No Man is an Island, neither Practical Work is
A Case Study into Undergraduate Life Sciences

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“…There can be no science without hands-on experience…”

“…Practical work is what scientists do…”

What is the problem?

- Big part of literature on practical work focuses in secondary education
- Lack of empirical evidence on the **understanding** of concepts and **development** of skills in undergraduate science degrees

What is the problem?

- Practical work: Time, Effort, Money

- **Financial** resources invested in
  - Equipment
  - Consumables
  - Recruitment of trained laboratory staff

- **Time** invested going through bureaucratic procedures concerning ethical clearance and health and safety.

- In England, practical work contributes to the **increase of tuition fees** for international students between science degrees and those in art and social science.

- Practical work is one of the most **expensive** aspects of science education.

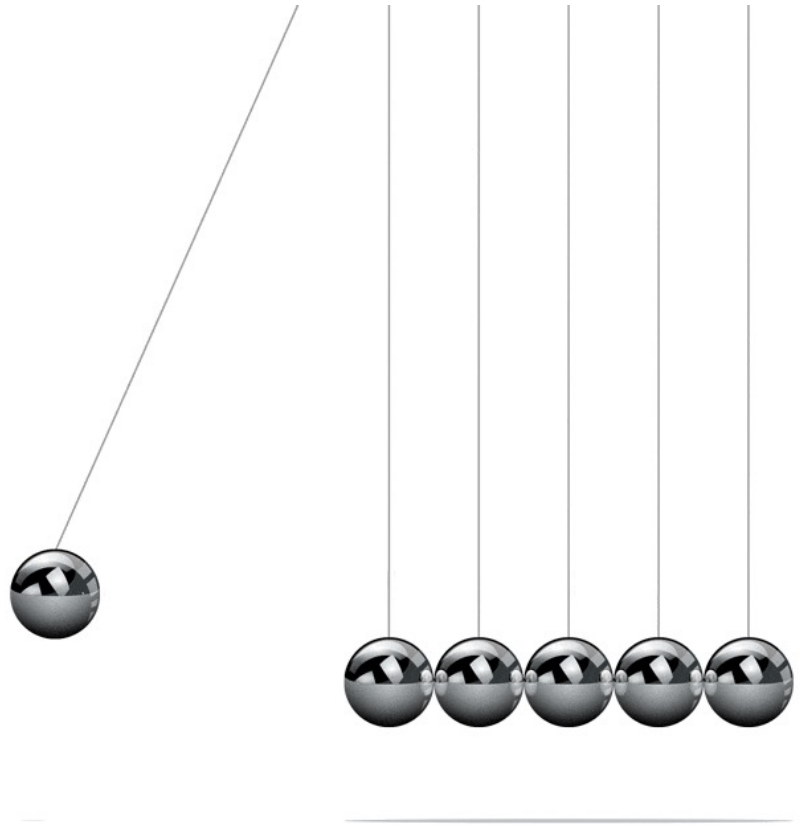
What is it for?

- “Despite 200 years [and more] of debate” (Millar,1987)

- The purpose of practical work: A Newton’s cradle.

From skills to discovery learning to skills and concepts

- Does it have to be hands-on? COVID-19: Time for truth



The effectiveness of practical work: *The cognitive argument*

- Practical work promotes understanding in sciences. Theory is visualized
- Is understanding the end result of practical work? Misconceptions can affect students' learning. Students see what they want to see
- Two studies concerned with undergraduate practical work showed that there was correlation between conceptual enhancement and experimentation in comparison to traditional lecture based classes.

The effectiveness of practical work: *The skills argument*

- Practical work has been considered as being important in training students for future employment
- However, a big percentage of STEM graduates do not work in their fields but use their degree related skills into a range of different occupations. However, they choose to study a science focused degree.
- At university level, lecturers expose undergraduates to processes similar to those in the industry. Is it realistic to expect them to know how to use all kinds of different apparatus or new equipment? No..But
- There have been claims that practical work promotes scientific methods helping students understand the nature of science. If students mostly engage with recipe style experiments they do not practice the way a scientist would.
- Students need to understand that experiments are rarely clear cut and certain. Experiments are not a liner process and this distorted view needs to stop. Research findings from this study, show otherwise.

Research Questions

- Is practical work effective in enabling undergraduates **do** what intended by members of staff?

- Is practical work effective in enabling undergraduates **learn** what intended by members of staff?

The Research

- A study was conducted exploring the effectiveness of practical work in undergraduate students' science conceptual understanding and skill development in the chosen university's school of life sciences.

Methods

- Case study
    - Year 1 and 2 students studying at the School of Life Sciences at a University in England
- Mixed methods approach
    - **Quantitative**:

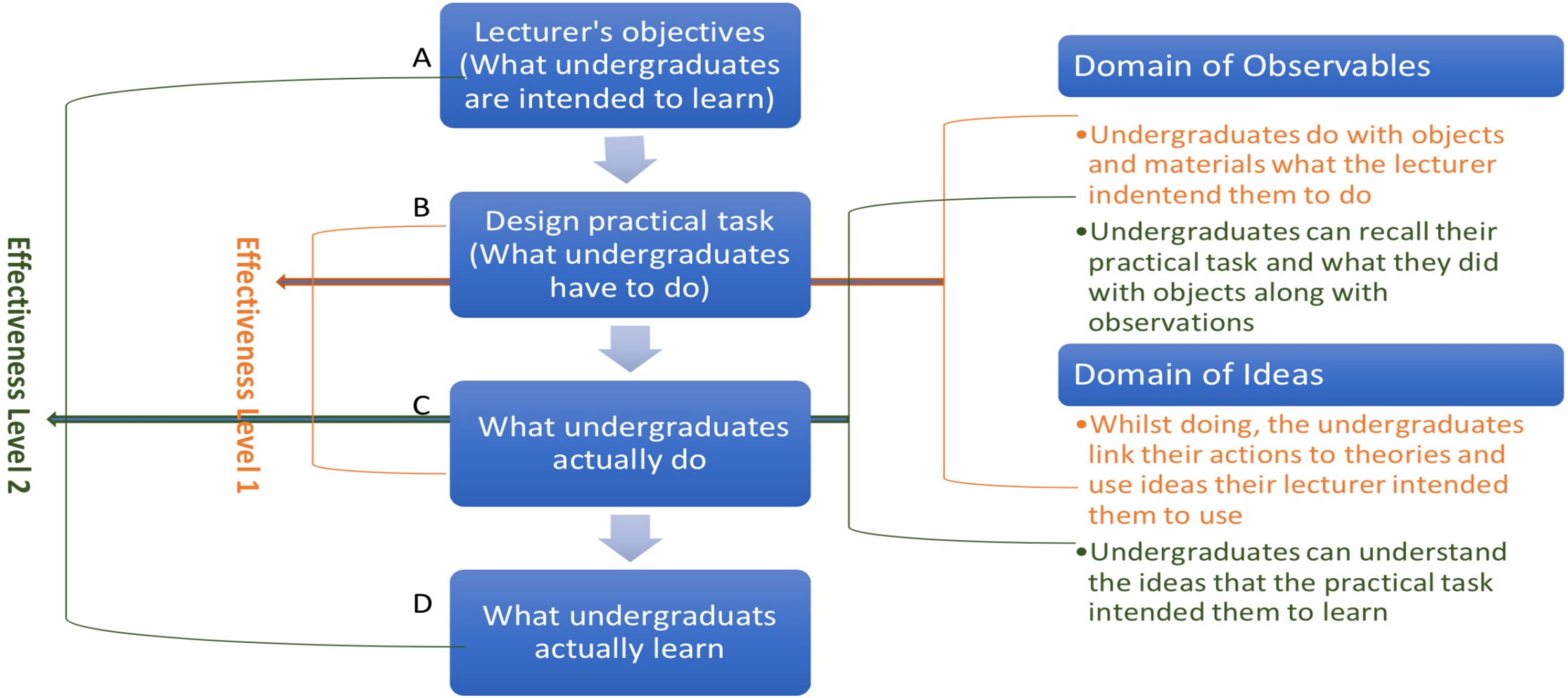
1. Pre and Post questionnaires assessing students' expectations (pre) of their practical work classes and whether those expectations are fulfilled by doing practical work (post).
2. Lecturers' activity: put in ranking order their perceived purpose of practical work for each academic year.

    - **Qualitative**:

1. Laboratory observations
2. Discussions with undergraduates
3. Interviews with academic staff

Theoretical Framework

Adaptation from
(Abrahams & Millar, 2007; Tiberghien,2000)



Preliminary Findings
Aims of Practical Work (Adapted by Kerr, 1963)

	YEAR 1	YEAR 2	YEAR 3
1	To promote simple, common sense scientific methods of thought	To give training in problem solving	To give training in problem solving
2	To make physical phenomena more real through actual experience	To promote simple, common sense scientific methods of thought	To be an integral part of the process of finding facts by investigation and arriving at principles
3	To develop manipulative skills	To encourage accurate observation and careful recording	To encourage accurate observation and careful recording

Constantinou & Fotou, 2020

Preliminary Findings from observations

Skill Development

- Majority of practical work lessons (18) focused on skill development
- Majority of undergraduates (Year1-256)(Year2-211) demonstrated abilities in :
  - Using equipment
  - Carry away experiments
  - Generate data indented
- Most undergraduate practical work lessons were expository/cookbook-like activities therefore members of staff **scaffolded** during experiments
- Undergraduates could NOT observe the outcomes or effects intended without assistance
- Skill training prioritized for career preparation and developed through **repetition**

Preliminary Findings from observations

Conceptual Understanding

- The importance of scientific ideas to carry out experiments was **not important**
- **Neither** the development of scientific knowledge **IN THE LABORATORY** while doing practical work
- Introductory discussions helped in communicating the rationale behind the experiment.
- In **17 out of 18** practical work lessons undergraduates could explain what the activity was for and why they were doing it. Undergraduates could not think about observations using scientific ideas **on their own**
- Practical work **on its own,** based on findings, **does not** aid in the better understanding of scientific theories.
- Undergraduates cannot think without **scaffolding** by members of staff
- An understanding of **50-88%** of the undergraduates was only observed in **4 out of 18** lessons for both Year 1 and 2

Preliminary Conclusions

- Practical work lessons where a conceptual understanding (50-88%) and recalling of observations (50-75%) was demonstrated through the linking of observables and ideas included the following characteristics.

  - Introductory discussions on experiments' purpose and scientific ideas
  - Confirmation of observations at the end
  - Small class size (40-52 undergraduates)
  - Scaffolding and probing from members of staff

  - Practical work was effective in helping undergraduates develop manipulative skills and promoting simple scientific methods of thought

  - Undergraduates **did not** have better understanding of scientific ideas, **not expected of them anyway**.

Preliminary Conclusions

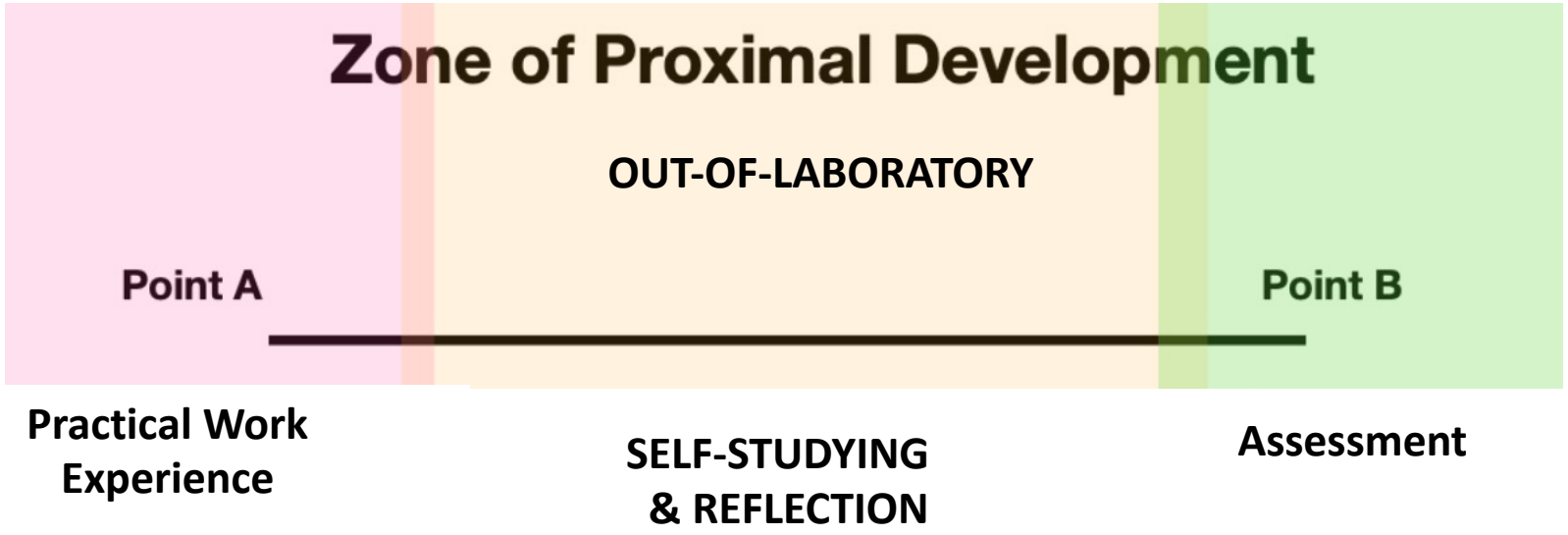
No man is an island, neither practical work is

- Practical work serves as a teaching medium
- Does not directly promote scientific theoretical understanding as a stand-alone practice
- Practical work is part of a big learning zone : The development of theoretical knowledge is a result of reflective processing of performance and information acquired from lectures and self study

Preliminary Conclusions

- The laboratory is a big **learning zone of proximal development** (Vygotsky,1978)
- More knowledgeable experts guide undergraduates through **scaffolded practical work** from point A of being **novices** to point B where they have **developed skills** and **better understanding**.

Preliminary Conclusions



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Thank you

You can read more about this research from the paper published in conference proceedings