University *of Ljubljana*
Faculty *of Mathematics*
and Physics

YPT toolkit

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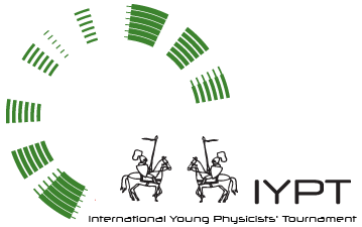
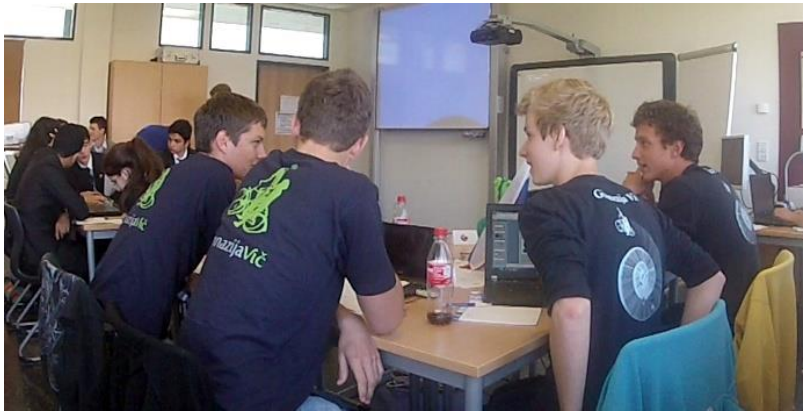


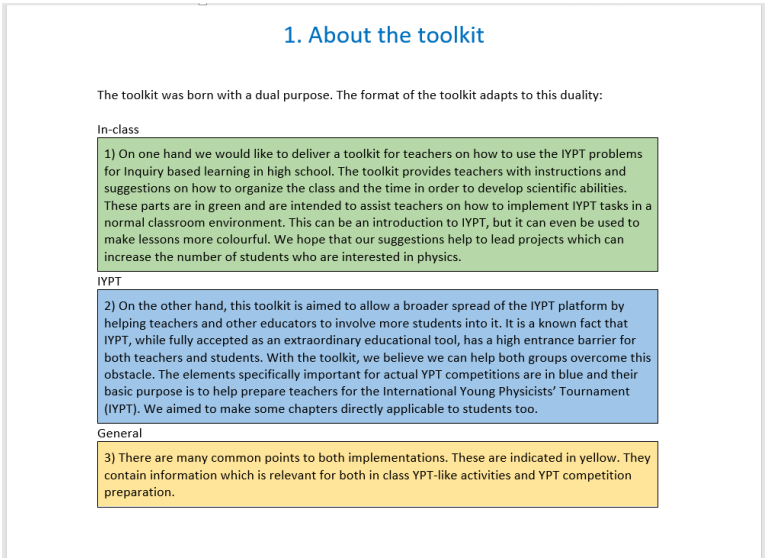
Goals

- YPT in class
  - Research
  - Presentation
  - Peer review (opposition)
  - Judgement (review)
  - *Testing experiment
- YPT competition preparation
  - Joint experiences



Structure

- Colour coded
- Main part
  - Conceptualization of physical (scientific) research
  - Description of steps in class
  - Additional steps for competitions
- Appendices
  - Conceptualization of different roles of experiments
  - Concrete example of in-class activity
  - Concrete example of IYPT preparation
  - Rubrics for scoring



1. About the toolkit

The toolkit was born with a dual purpose. The format of the toolkit adapts to this duality:

In-class

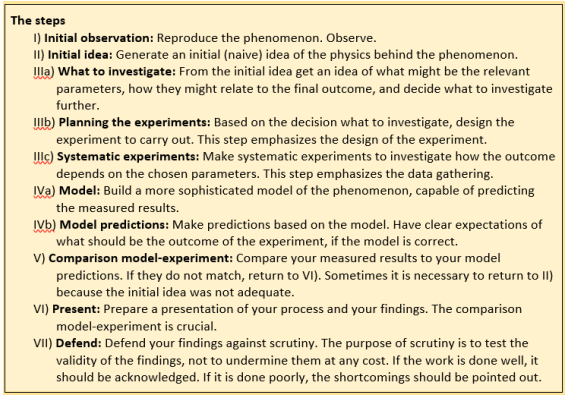
1) On one hand we would like to deliver a toolkit for teachers on how to use the IYPT problems for Inquiry based learning in high school. The toolkit provides teachers with instructions and suggestions on how to organize the class and the time in order to develop scientific abilities. These parts are in green and are intended to assist teachers on how to implement IYPT tasks in a normal classroom environment. This can be an introduction to IYPT, but it can even be used to make lessons more colourful. We hope that our suggestions help to lead projects which can increase the number of students who are interested in physics.

IYPT

2) On the other hand, this toolkit is aimed to allow a broader spread of the IYPT platform by helping teachers and other educators to involve more students into it. It is a known fact that IYPT, while fully accepted as an extraordinary educational tool, has a high entrance barrier for both teachers and students. With the toolkit, we believe we can help both groups overcome this obstacle. The elements specifically important for actual YPT competitions are in blue and their basic purpose is to help prepare teachers for the International Young Physicists' Tournament (IYPT). We aimed to make some chapters directly applicable to students too.

General

3) There are many common points to both implementations. These are indicated in yellow. They contain information which is relevant for both in class YPT-like activities and YPT competition preparation.



The steps

I) **Initial observation:** Reproduce the phenomenon. Observe.
II) **Initial idea:** Generate an initial (naive) idea of the physics behind the phenomenon.
IIIa) **What to investigate:** From the initial idea get an idea of what might be the relevant parameters, how they might relate to the final outcome, and decide what to investigate further.
IIIb) **Planning the experiments:** Based on the decision what to investigate, design the experiment to carry out. This step emphasizes the design of the experiment.
IIIc) **Systematic experiments:** Make systematic experiments to investigate how the outcome depends on the chosen parameters. This step emphasizes the data gathering.
IVa) **Model:** Build a more sophisticated model of the phenomenon, capable of predicting the measured results.
IVb) **Model predictions:** Make predictions based on the model. Have clear expectations of what should be the outcome of the experiment, if the model is correct.
V) **Comparison model-experiment:** Compare your measured results to your model predictions. If they do not match, return to VI). Sometimes it is necessary to return to II) because the initial idea was not adequate.
VI) **Present:** Prepare a presentation of your process and your findings. The comparison model-experiment is crucial.
VII) **Defend:** Defend your findings against scrutiny. The purpose of scrutiny is to test the validity of the findings, not to undermine them at any cost. If the work is done well, it should be acknowledged. If it is done poorly, the shortcomings should be pointed out.

Conceptualization of research

The steps

I) Initial observation: Reproduce the phenomenon. Observe.

II) Initial idea: Generate an initial (naive) idea of the physics behind the phenomenon.

IIIa) What to investigate: From the initial idea get an idea of what might be the relevant parameters, how they might relate to the final outcome, and decide what to investigate further.

IIIb) Planning the experiments: Based on the decision what to investigate, design the experiment to carry out. This step emphasizes the design of the experiment.

IIIc) Systematic experiments: Make systematic experiments to investigate how the outcome depends on the chosen parameters. This step emphasizes the data gathering.

IVa) Model: Build a more sophisticated model of the phenomenon, capable of predicting the measured results.

IVb) Model predictions: Make predictions based on the model. Have clear expectations of what should be the outcome of the experiment, if the model is correct.

V) Comparison model-experiment: Compare your measured results to your model predictions. If they do not match, return to VI). Sometimes it is necessary to return to II) because the initial idea was not adequate.

VI) Present: Prepare a presentation of your process and your findings. The comparison model-experiment is crucial.

VII) Defend: Defend your findings against scrutiny. The purpose of scrutiny is to test the validity of the findings, not to undermine them at any cost. If the work is done well, it should be acknowledged. If it is done poorly, the shortcomings should be pointed out.

Steps in class

20 minute time slots

20 min -	I) Initial observation
	II) Initial idea
	IIIa) What to investigate
40 min -	IIIb) Planning the experiments
60 min -	IIIc) Systematic experiments
80 min -	IVa) Model
	IVb) Model predictions
100 min -	V) Comparison model-experiment
	Prepare presentation
120 min -	VI) Present
	Peer review
	VII) Defend

Steps in class

20 minute time slots

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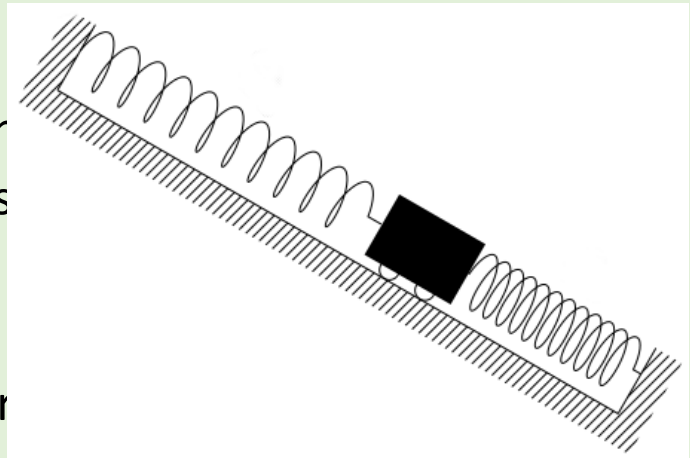

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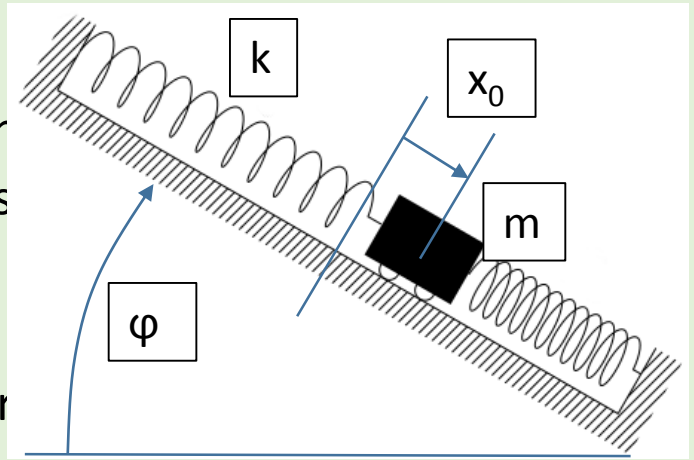

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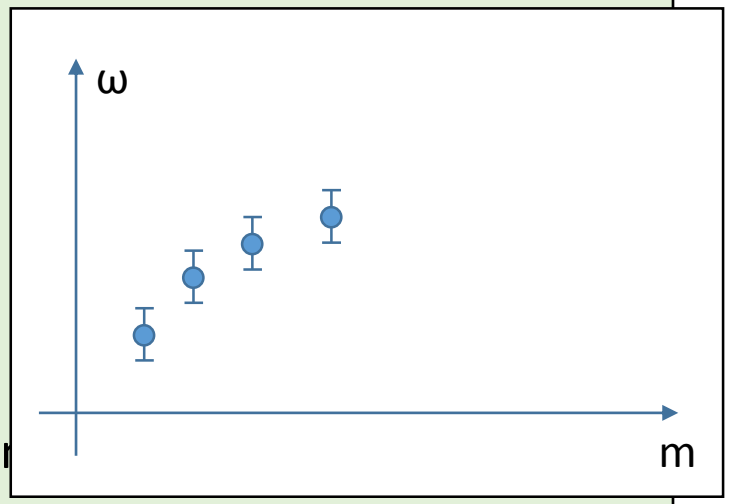

Steps in class

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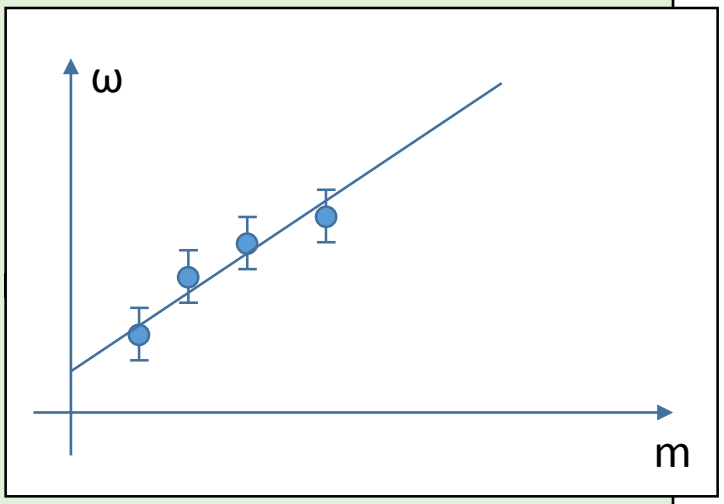
80 min -	**IVa) Model**
	IVb) Model predictions
100 min -	V) Comparison model-experime
	Prepare presentation
120 min -	VI) Present
	Peer review
	VII) Defend

Mechanistic analytical

$$\omega = C\sqrt{\frac{k}{m}}$$

Phenomenological



Steps in class

20 minute time slots

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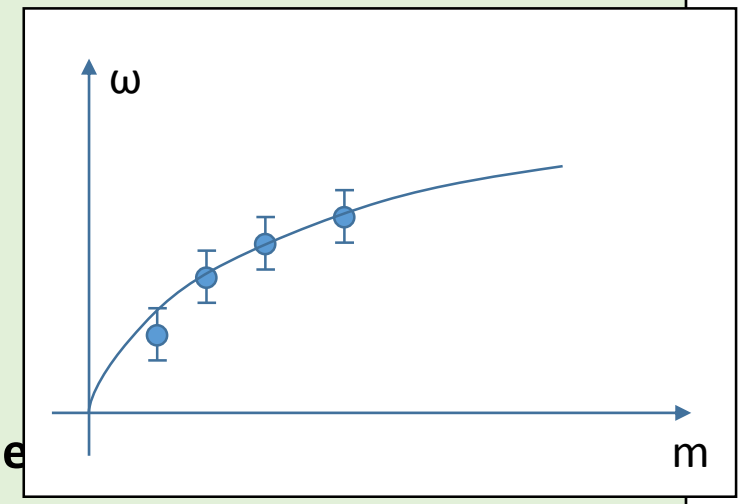

Steps in class

20 minute time slots

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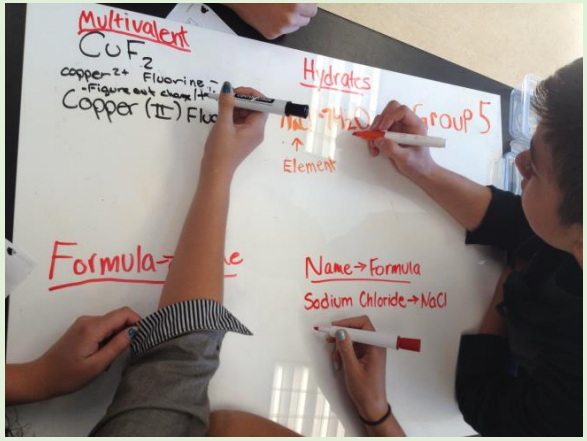

Using whiteboards saves time

Steps in class

20 minute time slots

20 min -	I) Initial observation
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	Prepare presentation
120 min -	**VI) Present**
	Peer review
	VII) Defend

Present, peer review, defend

- Both methods
  - One team reports
  - One team opposes
  - The rest review
  - Scoring rubrics
- Method Share good practices
  - Repeat twice
  - More in-depth discussion
  - Less teams try each role
  - See the best
- Method All teams report
  - Repeat until all (or many) teams report
  - Less in-depth discussion
  - More teams try each role
  - See all (or many)

Reviewer in YPT competitions

IYPT

Part of the Reviewer's job is similar to Opponent's critical analysis but requires covering many more topics within the same time. So, being concise, articulate and focused on the key features is even more important here.

In YPT competitions, the reviewer gets three opportunities to earn points: asking questions, evaluating the entire process, and giving judgement or own opinion. The reviewer is supposed to show their own understanding of physics while not being able to enter a discussion. As a "rule of thumb", the reviewer should do what the jury would like to do. Good grades are typically given when the reviewer addresses the points that the jury feels should be addressed.

Reviewer's questions: The reviewer should have followed the entire process carefully and should use this time to address issues which were not made clear enough or where their opinion differs from the reporter's, the opponent's, or both. Here are some types of question that the reviewer can ask:

- Ask for justification for a particular decision, if it was not given. This shows that the reviewer understands the physics and was able to spot that a justification was not given.
- Ask for the opinion of the reporter or opponent on a particular topic, if it was not given. Sometimes the opponent asks questions, but does not give their own opinion on the answer. In these cases, the reviewer can show that they followed the discussion and identified the shortcomings.

Reviewer's evaluation and judgement: The reviewer is supposed to give an evaluation of the presentation, the opponent's speech and the discussion. At the same time, they are supposed to give their own opinion on the essential topics. The usual strategy is the following:

- Evaluate the research done by the reporter, emphasizing its strengths and shortcomings. Some reports may have a strong experimental basis, but a poor theoretical model and some may be the other way around. Most reports are in the middle, so the reviewer should carefully consider which points are done well and which are lacking and what has remained unclear. The reviewer should **give judgement on the validity of the conclusions.**
- Pass judgement on the task fulfilment by the reporter and its evaluation by the opponent. Did the opponent correctly evaluate the task fulfilment of the reporter.
- The reviewer may give their own opinion on how the report could be improved.
- Summarize the opponent's speech. This mostly consists of the opponent's identification of strong and weak points of the report, and an evaluation of whether these strong and weak points have been pointed out also by the opponent. The reviewer may disagree with the opponent and may defend the reporter, if they find the critique unsubstantiated. They may also address points that the opponent missed.
- The reviewer should note all essential points of the discussion and indicate their opinion about each of them. Especially, all points of disagreement should be addressed and the reviewer's position on each of them clearly stated.
- The reviewer may qualify the discussion per se, for example they can express their opinion whether the discussion was useful for clarifying the report and went deeper into the physics involved or whether it did not contribute much in this aspect. Or whether it was interesting or boring; or whether it tackled important/relevant topics or wasted most of the time on minor details etc.
- It is a good practice to point out essential aspects of the problem (if any) which were not present either in the report, or in Opponent's analysis or in the discussion. The reviewer should specify why they find them important.
- The reviewer should give their opinion on the presentation, how convincing it was and how well did the opponent check its validity.

Appendices

Types of experiments

- Observational
- Testing

Most YPT problems

- Application

Invent yourself

Types of experiments

- Observational
- Testing

Most YPT problems

- Application

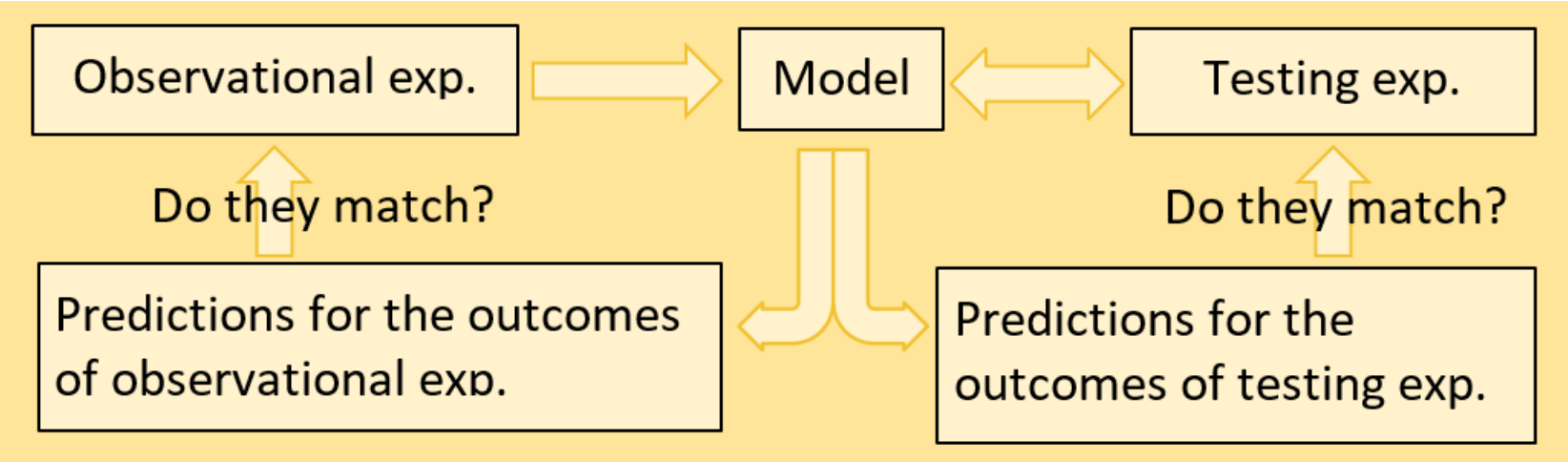
Invent yourself

Observational
- Observe
- Suggest explanation/model

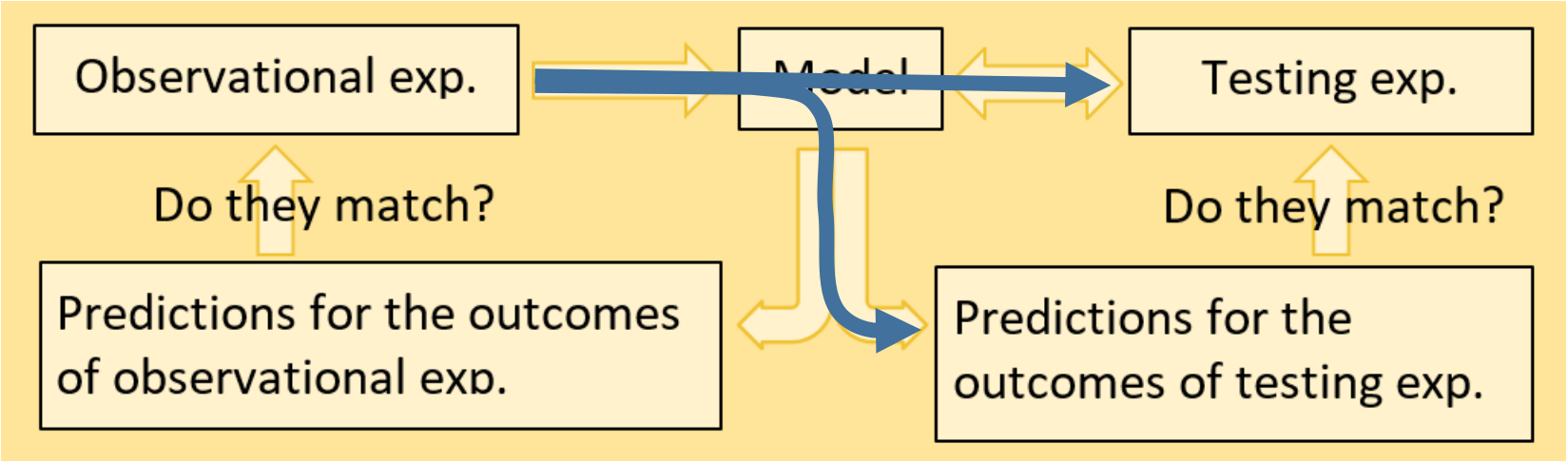
Testing
- Take suggested explanation/model
- Choose an expariment
- Predict the outcome
- Compare prediction with outcome
- Judge the explanation/model

Application
- Start from knowledge
- Solve a practical problem (build device, determine constant...)
- Test your result with independent method

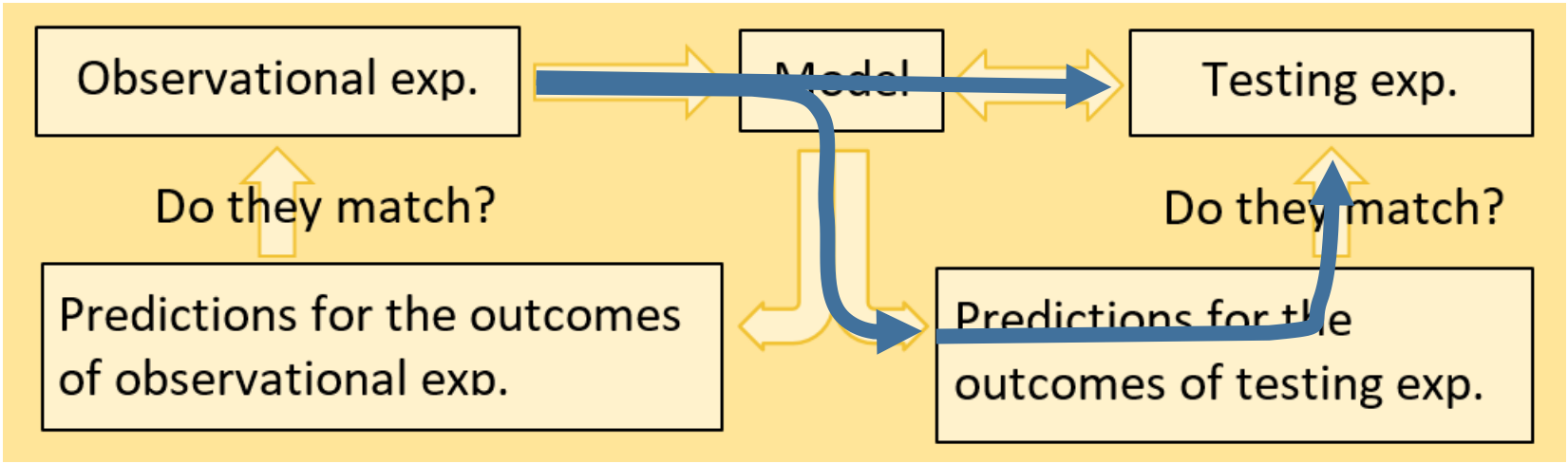
Testing experiments



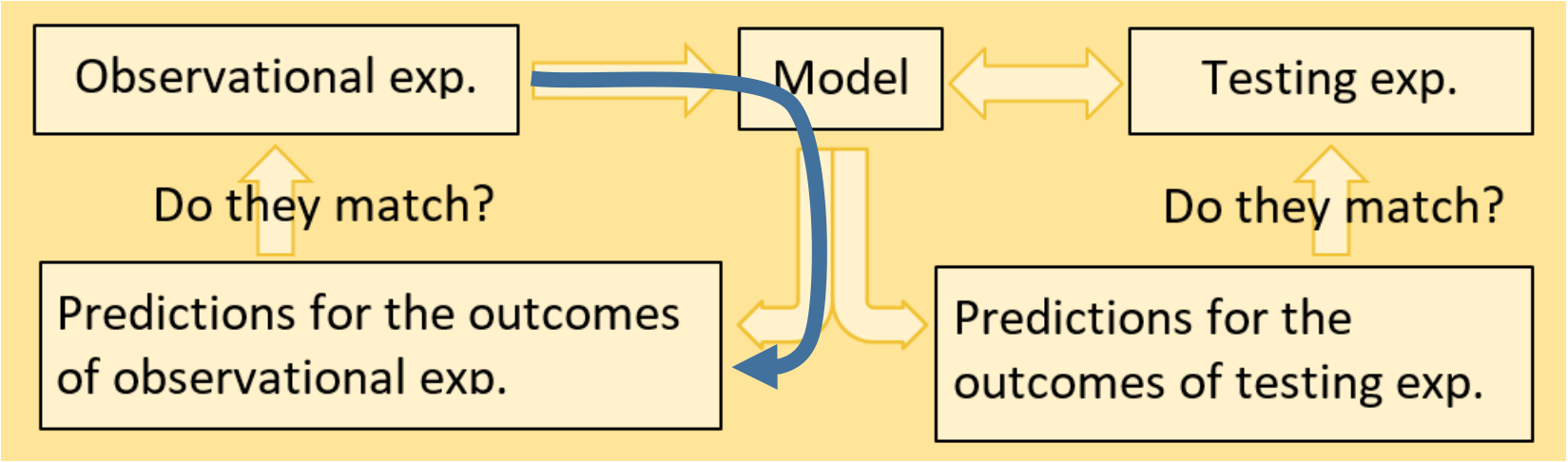
Testing experiments



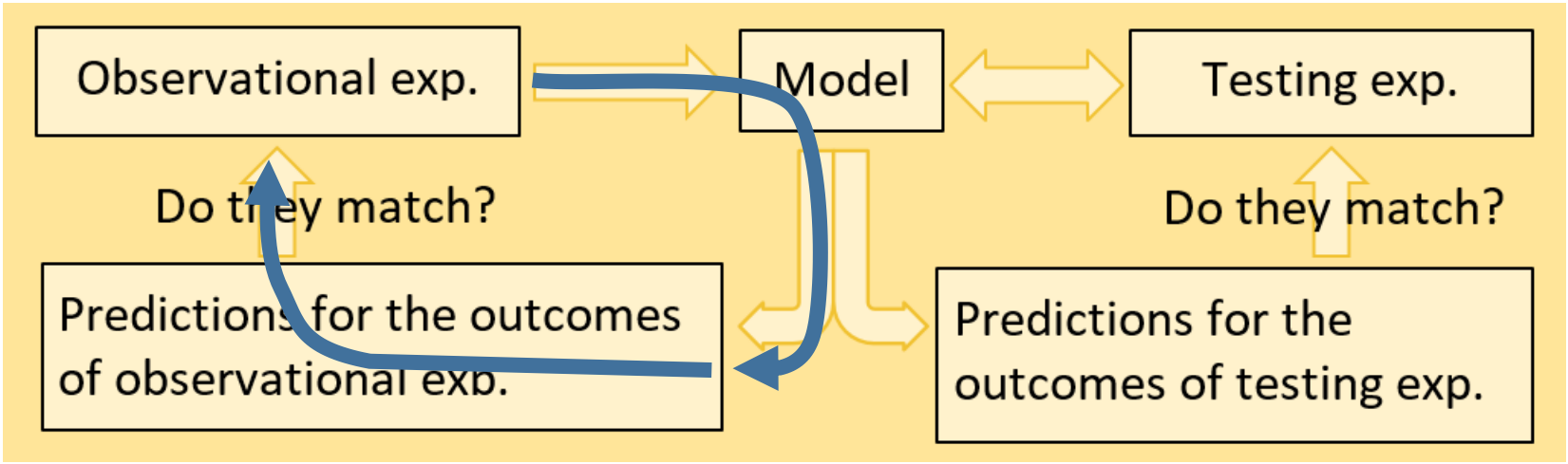
Testing experiments



Testing experiments



Testing experiments



Types of models

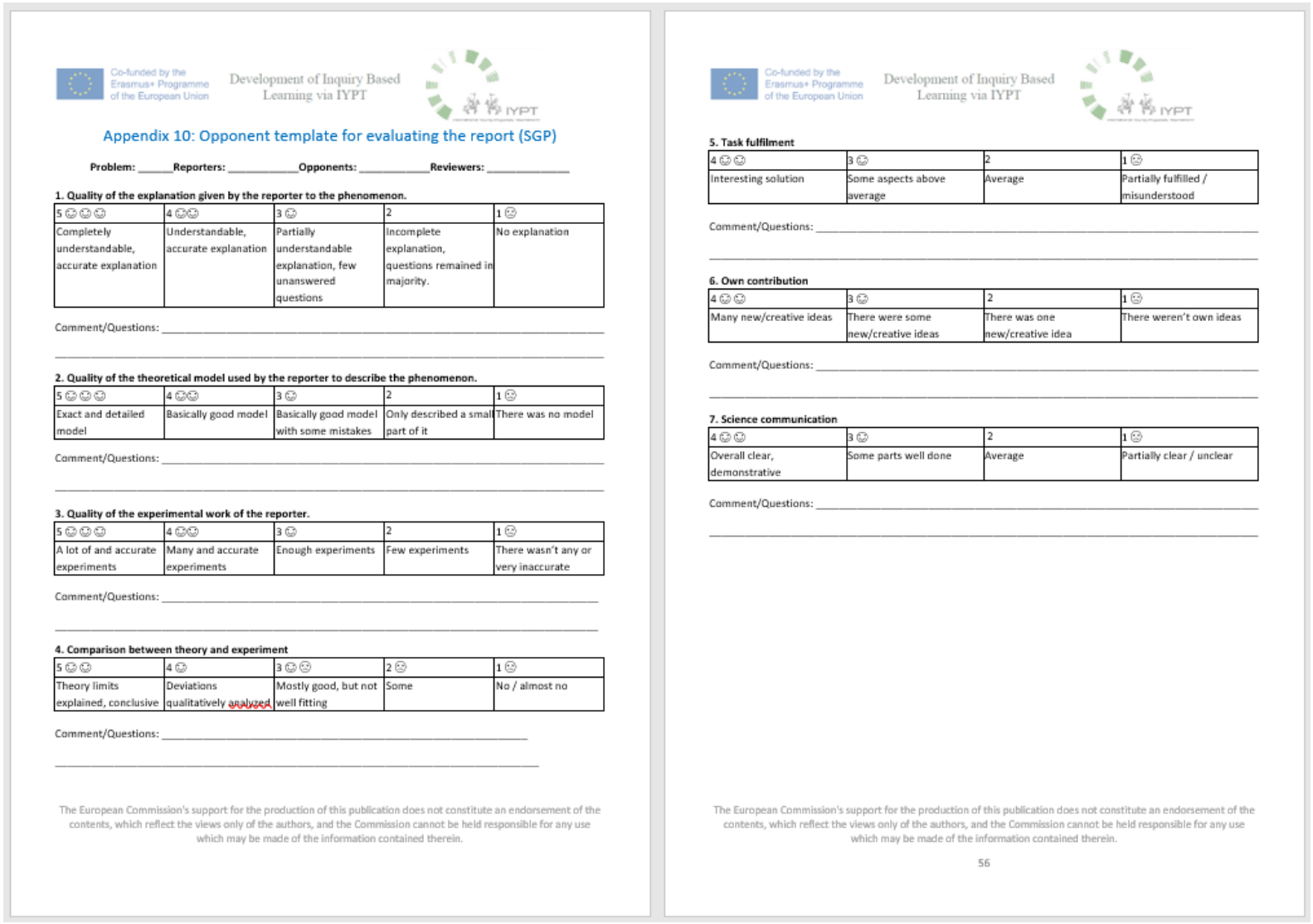
Model.

- **Phenomenological model.** Description
  - Function from data
- **Mechanistic model.** Relations
  - **Qualitative model.**
    Describe relations in words.
  - **Numerical quantitative model.**
    Get initial equations and symulate results.
  - **Understanding the existing quantitative model.**
    Get equation from literature and explain it.
  - **Analytical quantitative model.**
    Derive the equation.
- **Assumptions.**

Detailed examples

- See the toolkit ☺

Scoresheets (scoring rubrics)



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Appendix 10: Opponent template for evaluating the report (SGP)

Problem: _____ **Reporters:** _____ **Opponents:** _____ **Reviewers:** _____

1. Quality of the explanation given by the reporter to the phenomenon.

5 ☺☺☺	4 ☺☺	3 ☺	2	1 ☹
Completely understandable, accurate explanation	Understandable, accurate explanation	Partially understandable explanation, few unanswered questions	Incomplete explanation, questions remained in majority.	No explanation

Comment/Questions: _____

_____

2. Quality of the theoretical model used by the reporter to describe the phenomenon.

5 ☺☺☺	4 ☺☺	3 ☺	2	1 ☹
Exact and detailed model	Basically good model	Basically good model with some mistakes	Only described a small part of it	There was no model

Comment/Questions: _____

_____

3. Quality of the experimental work of the reporter.

5 ☺☺☺	4 ☺☺	3 ☺	2	1 ☹
A lot of and accurate experiments	Many and accurate experiments	Enough experiments	Few experiments	There wasn't any or very inaccurate

Comment/Questions: _____

_____

4. Comparison between theory and experiment

5 ☺☺	4 ☺	3 ☺☹	2 ☹	1 ☹
Theory limits explained, conclusive	Deviations qualitatively analyzed	Mostly good, but not well fitting	Some	No / almost no

Comment/Questions: _____

_____

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5. Task fulfilment

4 ☺☺	3 ☺	2	1 ☹
Interesting solution	Some aspects above average	Average	Partially fulfilled / misunderstood

Comment/Questions: _____

_____

6. Own contribution

4 ☺☺	3 ☺	2	1 ☹
Many new/creative ideas	There were some new/creative ideas	There was one new/creative idea	There weren't own ideas

Comment/Questions: _____

_____

7. Science communication

4 ☺☺	3 ☺	2	1 ☹
Overall clear, demonstrative	Some parts well done	Average	Partially clear / unclear

Comment/Questions: _____

_____

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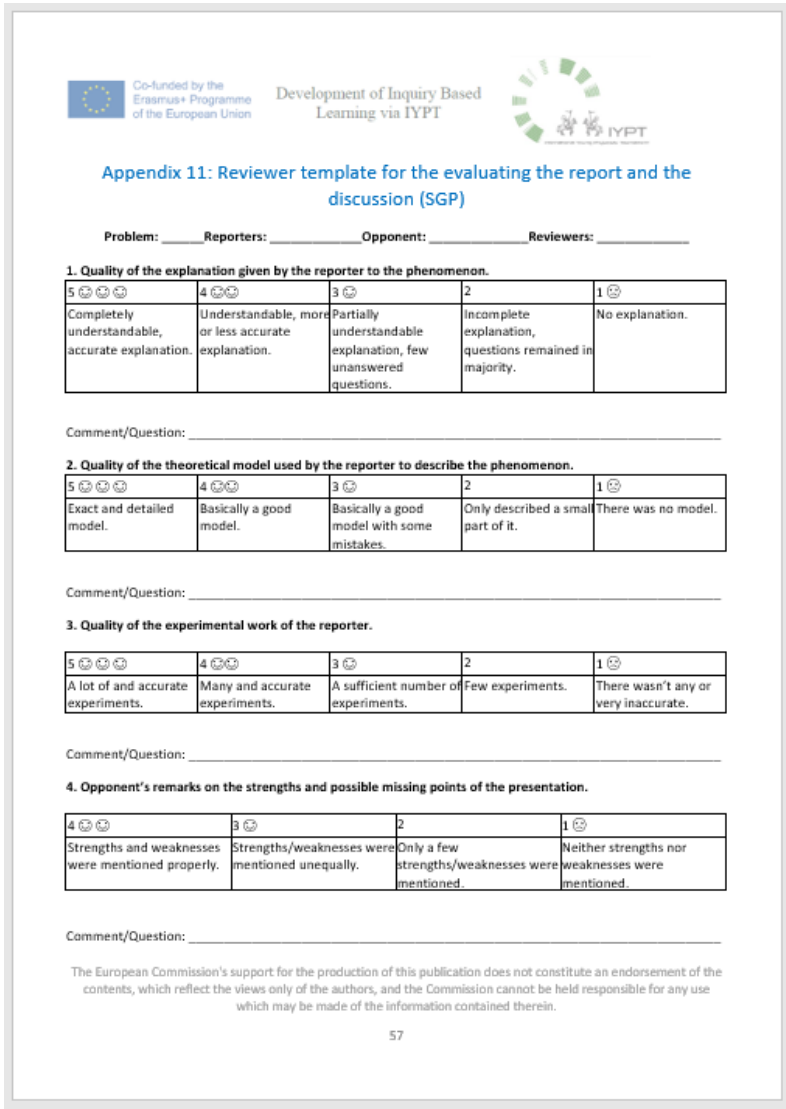
Scoresheets (scoring rubrics)



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Appendix 11: Reviewer template for the evaluating the report and the discussion (SGP)

Problem: _____ **Reporters:** _____ **Opponent:** _____ **Reviewers:** _____

1. Quality of the explanation given by the reporter to the phenomenon.

5 ☺☺☺	4 ☺☺	3 ☺	2	1 ☹
Completely understandable, accurate explanation.	Understandable, more or less accurate explanation.	Partially understandable explanation, few unanswered questions.	Incomplete explanation, questions remained in majority.	No explanation.

Comment/Question: _____

2. Quality of the theoretical model used by the reporter to describe the phenomenon.

5 ☺☺☺	4 ☺☺	3 ☺	2	1 ☹
Exact and detailed model.	Basically a good model.	Basically a good model with some mistakes.	Only described a small part of it.	There was no model.

Comment/Question: _____

3. Quality of the experimental work of the reporter.

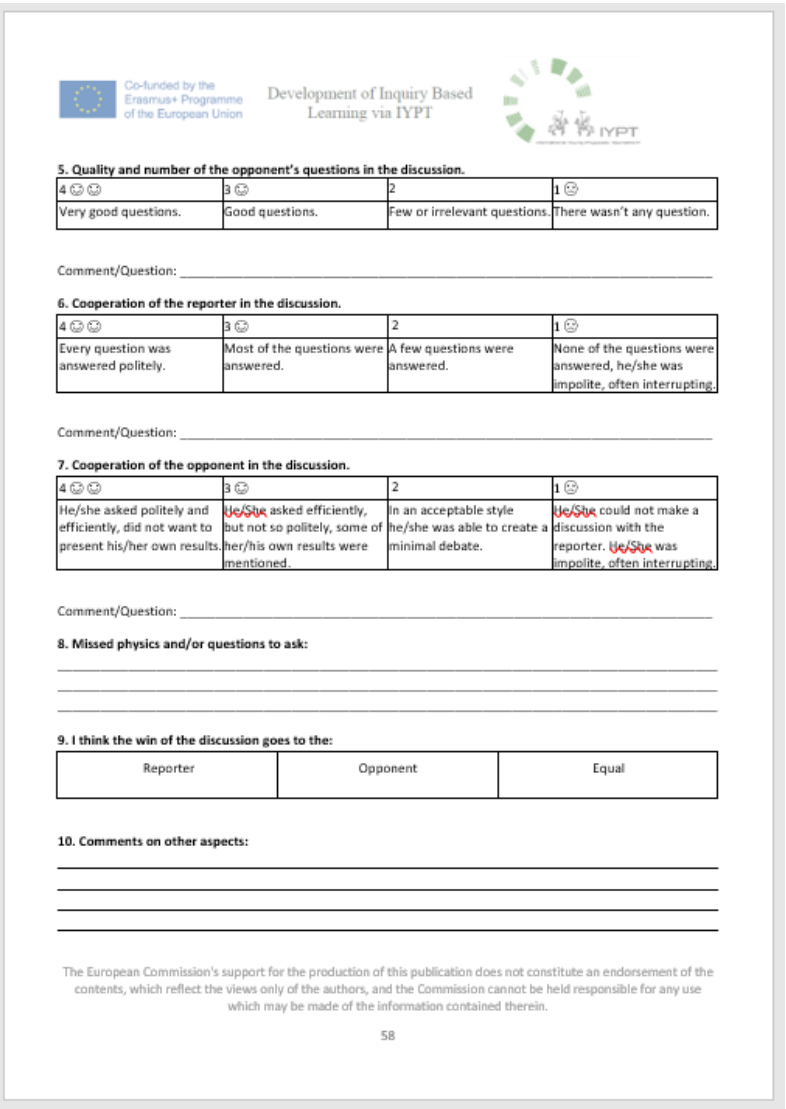
5 ☺☺☺	4 ☺☺	3 ☺	2	1 ☹
A lot of and accurate experiments.	Many and accurate experiments.	A sufficient number of experiments.	Few experiments.	There wasn't any or very inaccurate.

Comment/Question: _____

4. Opponent's remarks on the strengths and possible missing points of the presentation.

4 ☺☺	3 ☺	2	1 ☹
Strengths and weaknesses were mentioned properly.	Strengths/weaknesses were mentioned unequally.	Only a few strengths/weaknesses were mentioned.	Neither strengths nor weaknesses were mentioned.

Comment/Question: _____



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5. Quality and number of the opponent's questions in the discussion.

4 ☺☺	3 ☺	2	1 ☹
Very good questions.	Good questions.	Few or irrelevant questions.	There wasn't any question.

Comment/Question: _____

6. Cooperation of the reporter in the discussion.

4 ☺☺	3 ☺	2	1 ☹
Every question was answered politely.	Most of the questions were answered.	A few questions were answered.	None of the questions were answered, he/she was impolite, often interrupting.

Comment/Question: _____

7. Cooperation of the opponent in the discussion.

4 ☺☺	3 ☺	2	1 ☹
He/she asked politely and efficiently, did not want to present his/her own results.	He/She asked efficiently, but not so politely, some of her/his own results were mentioned.	In an acceptable style he/she was able to create a minimal debate.	He/She could not make a discussion with the reporter. He/She was impolite, often interrupting.

Comment/Question: _____

8. Missed physics and/or questions to ask:

_____

_____

_____

9. I think the win of the discussion goes to the:

Reporter	Opponent	Equal

10. Comments on other aspects:

_____

_____

_____

_____

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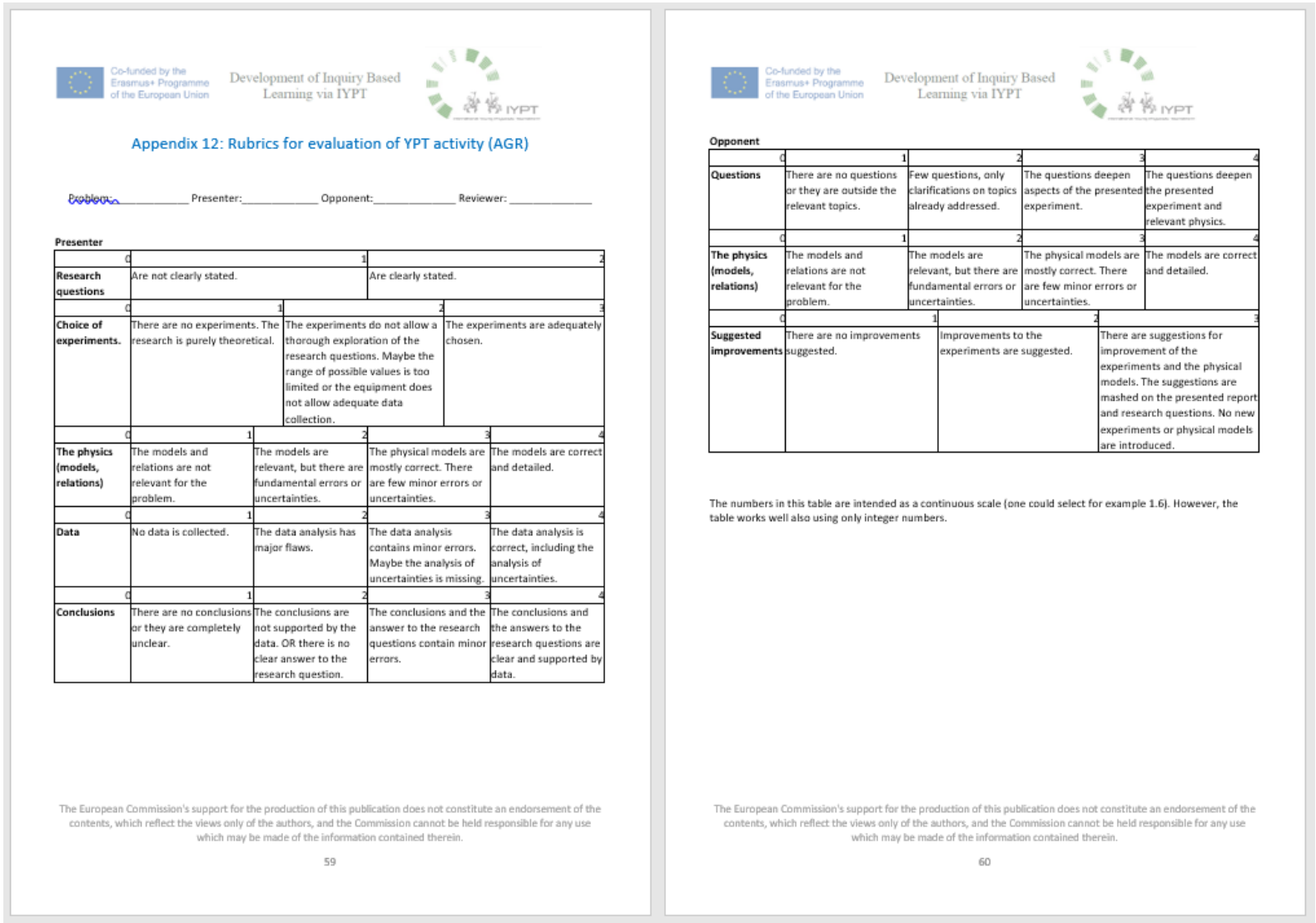

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Appendix 12: Rubrics for evaluation of YPT activity (AGR)

Problem:_____ Presenter:_____ Opponent:_____ Reviewer: _____

Presenter

0	1	2
Research questions	Are not clearly stated.	Are clearly stated.

0	1	2	3
Choice of experiments.	There are no experiments. The research is purely theoretical.	The experiments do not allow a thorough exploration of the research questions. Maybe the range of possible values is too limited or the equipment does not allow adequate data collection.	The experiments are adequately chosen.

0	1	2	3	4
The physics (models, relations)	The models and relations are not relevant for the problem.	The models are relevant, but there are fundamental errors or uncertainties.	The physical models are mostly correct. There are few minor errors or uncertainties.	The models are correct and detailed.
0	1	2	3	4
Data	No data is collected.	The data analysis has major flaws.	The data analysis contains minor errors. Maybe the analysis of uncertainties is missing.	The data analysis is correct, including the analysis of uncertainties.
0	1	2	3	4
Conclusions	There are no conclusions or they are completely unclear.	The conclusions are not supported by the data. OR there is no clear answer to the research question.	The conclusions and the answer to the research questions contain minor errors.	The conclusions and the answers to the research questions are clear and supported by data.

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Opponent

0	1	2	3	4
Questions	There are no questions or they are outside the relevant topics.	Few questions, only clarifications on topics already addressed.	The questions deepen aspects of the presented experiment.	The questions deepen the presented experiment and relevant physics.
0	1	2	3	4
The physics (models, relations)	The models and relations are not relevant for the problem.	The models are relevant, but there are fundamental errors or uncertainties.	The physical models are mostly correct. There are few minor errors or uncertainties.	The models are correct and detailed.

0	1	2	3
Suggested improvements	There are no improvements suggested.	Improvements to the experiments are suggested.	There are suggestions for improvement of the experiments and the physical models. The suggestions are mashed on the presented report and research questions. No new experiments or physical models are introduced.

The numbers in this table are intended as a continuous scale (one could select for example 1.6). However, the table works well also using only integer numbers.

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