should be on the discussions. The statements are also provided as cut-out cards for students to physically organise.

Students should work together to follow the instructions on either the worksheet or the PowerPoint. Giving each group one worksheet to complete between them is helpful for encouraging discussion, but each member should be able to report back to the class. Listening in to the conversations of each group will often give you insights into how your students are thinking.

If there is disagreement when you take feedback, a good way to progress might be through structured class discussion. Ask one student to explain why they gave the answer they did; ask another student to explain why they agree with them; ask another to explain why they disagree, and so on. This sort of discussion gives students the opportunity to explore their thinking and for you to really understand their learning needs.

*Differentiation*

The quality of the discussions can be improved with a careful selection of groups; or by allocating specific roles to students in the each group. For example, you may choose to select a student with strong prior knowledge as a scribe, and forbid them from contributing any of their own answers. They may question the others and only write down what they have been told. This strategy encourages contributions from more members of each group.

**Expected answers**

Olivia is correct that Kevin’s hand will always need to push up with the same sized force, in the opposite direction, as the weight.

Mia thinks the weight needs to be bigger than the upward force so that it is held down. If weight was bigger than Kevin’s push, the book would push his hand down.

Noah is thinking that because nothing is changing there is no force, but if there was no force Kevin would not feel the weight of the book in his hand. The force from Kevin’s hand balances the weight so there is ‘no force left over’.

Parker thinks that because Kevin’s hand is not moving or weighing something down it is not exerting a force. ‘Getting in the way’ is a way of saying the hand is pushing up without using the notion of force. But if Kevin is not pushing up and the book is pushing down, then the book will push his hand down.

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Images: Peter Fairhurst (UYSEG).

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