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IN-SERVICE AND PRE-SERVICE TEACHER VIEWS ON CHEMISTRY EXPERIMENTAL DESIGN WORKSHEETS

MTA-ELTE Research Group on Inquiry-based Chemistry Education

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Content

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III. Systems thinking tasks for motivation
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I.1. Types of inquiry-based education

- „**i**nquiry-**b**ased **s**cience **l**earning/**t**eaching/**e**ducation" (IBL, IBST, **IBSE**): teaching/learning process is **modelling the steps of scientific research**
- **classification** e.g. according to the level of **students' independence**:

Type of inquiry	Is it known for the students…		
	…the research question?	…the research method?	…the explanation of the results?
Open	no	no	no
Guided/Bounded	yes	no	no
Structured	yes	yes	no
Confirmation/Closed*	yes	yes	yes

*Essentially no inquiry: Xu, H.; Talanquer, V. (2013)

I.2. Pros & cons

ADVANTAGES

- Increases motivation among '*curious*' and '*socially motivated*' students (Hofstein and Kempa, 1985)
- Increases conceptual understanding (Minner *et al.*, 2010)
- Develops higher order cognitive skills (Tomperi and Aksela, 2014)
- Positive impact on situational interest (Lavonen *et al.*, 2021)
- Better understanding of the difference between science and pseudoscience (Finlayson *et al.*, 2015)

DISADVANTAGES

- ↔ Disliked by '*achiever*' and '*conscientious*' students (Bolte, Streller and Hofstein, 2013)
- ↔ Less efficient - misconceptions or incomplete or disorganized knowledge (Kirschner, Sweller and Clark, 2006)
- ↔ Less effective if cognitive load is not properly managed (Sweller, 1988)
- ↔ EU projects did not increase interest in science careers (Lavonen *et al.*, 2021)
- ↔ PISA 2015: inquiry activities - lower test scores in disorderly classrooms (Mostafa *et. al.*, 2018)
- Teachers' scepticism: large class size, lack of time, public examinations (Cheung, 2011)

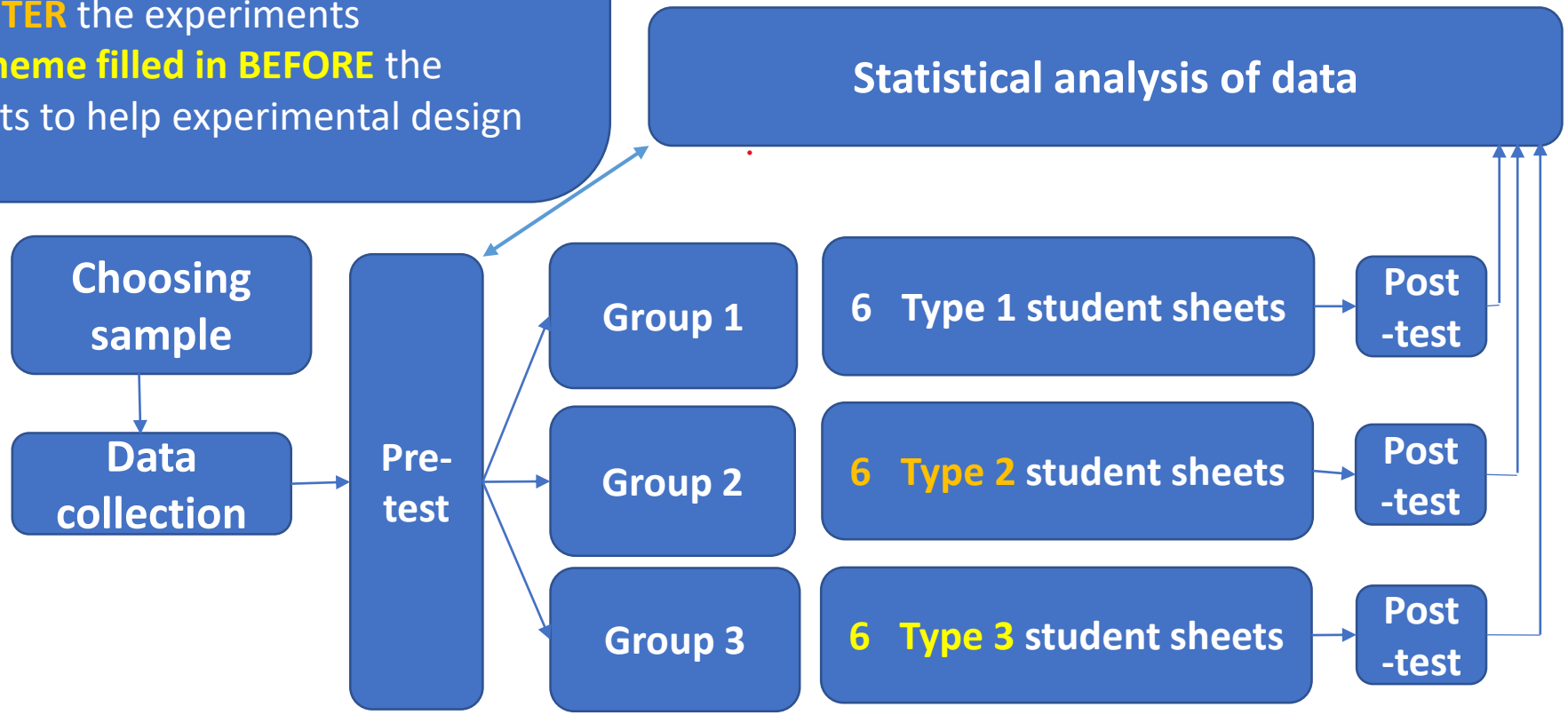
II.1. Research method and sample

	Longitudinal research: 4 school years 2021-2025 (Grade 7-10)
Intervention	6 lessons/school year (=24 lessons, partially spent with the worksheets)
Tests	Test 0 (**T0**): September 2021 + **T1** (**T2**, T3, T4): end of each school year
Number of students	**T0: 890;** **T1: 886;** **T2: 811** students wrote each test
Age of students (years)	12/13 (in the first year)
Number of teachers	31 (in the first year)
Number of schools	25 (in the first year)
Group 1 (control)	only step-by-step experiments
Group 2 (experimental)	Scheme to teach experimental design **AFTER step-by-step experiments**
Group 3 (experimental)	Scheme to help experimental design **BEFORE planning experiments**
+ Motivation	Context-based tasks + elements of systems thinking for all the students

II.2. Research model for 2021/2022.

6 student sheets for 6 lessons in 3 versions:
Type 1: only step-by-step experiments
Type 2: step-by-step experiments + **scheme filled in AFTER** the experiments
Type 3: scheme filled in BEFORE the experiments to help experimental design

Direct teaching of the experimental design skills worked better in the previous project → Has the teaching of using a scheme to develop experimental design even more effect on experimental design skills?



Note: Context-based / systems thinking tasks are on each type of the student worksheets for motivational purposes.

II.3.a The scheme of the experimental design (EDS) tasks

E.g. EDS task **g 40%, 60%, 80% alcohol)** **e the chocolate sau** aterials)

a) Which of t ass during the experiments?

b) How should sauces that are made from dif

c) What shoul to question b) above?

d) Which of t tested in each experiment?

e) How can yo swer to d)?

f) How can you xperiments?

(g) Put a (+) si ortant…

II.3.b EDS on worksheets – research questions, e.g.:

Worksheet 1: Particle modell of matter

- How does the speed of the particles depend on temperature?

Worksheet 2: Chemical reactions

- Which of the three ingredients in baking powder is NOT needed to produce the carbon dioxide?

Worksheet 3: Solubility

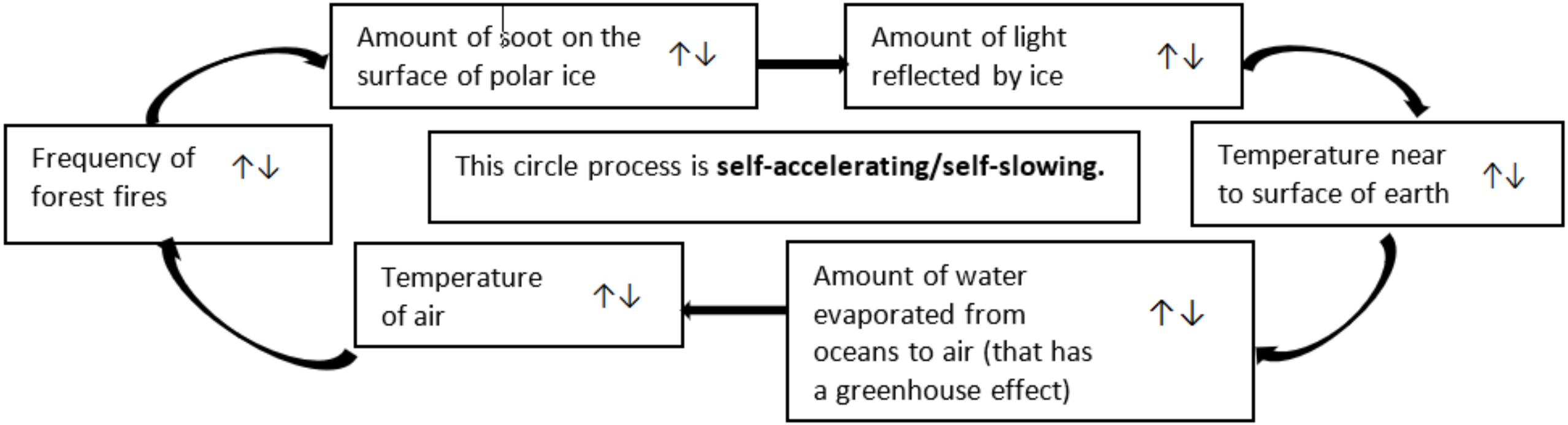
- How does the greasing of the ducks' feathers affects whether they can swim or they sink in clean water or water containing dishwashing liquid/soap?

Worksheet 6: Conditions of combustion

- Are all the three of conditions really necessary for combustion?

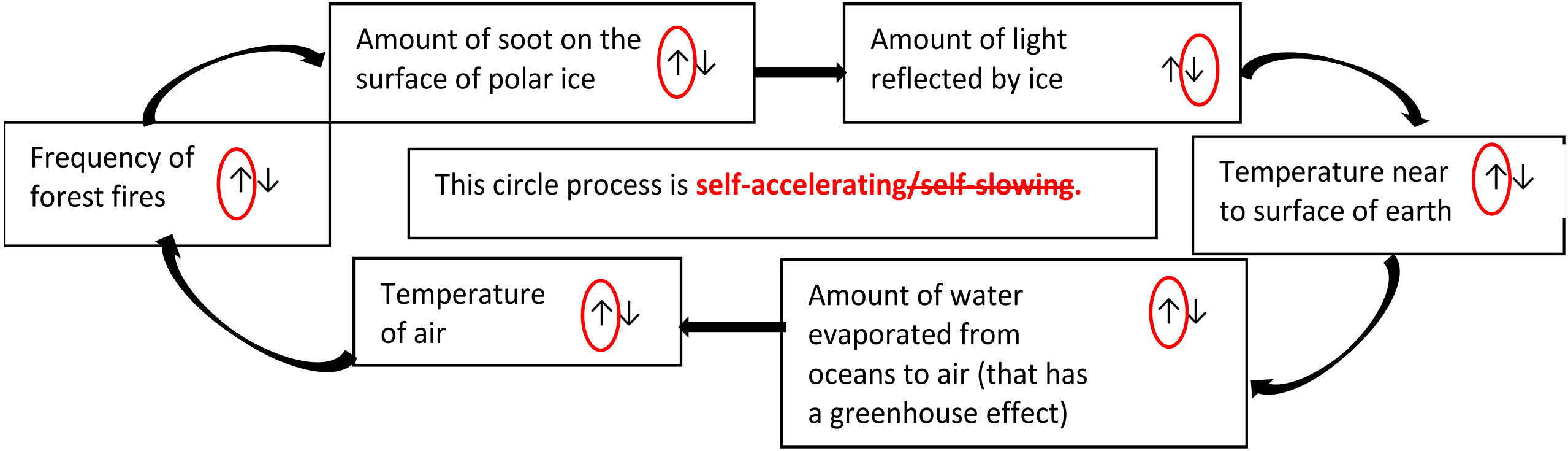
III. Systems thinking tasks for motivation (e.g.)

Worksheet 6: Conditions of combustion: Circle the up or down arrows in the diagram that show the change of the amount as the frequency of forest fires increases.



III. Systems thinking tasks for motivation (e.g.)

Worksheet 6: Conditions of combustion – Correct solution in red.



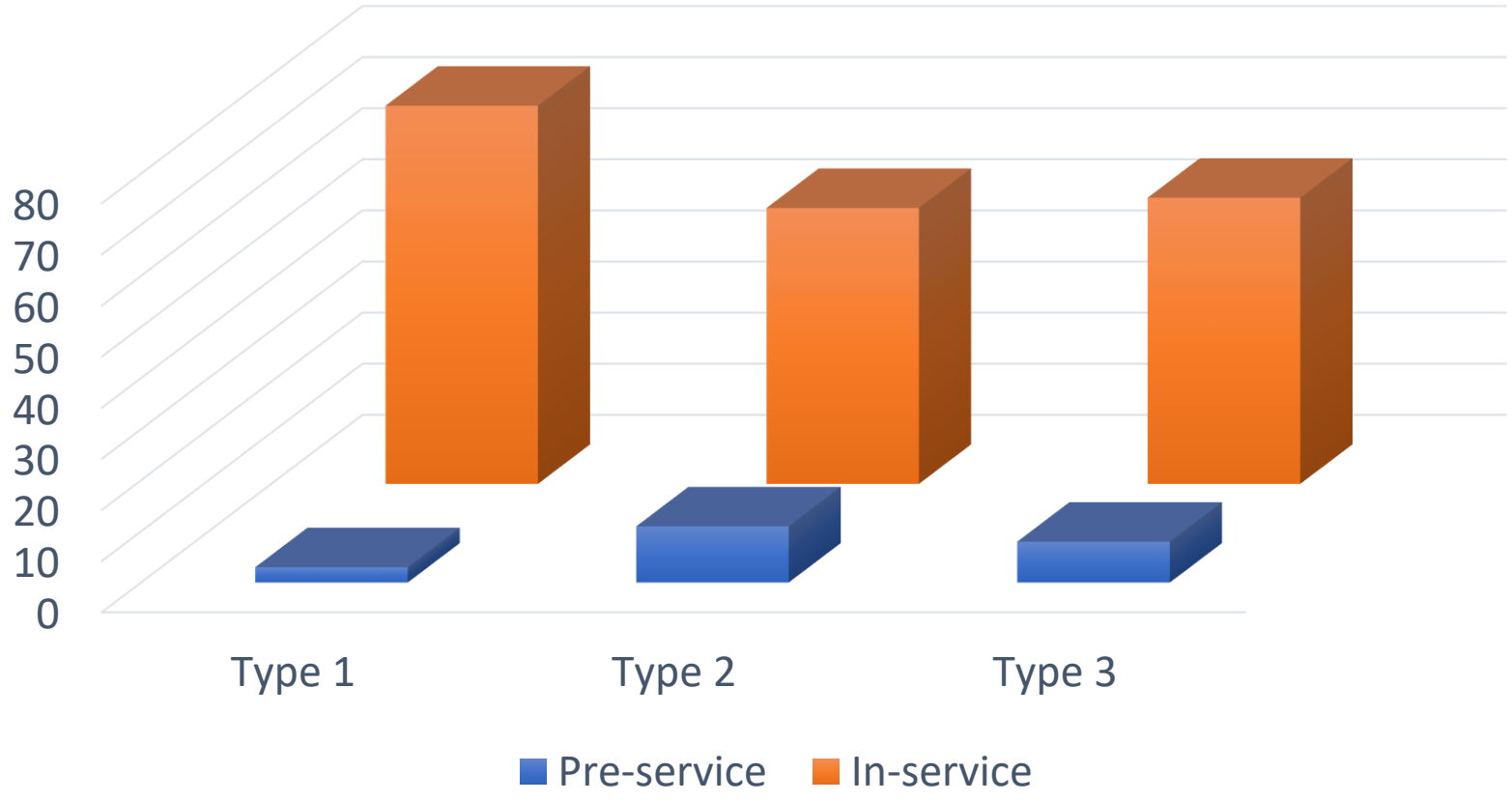
IV.1. Teachers' views: questionnaire filled in (2022/2023.) by 32 in-service and 36 pre-service teachers

- **Metadata** [name; member of our research group?/which course attended? etc.]
- **Piloting of worksheets:**
  - Which type and which one of the worksheet(s) has (s)he tried/wants to try in future with students and with how many classes?
  - Why did (s)he choose that type and that one(s) of the worksheets?
- **Experimental design tasks:** Which (s)he think is/are easy/difficult to use, why?
- **Worksheets:** How easy/difficult to use them in theoretical/practical aspects, why?
- **Context-based/systems thinking tasks:** How useful are they in terms of motivation/understanding?
- **Individual opinion/advice:** How to improve the worksheets?
- **Type 2 and 3 worksheets:** How independently could students work?

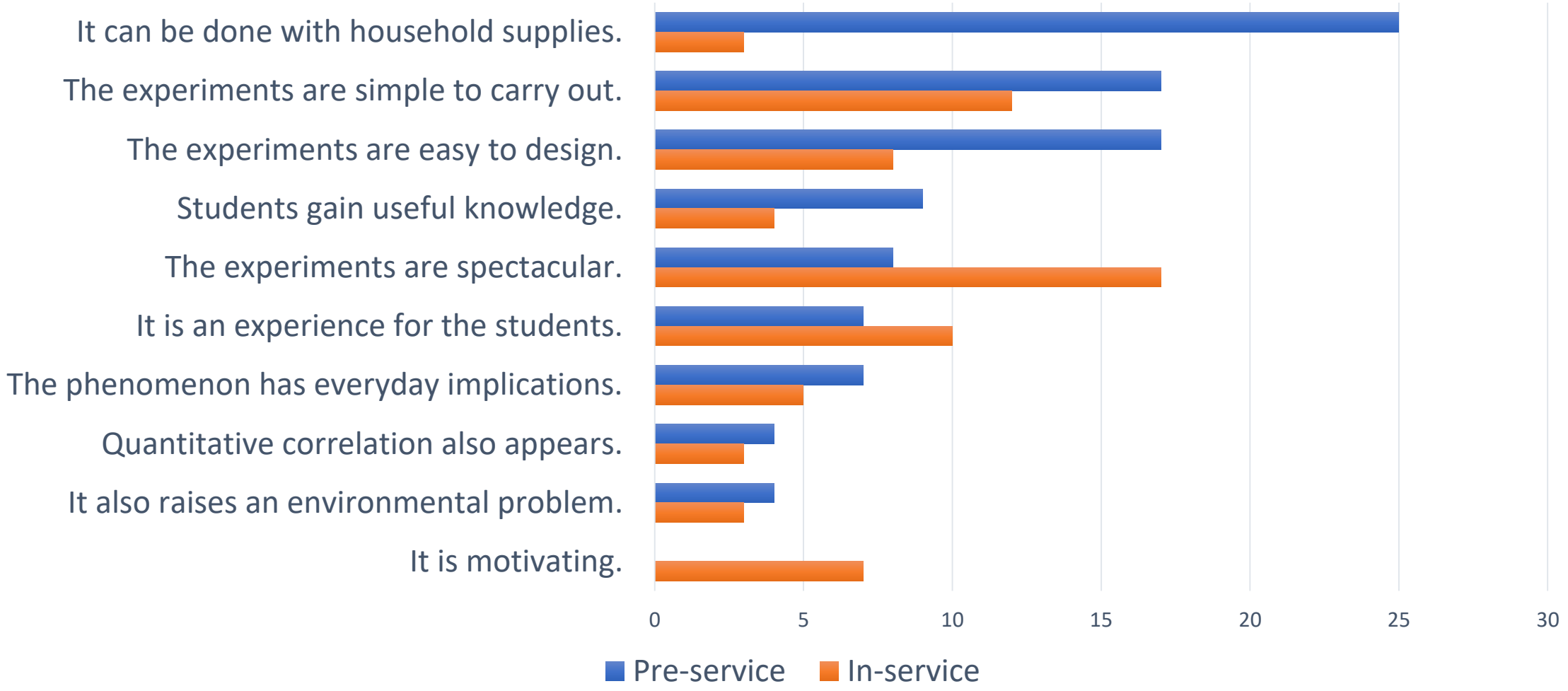
The questionnaires for the in-service/pre-service teachers contained the same type of questions with relevant modifications.

IV.2.a Results

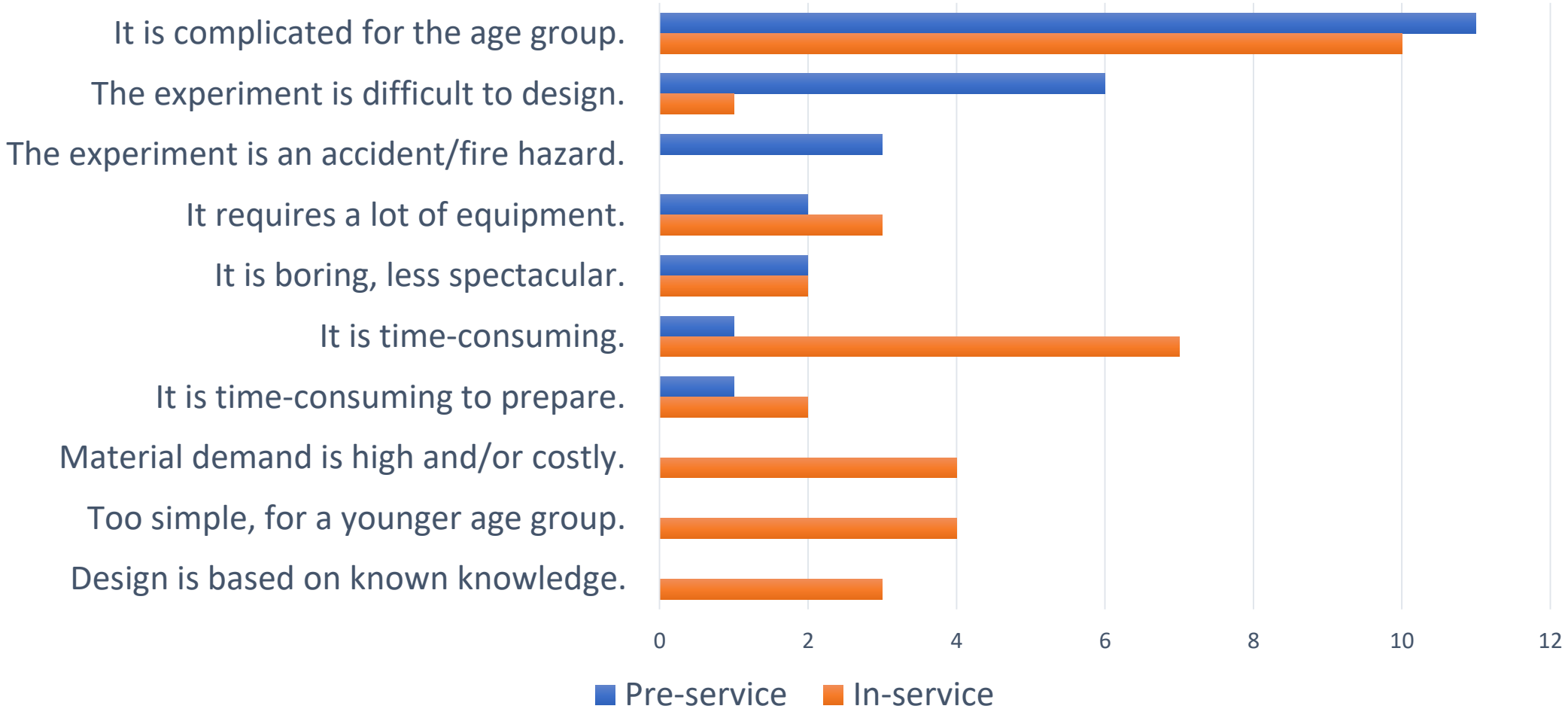
How many times had been the worksheets piloted by the 32 in-service teachers and the 36 pre-service teacher students?



IV.2.b Results
Reasons that make worksheets easy to use



IV.2.c Results
Reasons that make worksheets difficult to use



IV.2.d Results
How motivating are the context-based tasks?

V. Conclusion: the worksheets…

majority of 32 in-service teachers' views:

- ✓ are age-appropriate
- ✓ are relevant to the Grade 7 curriculum
- ✓ build on prior knowledge
- ✓ have a motivating effect
- ✓ develop students' manual dexterity
- ✓ teamwork is beneficial
- ✓ teach laboratory equipment/operations
- ✓ most frequent choice is: type 3

36 pre-service teachers' views:

- some have reservations:
  - safety is very important!
  - the complexity of the wording makes some difficult to understand
  - the complicated design of the experiments makes some hard to use
- most frequent choice is: type 2

In general the majority wrote: - sufficient theoretical difficulty
- experiments are easy to perform
- equipment and materials are easy to obtain.

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