

# Interactive On-Line Learning Environment Prep for Enhanced Confidence in Chem Eng Labs

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Sustainability Awards  
SILVER - LABS

# Chemical Engineering



<http://www.apirho.com/chemical-engineer/#step3>



Grangemouth Petrochemical Plant



North Sea Oil Extraction Platform



Tarmac Cement



Torness Nuclear Plant



Johnson Matthey Pharma



FCC Miller Recycling & Energy Recovery



Seafeld Water Treatment



THE UNIVERSITY of EDINBURGH  
School of Engineering

Chemical Engineering

Chemical Engineering Laboratory 3

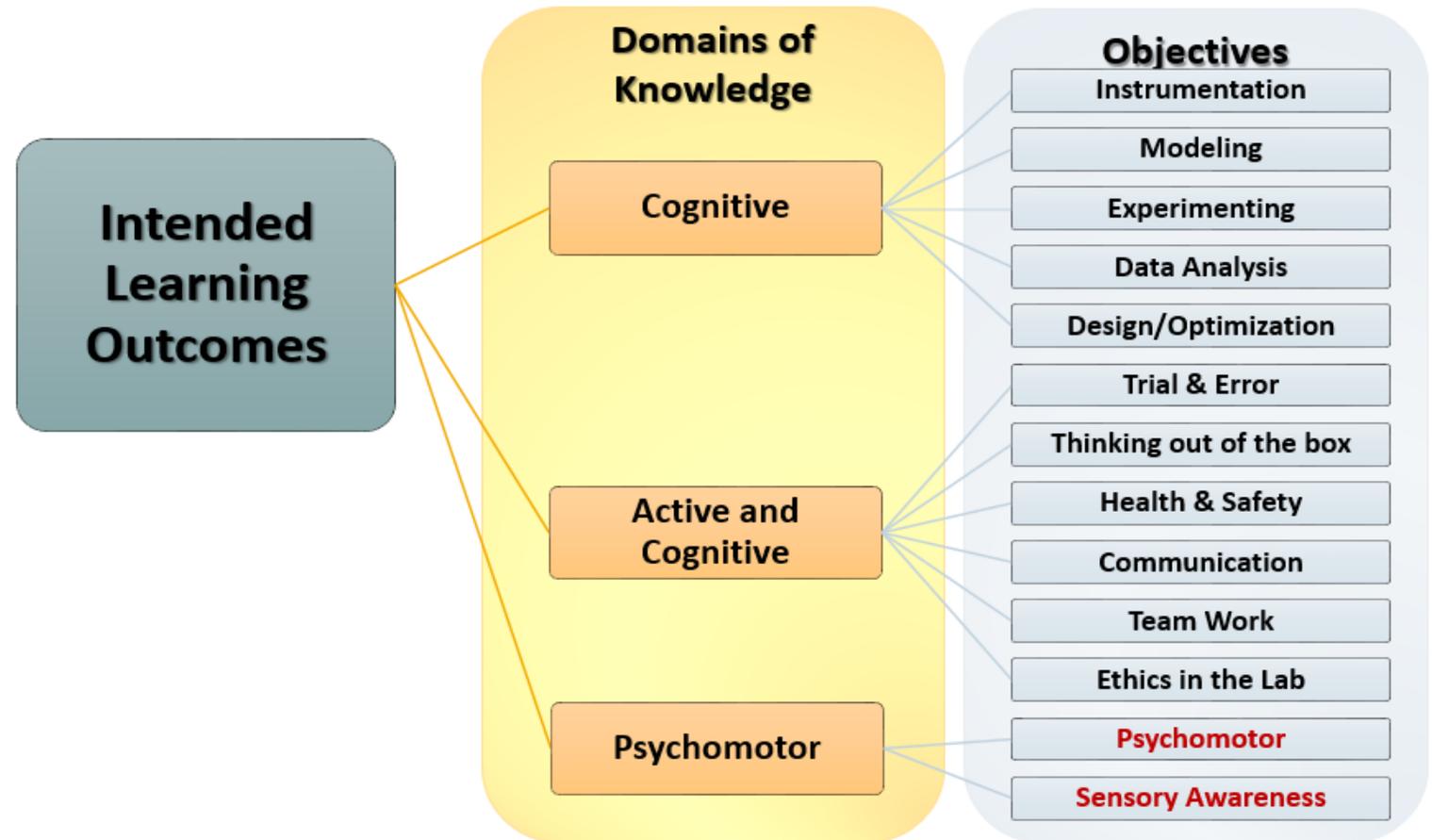
Slide 2

# Why Practical Chem Eng Labs?

## II. HISTORICAL ROLE OF ENGINEERING INSTRUCTIONAL LABORATORIES

Engineering is a practical discipline. It is a hands-on profession where doing is key. Consequently, prior to the creation of engineering schools, engineering was taught in an apprenticeship program modeled in part after the British apprenticeship system. These early engineers had to design, analyze, and build their own creations—learning by doing. Engineering education, even today, occurs as much in the laboratory as through lecture [3]. However, from the onset of formal engineering education, a tension between theory and practice evolved. During these early years the focus was clearly on practice.

Feisel and Rosa, *J. Eng. Edu.* **94**, 2005



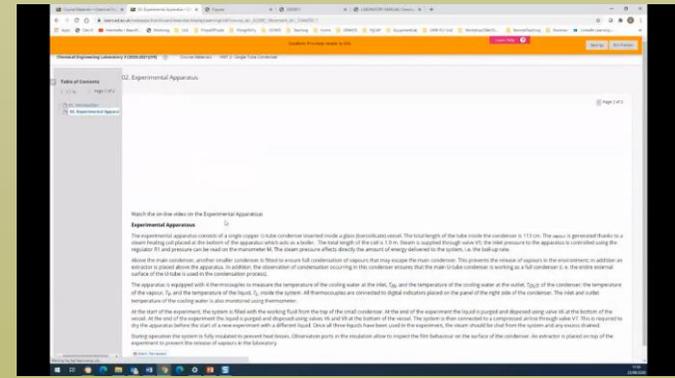
ABET: Accreditation Board for Engineering and Technology Supported by the Sloan Foundation, 2002 from Feisel and Rosa, *J. Eng. Edu.* **94**, 2005

# Laboratory Delivery Modes

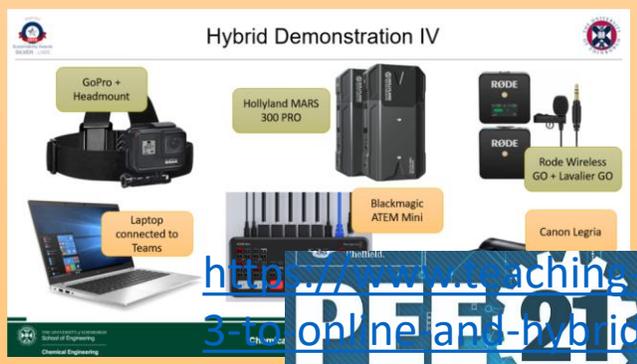
## Traditional



## Online



## Hybrid Demonstration



<https://www.teaching-matters-blog.ed.ac.uk/adaptation-of-the-chemical-engineering-laboratory-3-to-online-and-hybrid-teaching/>

## Hybrid Practical



Adaptation of the Chemical Engineering Laboratory 3 to online and hybrid teaching

In this post, Dani Orejon walks us through the process of turning a practical course entirely into online delivery, tackling the conundrum on how to properly teach in-situ demonstrations through on...

Teaching Matters blog



Laboratory 3

Slide 4

# Laboratory Delivery Modes

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## Hybrid Demonstration

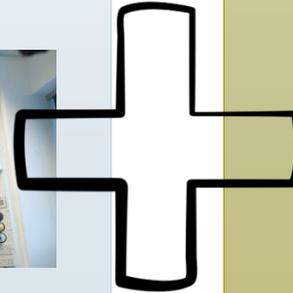


## Hybrid Practical

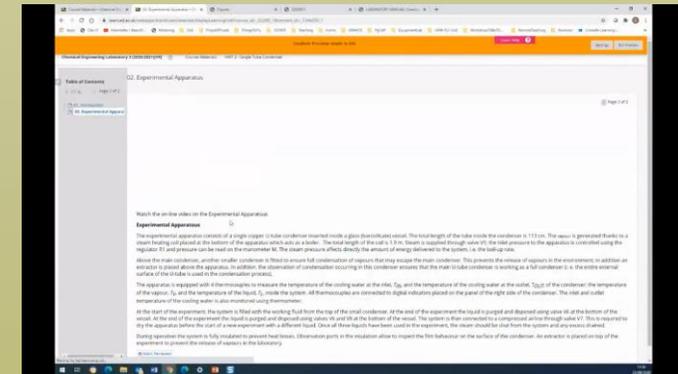


# Laboratory Delivery Modes

## Traditional



## Online



# Interactive Environment Online Prep I



Engaging virtual learning environment within Learn capabilities

THE UNIVERSITY of EDINBURGH | Learn

My Learn Self-Enrol Help

Chemical Engineering Laboratory 3 (2020-2021)[YR] Welcome

Chemical Engineering Laboratory 3 (2020-2021) [YR]

- Welcome
- Course Information
- Course Enhancement Questionnaires (CEQs)
- Announcements
- Course Materials
- Library Resources
- Assessment
- Course Conversations

School of Engineering

Welcome

**Hybrid Seminar Information**

**Hybrid Seminars**

The hybrid seminars in this course combine students who are attending in-person with students who are attending digitally in the same learning environment.



2022/2023

LABORATORY MANUAL  
Chemical Engineering Laboratory 3  
CHEE09016



School of Engineering  
University of Edinburgh

# Interactive Environment Online Prep I

## Engaging virtual learning environment within Learn capabilities

## Videos with Quizzes to test students knowledge

The screenshot shows the LMS interface for 'Chemical Engineering Laboratory 3 (2022-2023) [YR1]'. On the left is a navigation sidebar with options like 'Read Me First', 'Welcome', 'Course Information', 'Announcements', 'Course Guide', 'Course Materials', 'Assessment', 'My Groups', 'My Grades', 'Discussion Board', 'Course Contacts', 'Have Your Say', 'Library Resources', 'Help and Support', 'Archive', and 'Course Management'. The main content area displays a 'Table of Contents' with items such as '01. HMT1 - Introduction video with Quiz', '02. Experimental Apparatus HMT1', and '03. Risk Assessment Practice HMT1'. The selected item, '01. HMT1 - Introduction video with Quiz', is expanded to show an introduction text, a video player (HMT1-02.ExpApp.mp4), and a quiz section. The introduction text discusses practical cooling technologies and boiling heat transfer. The quiz section includes two references: [1] J. G. Leidenfrost, De Aquae Communis Nonnullis Qualitatibus Tractatus, 1756; and [2] E.A. Farber, E.L. Scora, Heat transfer to water boiling under pressure, Transactions of the ASME, 1948, 70, 369-384.

## Two-phase Heat Transfer

### 1. Introduction

# Interactive Environment Online Prep I



Engaging virtual learning environment within Learn capabilities

Videos with Quizzes to test students knowledge

Untitled Question 1 of 4 Hide

What is the most efficient way of heat transfer amongst the options below?

- Forced convection heat transfer
- Natural convection heat transfer
- Single-phase heat transfer
- Two-phase heat transfer

Submit Answers

Untitled Question 1 of 4 Correct Hide

What is the most efficient way of heat transfer amongst the options below?

Correct, two-phase heat transfer is one of the most efficient ways of transferring heat as it takes advantage of the latent heat of vaporisation/condensation, which provides orders of magnitude higher heat transfer coefficients than sensible heat or single phase.

- Forced convection heat transfer
- Natural convection heat transfer
- Single-phase heat transfer
- Two-phase heat transfer

Untitled Question 2 of 4 Incorrect Hide

What are the heat transfer regimes ensuing on a surface as the heating or power of the surface increases?

Incorrect. The heat transfer regimes ensuing as the temperature increases are: free convection, forced convection, nucleate boiling, unstable film boiling, stable film boiling. Where convection takes place in single phase, then phase change with nucleate boiling occurs and last film boiling.

- Forced convection, free convection, nucleate boiling, stable film boiling and unstable film boiling
- Free convection, forced convection, nucleate boiling, unstable film boiling, stable film boiling
- Free convection, forced convection, unstable film boiling, stable film boiling, nucleate boiling

Previous Continue

# Interactive Environment Online Prep II



Engaging virtual learning environment within Learn capabilities

Videos with Quizzes to test students knowledge

Interactive Activities: fill the blank and mix and match

## Question 1

100 points

Save Answer

Fill in the blanks with the following words **copy exactly the word/s separated by a coma and paste them in the blanks** as the corrections are case sensitive; inlet, water, thermometer T3, pressure, power, outlet, thermocouple T1, pressure gauge, pentaflouorobutane, electric heater, thermometer T2, condenser, valve V1

The experiment consists of a glass cylindrical pressure vessel filled with . An  where the  is controlled and known is used as the heating surface. The temperature of the heater is measured using , that of the liquid by  and that of the vapour by . A  is utilised additionally to condense the pentaflouorobutane vapour so to be able to control the  inside the system, which is measured with a . The  and  temperatures of the cooling water running through the condenser are measured via the thermometer T5 and thermometer T4, respectively, while the flow of cooling  running through the condenser is controlled with .

### QUESTION 1

Match up the following hazards with their respective control measures.

- Over pressurisation of the chamber
- Overheating of the copper heater
- Pentaflouorobutane
- Hot Surfaces
- Water Spillage
- Electrocutation

- A. Not harmful. Contained in low pressure cylinder for refilling and inside the sealed chamber
- B. Pressure relieve valve
- C. Make sure and check periodically that there are no leaks around the glass cylindrical pressure vessel
- D. Safety controller switches ON at  $T > 160\text{ }^{\circ}\text{C}$
- E. Make sure and check periodically that there are no leaks around the glass cylindrical pressure vessel and that is the case shut down all the electric components promptly
- F. The boiling temperature of pentaflouorobutane is  $40.2\text{ }^{\circ}\text{C}$  and an insulating glass cylindrical pressure vessel ensures that temperature around the vessel is near that of the ambient temperature

100 points

Save Answer

Click Submit to complete this a

# Interactive Environment Online Prep II

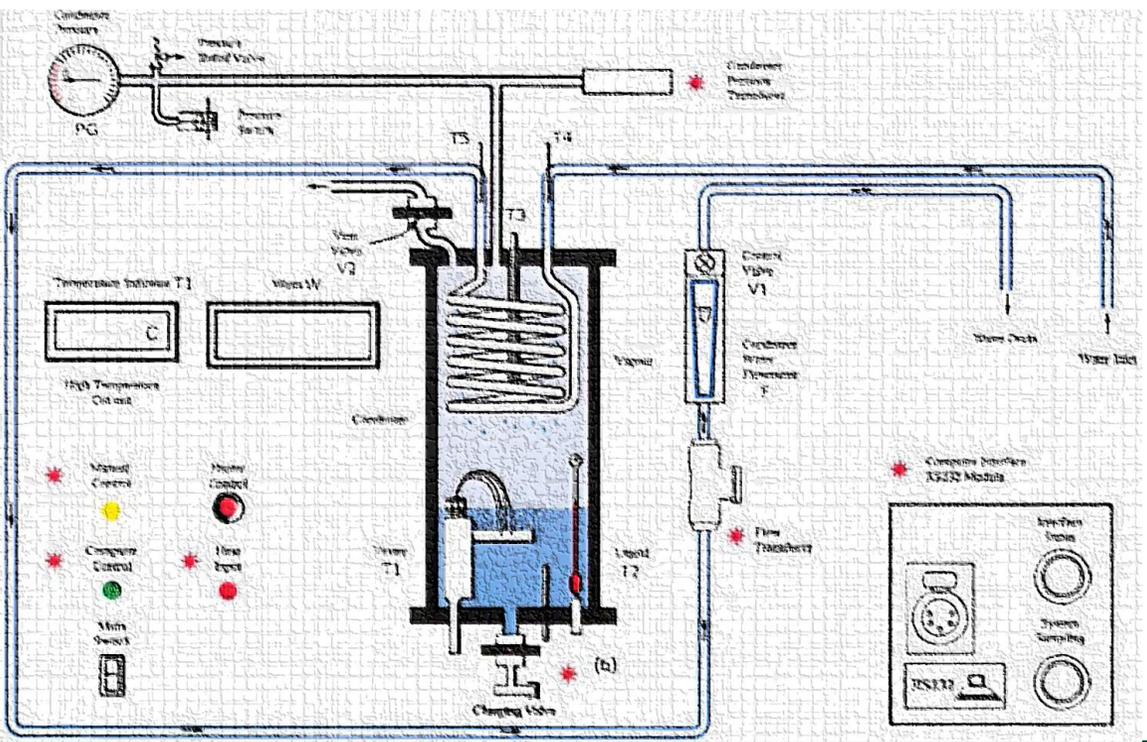


Engaging virtual learning environment within Learn capabilities

Videos with Quizzes to test students knowledge

Interactive Activities: fill the blank and mix and match

Small Formative Assignments



**Risk Assessment**

THE UNIVERSITY OF EDINBURGH School of Engineering

Risk Ref No: Eng - RA - 7611/2022  
Date: 7/11/2022  
Review Date: [Blank]  
Risk = Consequence x Likelihood

Location: Chemical Engineering Teaching Laboratory - 1<sup>st</sup> year  
Task: NMT1 - Two-Phase Heat Transfer  
Supervisor/Manager: DANIEL OREJON  
Assessment Completed By: DANIEL OREJON  
Signed: [Signature]

Hazards	People at Risk*	Initial Level of Risk			Control Measures	Revised Level of Risk			Controls implemented by
		H	M	L		H	M	L	
Over pressurisation of the chamber	E	H	M	L	Pressure relieve valve integrated in the system	L	L	L	E
Overheating of the copper heater	E	H	M	L	Safety controller switches ON at $T > 160$ °C	L	L	L	E
Pentafluorobutane	E	L	L	L	Not harmful Contained in low pressure cylinders for refilling and inside the sealed vessel Amount of Pentafluorobutane vented when decreasing system pressure not harmful	L	L	L	E
Hot surfaces	E	L	L	L	Pentafluorobutane boils at 40.2 °C at ambient temperature and insulating transparent vessel contains the boiling fluid ensuring the temperature on the surface is always lower than that of human body	L	L	L	E
Fluid spillage	F	L	L	L	Pentafluorobutane is contained in a sealed vessel mitigating any possible leakage. If that happens clean staffs with a cloth spill mat or mop. Be mindful of any electrical component around spillage	L	L	L	E
1,1,1,1-Pentafluorobutane	F	L	L	L	Pentafluorobutane is contained in a sealed vessel mitigating any possible leakage or exposure to the ambient Retained in very small amounts compared to the laboratory size Do read carefully the COSHH form	L	L	L	E

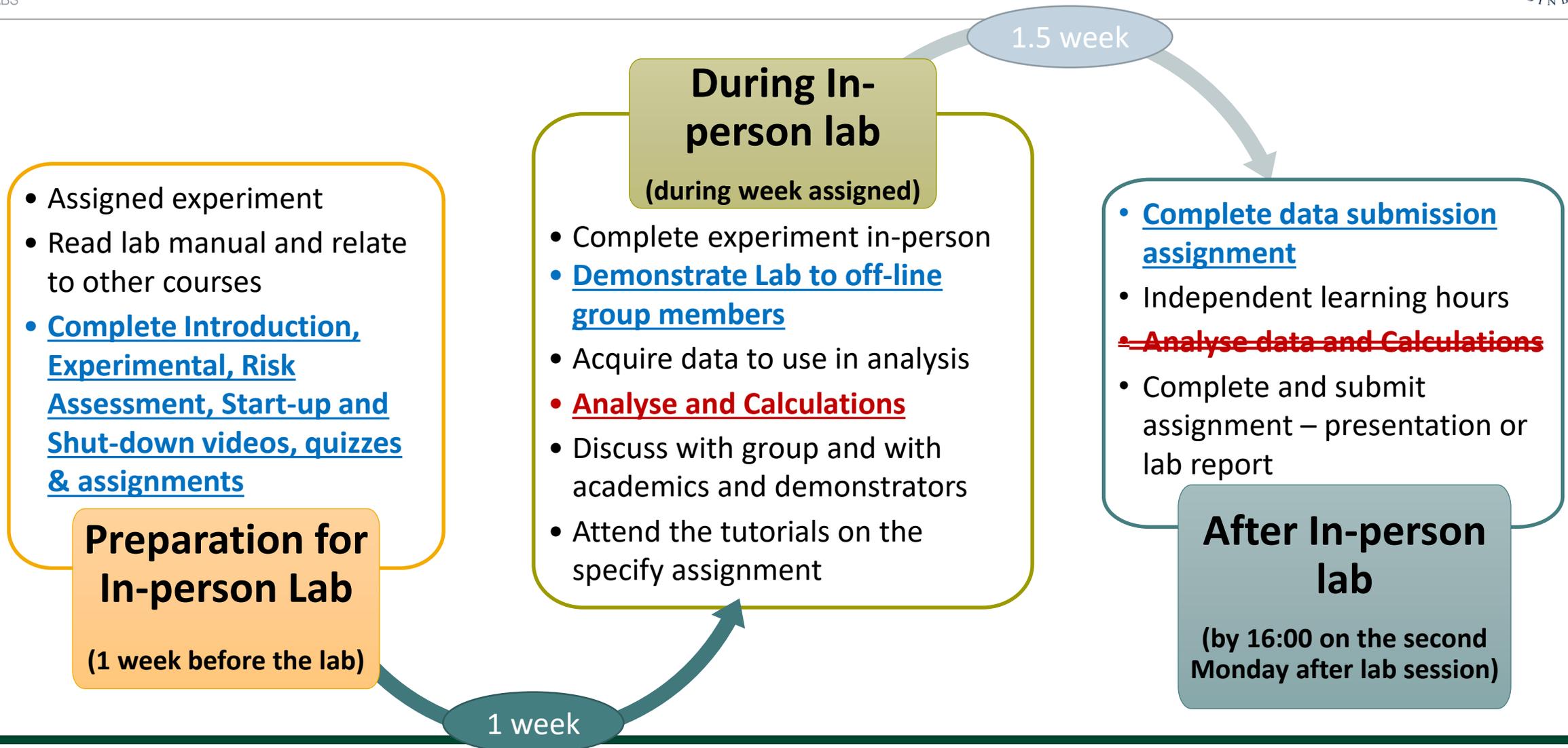
\* People at Risk:  
E - Employees/Student, C - Contractor, P - Member of Public

# Interactive Environment Online Prep III

Introduction	<ul style="list-style-type: none"><li>• Overview of experiment</li><li>• Industrial applications</li><li>• <b>Camtasia Quiz (0.4%)</b></li></ul>
Experimental	<ul style="list-style-type: none"><li>• Video Walk-through of apparatus</li><li>• <b>Submission of schematic diagram</b></li><li>• <b>Fill-in-the-blank on Learn (0.4%)</b></li></ul>
Risk Assessment	<ul style="list-style-type: none"><li>• <b>Submission of Risk Assessment</b></li><li>• Video Hazards and control measures</li><li>• <b>Match-up task on Learn (0.4%)</b></li></ul>
Start-up	<ul style="list-style-type: none"><li>• Video Safe set-up</li><li>• <b>Submission of Preparation Table</b></li><li>• <b>Camtasia Quiz (0.4%)</b></li></ul>
Shutdown	<ul style="list-style-type: none"><li>• Video Safe shutdown</li><li>• <b>Submission of the Experimental Data</b></li><li>• <b>Camtasia Quiz (0.4%)</b></li></ul>

**ALL Video quizzes, Learn Activities, and Assignments must be submitted before the laboratory session (except Experimental Data)**

# Interactive Environment Online Prep IV



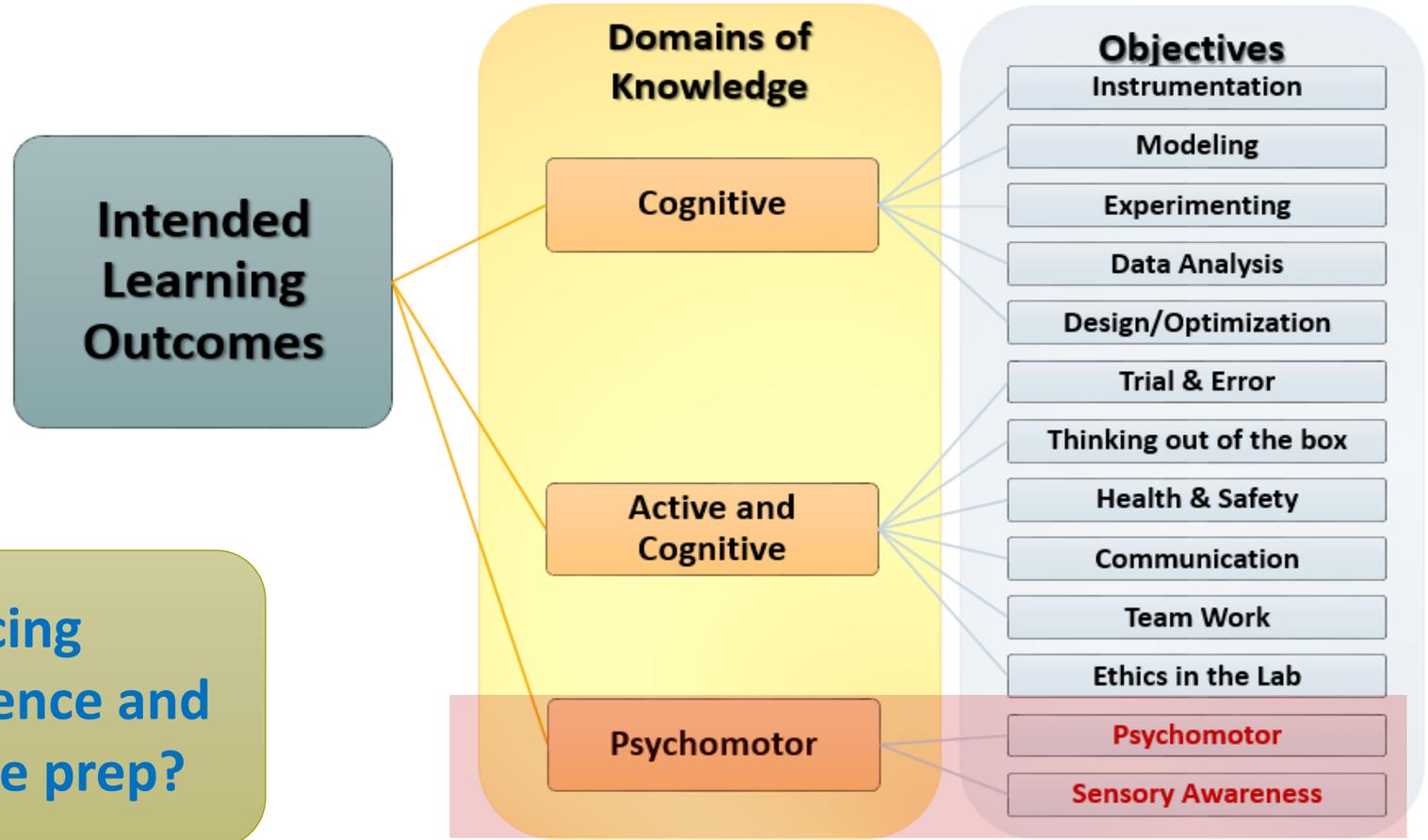
# Online Prep I – Research Question?

## II. HISTORICAL ROLE OF ENGINEERING INSTRUCTIONAL LABORATORIES

Engineering is a practical discipline. It is a hands-on profession where doing is key. Consequently, prior to the creation of engineering schools, engineering was taught in an apprenticeship program modeled in part after the British apprenticeship system. These early engineers had to design, analyze, and build their own creations—learning by doing. Engineering education, even today, occurs as much in the laboratory as in the classroom. The onset of formal engineering education and practice evolved. Learning on practice.

Feisel and

**Are we enhancing preparation, confidence and learning via On-Line prep?**



ABET: Accreditation Board for Engineering and Technology Supported by the Sloan Foundation, 2002 from Feisel and Rosa, *J. Eng. Edu.* **94**, 2005



# Online Prep II - Survey



Orejon Online Prep Survey Chem Eng Labs 3

## Interactive Learning Environment On-Line Preparation for Enhanced Confidence and Learning in Chemical Engineering Experimental Laboratories

The objective of this survey is to inform, academics and demonstrators within the Chemical Engineering Discipline on the effectiveness of the Online Preparation within Chemical Engineering Laboratory 3 (CEL3), as well as to disseminate knowledge of the approach to other Disciplines within the School of Engineering and others where practical laboratory teaching is carried out.

Traditionally students have been requested to read the laboratory manual and additional supporting information prior to a laboratory session. Occasionally, students are asked to prepare material, such as data sheets, prior to a laboratory session, but this tends not to be mandatory except for a Risk Assessment.

While this preliminary preparation can be useful and intrinsic to all disciplines, the case of Chemical Engineering seems particularly appropriate as some students face difficulties with confidence and/or even engagement during the laboratory session.

Extensive video and support material created during the Covid-19 pandemic for the delivery of the labs fully remotely, has been shifted into preparatory work given a step-by-step online preparation format. The online preparation consists of videos, and quizzes and assignments to reinforce the concepts seen on the videos and/or from the laboratory manual. This material is broken down into an Introduction (short video with an embedded Camtasia quiz), Experimental Apparatus (video with

mission), Risk Assessment (video with a follow up quiz), Start-up (video with quiz and blank datasheet submission), and Experimental Datasheet Submission (video with quiz and blank experimental datasheet submission). These online materials are designed to allow students to reflect on the information for each of these individual online preparation activities.

This survey is motivated by the encouraging and insightful comments received from students during the CEL3 Mid-Term questionnaire in Semester 1 2022/23, including comments such as:

*"Pre-lab work: really detailed, helped me so much with preparation for the actual lab"*

*"Preparation before lab tasks are very useful"*

*"The systematic arrangement of the things we have to do before the lab on Learn"*

With this Survey we would like to gather a representative set of student opinion on the effectiveness of on-line material in preparing them for an experimentation session and the impact on students' level of confidence towards tackling experiments.

The findings of this survey will be presented at [The University of Edinburgh's Learning and Teaching Conference](#), taking place on 27th and 28th June 2023 under the sub-theme **Innovation and creativity in teaching: Have you been motivated to do something different than what has been done before to inform or improve your teaching practice?** Submissions could include examples of innovative and creative approaches, with a focus on the outcome of the inquiry (e.g., developing new pedagogies; ways of teaching) or a focus on the process of the inquiry (e.g., new methodologies).

In addition, CEL3 academics also aim to report such findings in [Education for Chemical Engineers](#) international peer reviewed journal and inform the Higher Education Academy. A related report on the effectiveness of large-scale implementation of hybrid labs for experimental learning can be found at: <https://www.sciencedirect.com/science/article/pii/S1749772822000082?via%3DIihub>

CEL – Online Prep Survey 1

Orejon Online Prep Survey Chem Eng Labs 3

## Survey on the students' info

I agree for the results of this survey to be anonymized and to be used and shared for events on Learning and Teaching as well as for publications on Learning and Teaching.

- Specify your course of study
  - 2<sup>nd</sup> year
  - 3<sup>rd</sup> year
  - 4<sup>th</sup> year
- Select the modes (all those that apply) of laboratory delivery you have experienced so far:
  - Fully online
  - Hybrid (academic or other student in the lab and you remotely)
  - Hybrid (you in the lab and other student remotely)
  - In-person
- Select the modes (all those that apply) of laboratory preparation you have experienced so far:
  - No preparation prior to the lab
  - Laboratory Manual and/or reading materials
  - Online preparation material only
  - Online preparation and laboratory manual and/or reading materials

## Survey on the effectiveness of the different preparation modes

- From these modes of laboratory preparation, which ones do you consider the most effective in terms of: Preparing you on the **fundamentals and concepts of the experiment?** (Evaluate each from 0 Not Effective at all to 5 Extremely Effective)

a. No preparation prior to the lab	0	1	2	3	4	5
N/A						

b. Laboratory Manual and reading materials	0	1	2	3	4	5
N/A						

c. Online preparation	0	1	2	3	4	5
N/A						

d. Online preparation and reading materials including laboratory manual	0	1	2	3	4	5
N/A						

- From these modes of laboratory preparation, which ones do you consider the most effective in terms of: Preparing you on the **practicality towards applying the concepts in the lab?** (Evaluate each from 0 Not Effective at all to 5 Extremely Effective)

a. No preparation prior to the lab	0	1	2	3	4	5
N/A						

b. Laboratory Manual and reading materials	0	1	2	3	4	5
N/A						

c. Online preparation	0	1	2	3	4	5
N/A						

d. Online preparation and reading materials including laboratory manual	0	1	2	3	4	5
N/A						

CEL – Online Prep Survey 2

Previous Lab Prep Experiences

Effectiveness of Preparation modes

Purpose Survey



# Online Prep II - Survey

Effectiveness of Preparation modes

Online Prep Specifics

Orejon Online Prep Survey Chem Eng Labs 3

6. From these modes of laboratory preparation, which ones do you consider the most effective in terms of furnishing you with confidence towards tackling the experiment?  
(Evaluate each from 0 Not Effective at all to 5 Extremely Effective)

e. No preparation prior to the lab	N/A	0	1	2	3	4	5
f. Laboratory Manual and reading materials	N/A	0	1	2	3	4	5
g. Online preparation	N/A	0	1	2	3	4	5
h. Online preparation and reading materials including laboratory manual	N/A	0	1	2	3	4	5

Survey on the usefulness of the different online prep activities

7. Specific questions on the online preparation (only if selected Online preparation material only and/or Online preparation and laboratory manual and/or reading materials in Q3)  
(Evaluate each from 0 Not Effective at all to 5 Extremely Effective)

a. How useful do you find the videos with quizzes for the different online preparation	N/A	0	1	2	3	4	5
b. How useful do you find the intermediate graded assignments (such as mix and match, fill the gap, and online quizzes).	N/A	0	1	2	3	4	5
c. How useful do you find the intermediate submission assignments (such as Apparatus Schematics, Risk Assessment and Data sheets)	N/A	0	1	2	3	4	5

8. Specific questions on the online preparation (only if selected Online preparation material only and/or Online preparation and laboratory manual and/or reading materials in Q3)  
(Evaluate each from 0 Strongly Disagree to 5 Strongly Agree)

a. Enhances my preparation	N/A	0	1	2	3	4	5
b. Enhances my confidence	N/A	0	1	2	3	4	5
c. Enhances my learning	N/A	0	1	2	3	4	5
d. The different short videos and activities broken down in a step-by-step systematic and reflective manner benefits my preparation	N/A	0	1	2	3	4	5
e. Enables me to interact and communicate better with academics and demonstrators	N/A	0	1	2	3	4	5
f. Online preparation is as useful as manual and additional readings	N/A	0	1	2	3	4	5
g. Motivates me as it contributes towards my final grade	N/A	0	1	2	3	4	5
h. Should be optional	N/A	0	1	2	3	4	5

CEL - Online Prep Survey 3

Orejon Online Prep Survey Chem Eng Labs 3

Additional Comments

9. What did you like/went well with the online prep?

10. What did not you like/went wrong with the online prep?

11. How can this be improved?

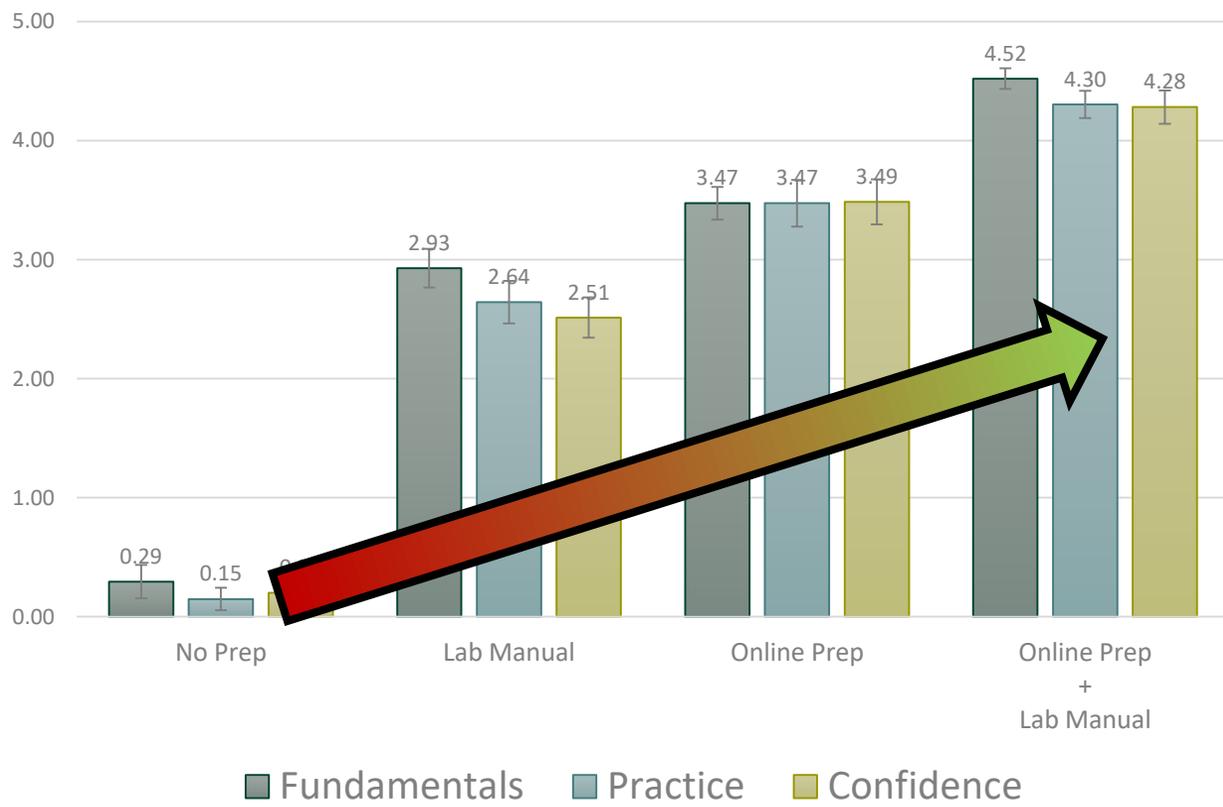
CEL - Online Prep Survey 4

Additional Comments

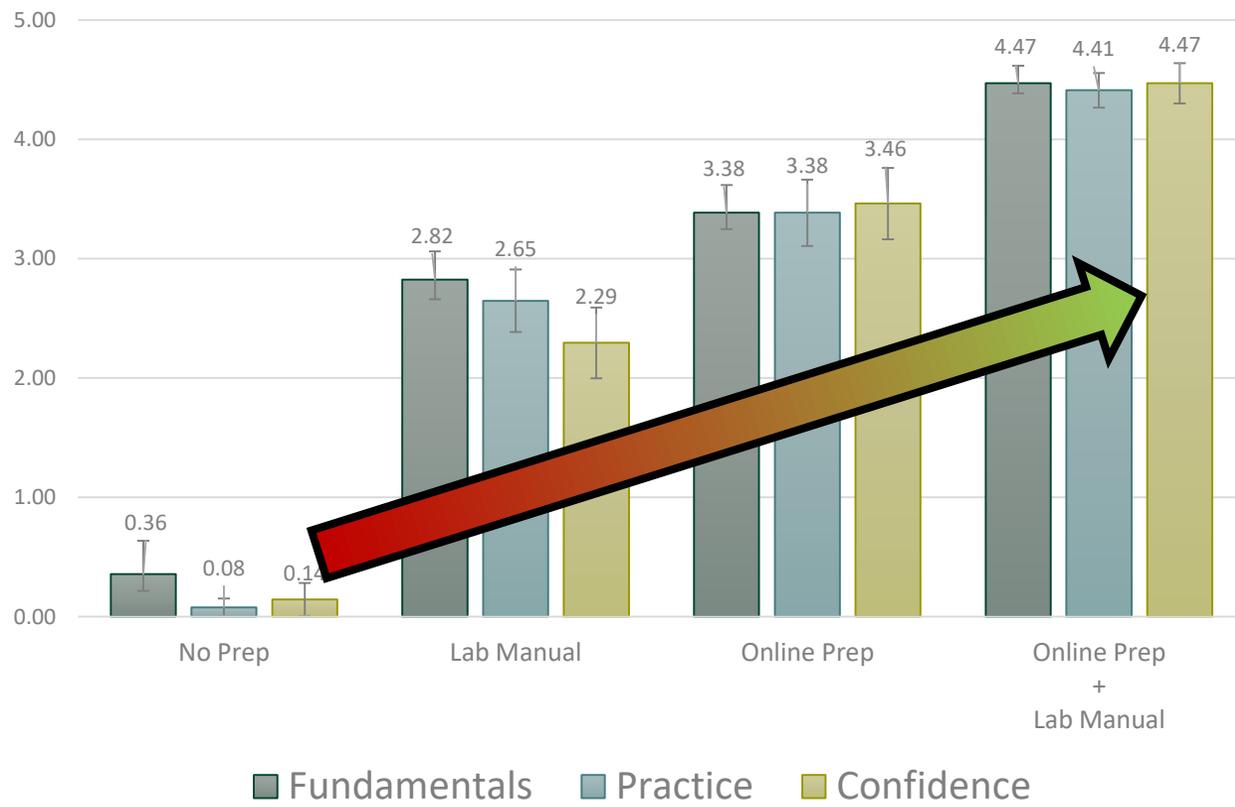
# Online Prep III – Main Findings I

✓ The two sets of data are equally representative!  
 ✓ Focus on right-hand side data!

Effectiveness - All Students Agreed (46/48)



Effectiveness - Students Experience Different Prep Modes (17/48)



■ Fundamentals ■ Practice ■ Confidence

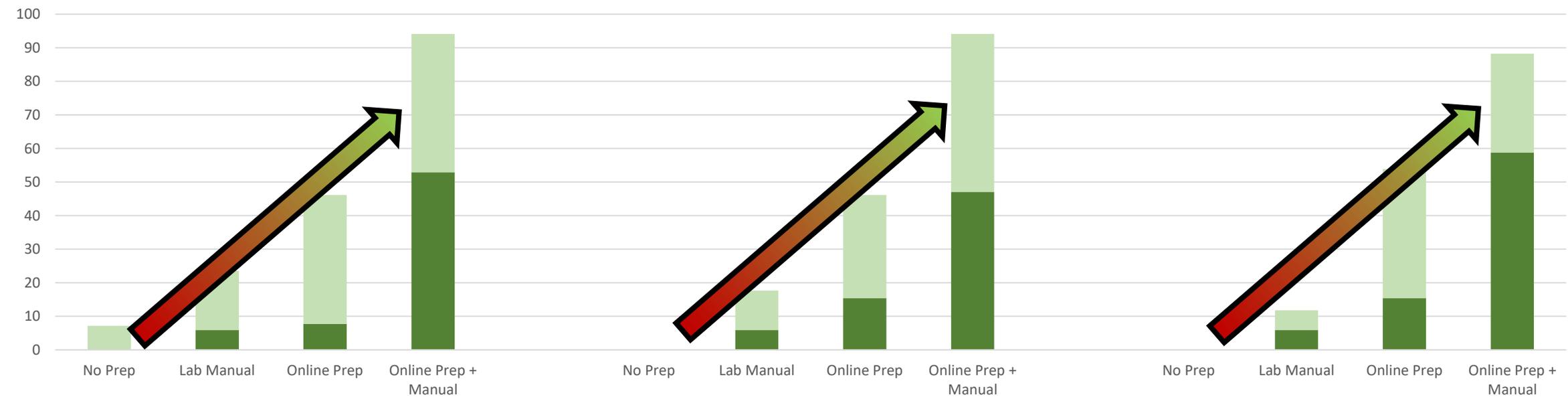
■ Fundamentals ■ Practice ■ Confidence

0 – Not Effective at All → 5 – Extremely Effective

# Online Prep III – Main Findings II

✓ **Online Prep enhances Fundamentals, Practical and Confidence**

Fundamentals Practice Confidence



■ Extremely Effective ■ Very Effective

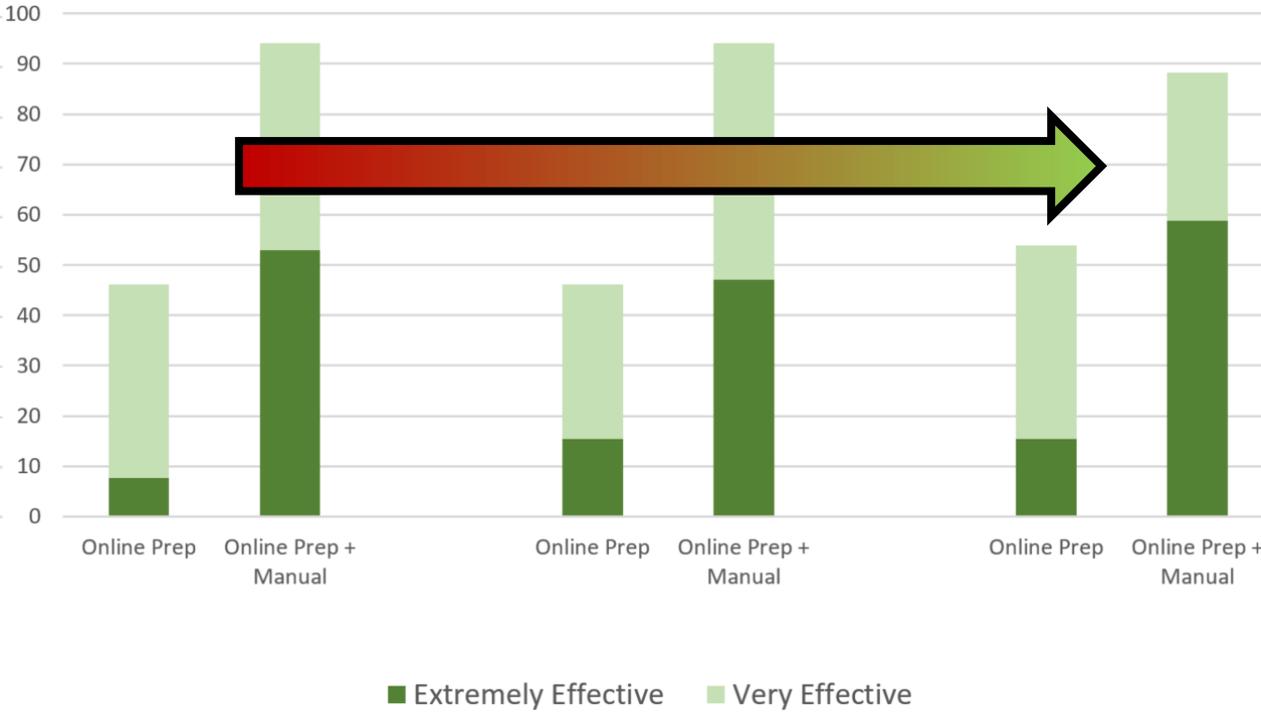
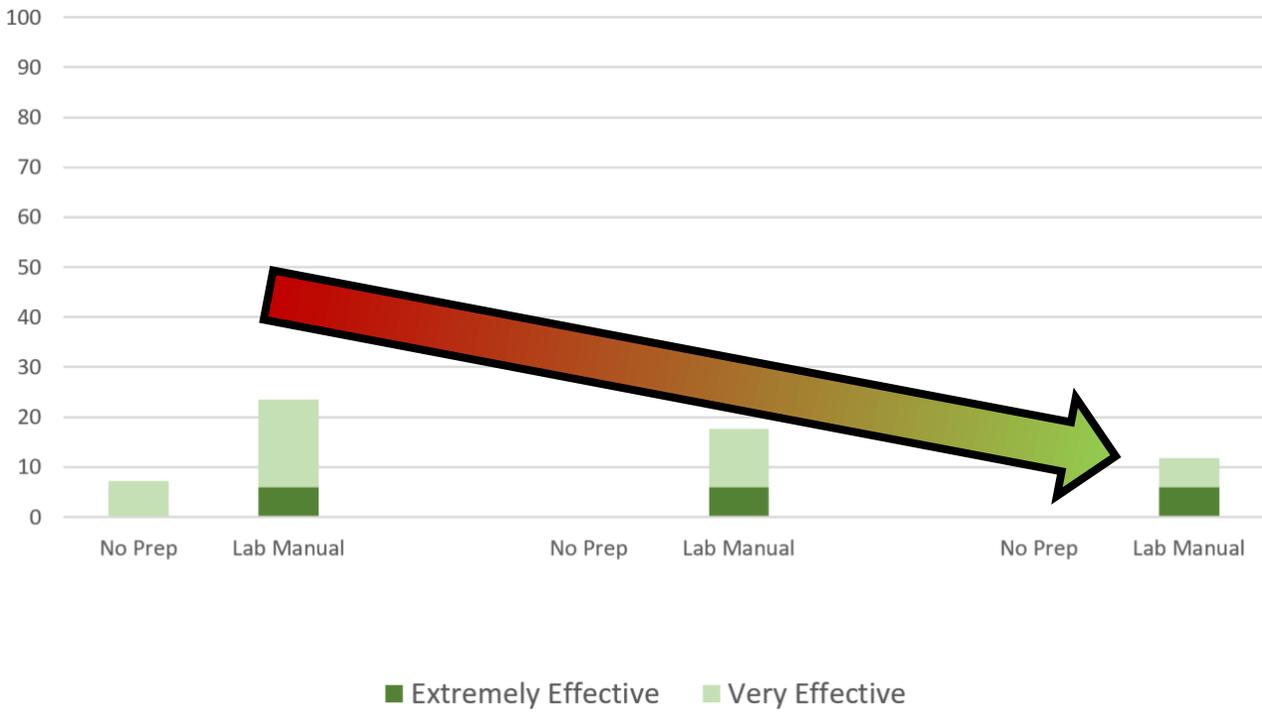
No Prep: 0% - 7% Effective  
 Lab Manual Prep: 12% - 24% Effective  
 Online Prep: 46% - 54% Effective  
**Online + Lab Manual Prep: 88% - 94% Effective**

# Online Prep IV – Specific Findings I



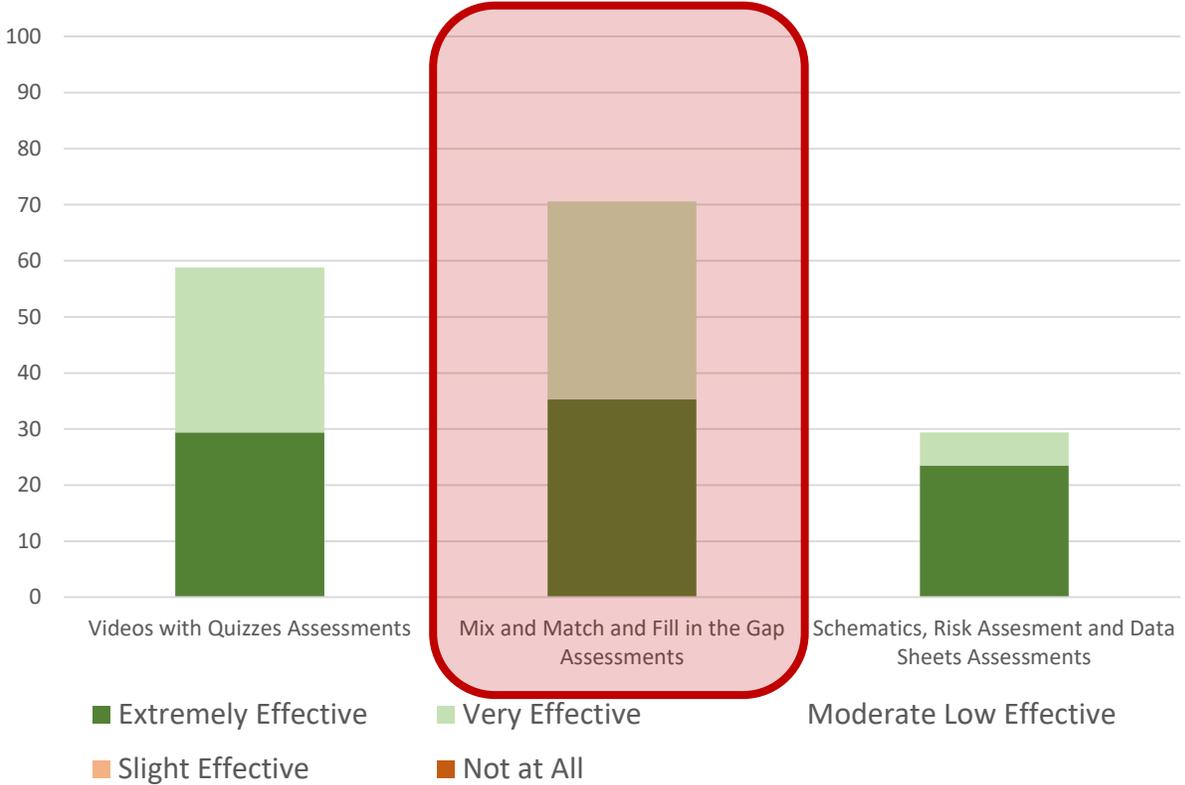
✓ No prep or only Lab Manual mainly not effective on Fundamentals, Practice and Confidence prep  
 ✓ Lab Manual Effectiveness the least for Confidence

✓ Similar perception on Fundamentals, Practice and Confidence prep for online and online + lab manual prep

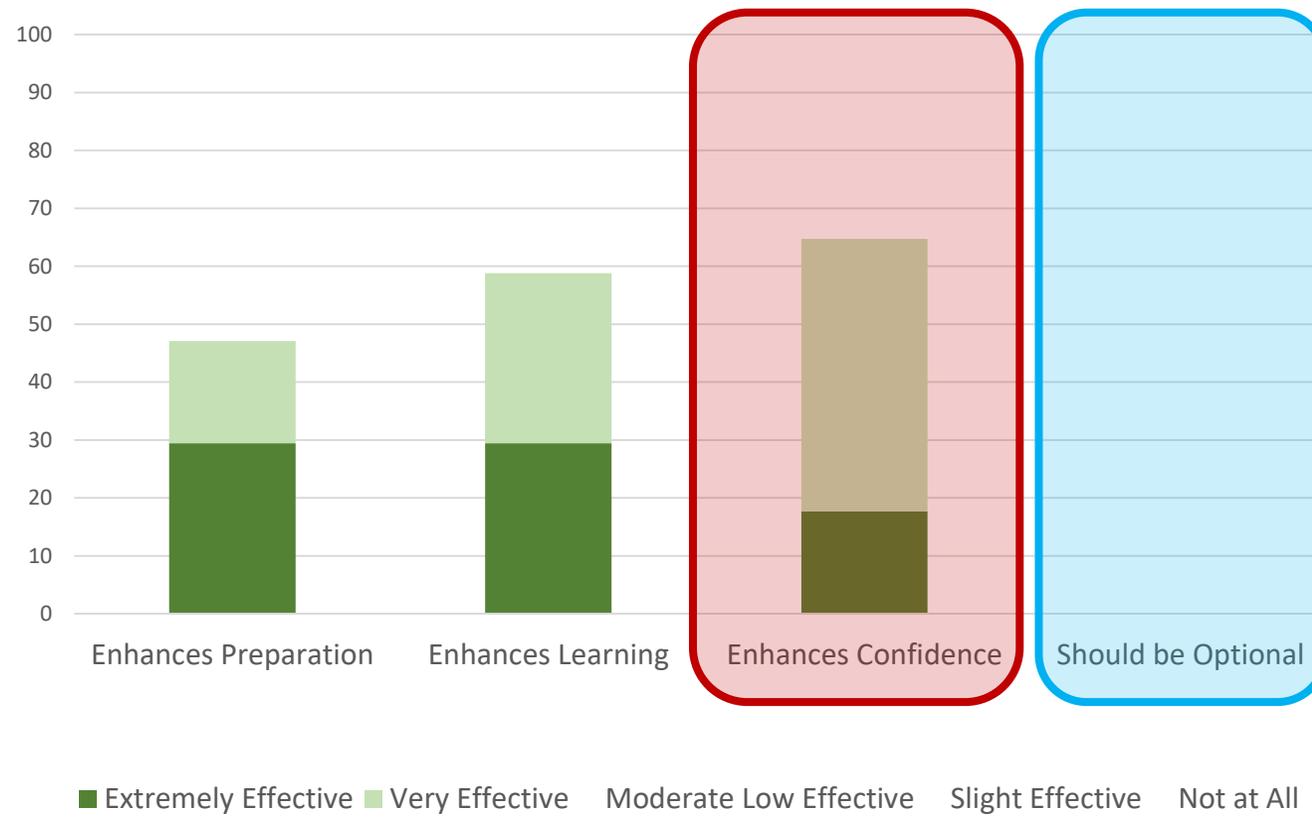


# Online Prep IV – Specific Findings II

## Effectiveness - Online Prep Activities

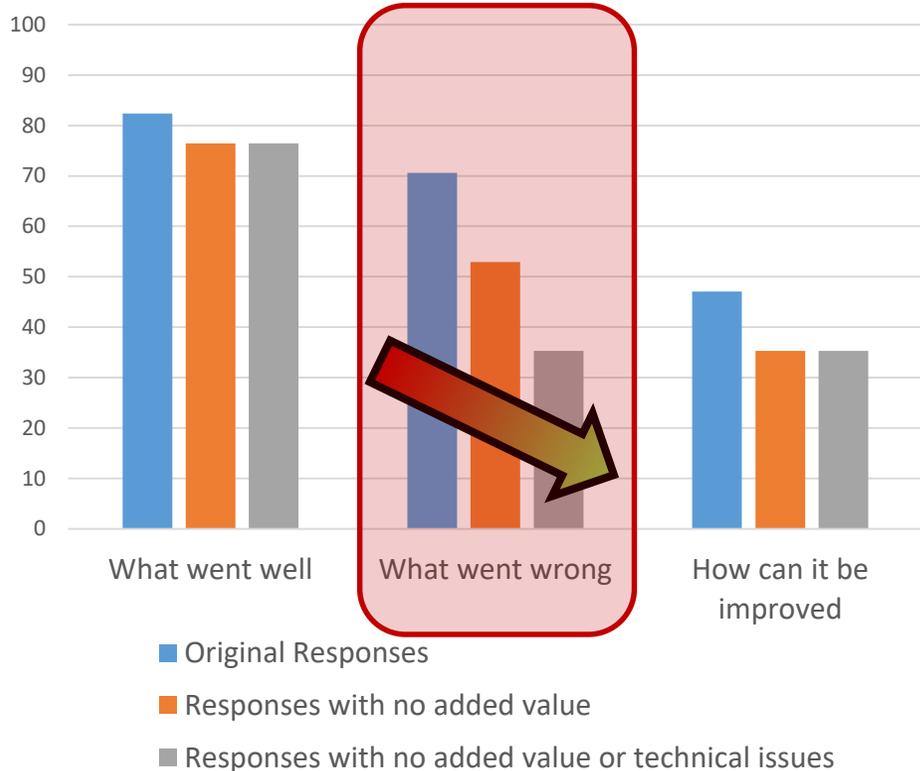


## Enhancement Prep, Learning and Confidence



# Online Prep V – Students’ Comments I

Students Comments



## What went well:

- “It gives a good understanding of an upcoming lab and I have a chance to get familiar with materials”
- “Watching prep video, we can better understand what are we going to do in a lab. See the apparatus and valves/buttons we are practically going to change. Really helpful. “

## What went wrong:

- “Some questions are not covered in videos and require research outside the material given which can be confusing”
- “Some of the content in the videos seems unnecessary”
- “Don’t like schematics and prep sheet creation.”

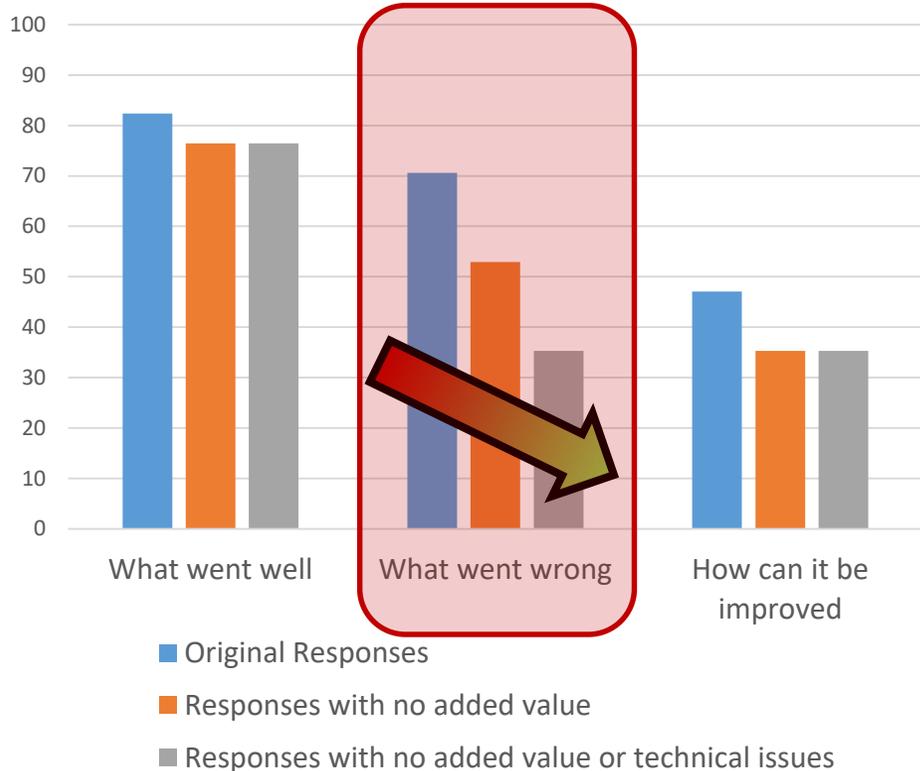
## What to improve:

- “Perhaps the experimental theory could be presented in online videos. This would be vey useful for when the lab manual and additional materials for read are not enough”
- “Edit the videos so that the waiting around time is shorted (edited out) Incorporate true schematics/experiments into the mix and match exercise (more engaging). “

# Online Prep V – Students’ Comments II



## Students Comments



### Opposite Views:

✓ “There were very useful in understanding the apparatus, the methodology as well as the measurements to be taken “

✗ “Don’t like having to draw the schematics diagram (don’t find it useful)”

✓ “we get a good insight into what the experiment is going to be. Therefore we can ensure that our excel sheet is appropriate”

✗ “Don’t like schematics and prep sheet creation. Prep sheet especially because from manual we do not know exactly which variables we are going to change and which should be recorded.”

# Conclusions

✓ Online Prep enhances Fundamentals, Practical and Confidence **88% - 94% Effective**

✓ Lab manual & No prep provides the least Confidence **< 15% Effective**

✓ Online Prep enhances Confidence the most **> 65% Effective**

✓ Other Students and Practical Disciplines may also benefit from it

## Other Comments:

- *"Nothing bad to mention"*
- *"You are doing great!"*
- *"I think I learned a lot from doing them"*
- *"Different activities so it is more engaging"*
- *"Makes me do it to the best of my ability"*

