Explicit Teaching of 'Problem Solving' Using Worksheets in Lectures and Tutorials

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Abstract

Worksheets have been shown to be an effective tool that helps engage students during lectures. The worksheets used in this study were developed in Thailand and implemented in a large lecture class with first-year physics students. These worksheets were subsequently adapted for use at The University of Sydney. The worksheets were deployed in both lectures and tutorials. The sample groups were comprised of 392 students from the Fundamental (FUN) and Regular (REG) classes in 2019. The worksheet was structured into three columns, (a) clarifying a situation, (b) identifying variables, and (c) drawing a diagram. The aim of the study is to examine whether the in-class practice in the worksheets improved student's conceptual understanding and problem solving skills. The efficacy of this work was calculated by using the average examination score and SOLO taxonomy which refers to the levels of students' understanding.

Methodology and Sample Group

- The worksheets were deployed in the lecture and in the tutorials for the Fundamental class. For Regular class, the worksheets were deployed in the tutorials.
- The worksheets were collected at the end of each class and student responses analysed using the SOLO taxonomy framework [2].
- In addition, responses to pre-test, mid-semester test and final selected examination questions were also analysed using this same framework.

SOLO Taxonomy

SOLO level	Explanation
Relational/Extended Abstract (R)	Understanding of physics behind question. Errors, if any, are mainly in use of language or expression.
Multistructural (M)	Use of Physics concepts, but these were either not primarily related to question, or incomplete.
Unistructural (U)	Real world links with tendencies of naïve beliefs. Some mention of unrelated biology or chemistry references.
Prestructural (P)	Random responses that made little sense.

Worksheet Structure and SOLO Classifying Example

Multistructural level
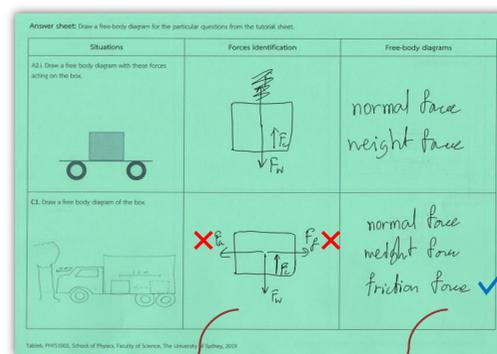
Students rarely used the correct physics concept. In this case they had forces concept but drew an incorrect diagram.

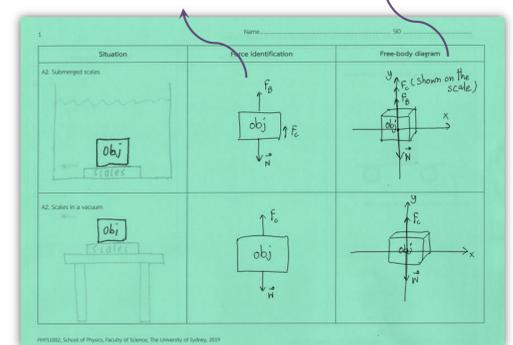Student answer is in wrong column, but the physics concepts are correct.
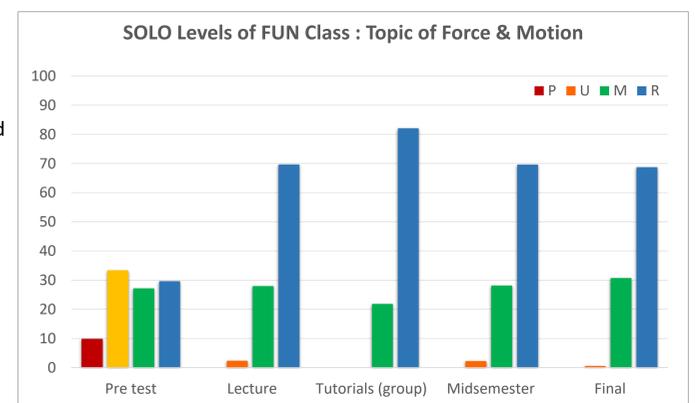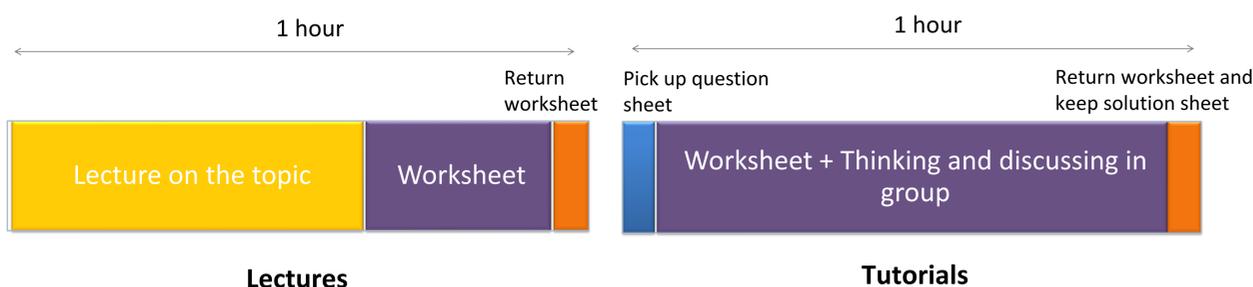
Relational/Extended abstract level

They used the right physics concept in order to identify forces in the question.

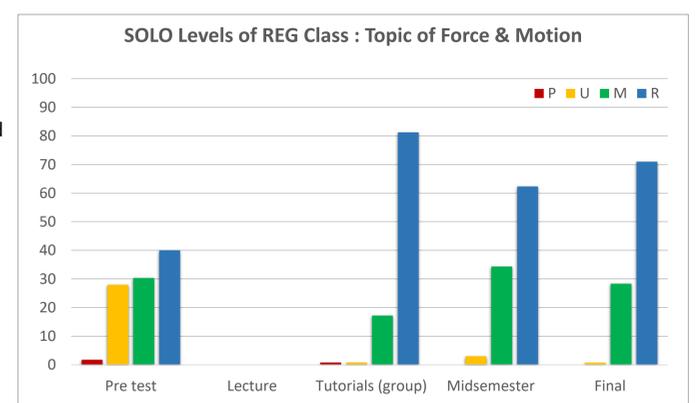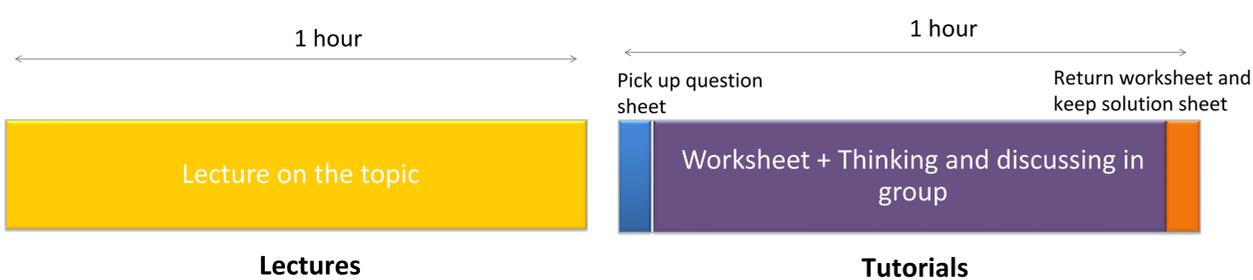They could draw the free-body diagram with the correct answer.

How to Connect Worksheets in Physics Course & Results and Discussion on the Topic of Force and Motion

Fundamental Cohort (133)

1 hour
Lecture on the topic | Worksheet | Return worksheet
Lectures

1 hour
Pick up question sheet | Worksheet + Thinking and discussing in group | Return worksheet and keep solution sheet
Tutorials

SOLO Levels of FUN Class : Topic of Force & Motion

Regular Cohort (259)

1 hour
Lecture on the topic
Lectures

1 hour
Pick up question sheet | Worksheet + Thinking and discussing in group | Return worksheet and keep solution sheet
Tutorials

SOLO Levels of REG Class : Topic of Force & Motion

Average examination scores years 2018 and 2019

FUN (Years) Full score=10	Kinematics (SEM)	Momentum (SEM)	Waves (SEM)
2018 (N=166)	7.62 (0.20)	5.30 (0.27)	5.54 (0.24)
2019 (N=133)	7.74 (0.25)	5.50 (0.25)	6.30 (0.26)

REG (Years) Full score=10	Force & Motion (SEM)	Momentum (SEM)	pV-diagram (SEM)
2018 (N=288)	3.82 (0.10)	5.71 (0.16)	3.02 (0.13)
2019 (N=259)	6.06 (0.12)	7.12 (0.13)	3.12 (0.13)

Comparison of examination scores of some topics also revealed an increase in the scores from 2018 to 2019, demonstrating the efficacy of the worksheets.

The SOLO analysis showed an increasing level of understanding from the pre-test through to the examination for both FUN and REG cohorts. Most of them were working at the Relational and Multistructural levels.

Conclusion

Using worksheets where students practiced problem solving has resulted in increased levels of understanding, as measured by SOLO taxonomy and improvement in average exam scores for specific questions.

Our study demonstrates the efficacy of worksheets.
We recommend the use of worksheets.

Acknowledgements

References

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[2] Georgiou, H., & Sharma, M. (2010). A report on a preliminary diagnostic for identifying thermal physics conceptions of tertiary students.