How do pre-service teachers interact with AI during the modelling process? Characterising the use of ChatGPT in solving Fermi problems

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Motivation

Modelling problems

Fermi problems

"Mini" modelling problems in which quantities must be estimated by breaking the initial problem into several subproblems (Ärlebäck, 2009), there are accessible to primary school students. It's important to introduce them to primary school pre-service teachers. Despite their accessibility, it has been found [illegible] blem (Segura & Ferra

We are interested in characterising the use of ChatGPT during the process of solving Fermi problems.

Use of AI in mathematics education

AI has a great educational potential (Lo, 2023), particularly Large Language Models (LLMs). Although there is little research on the use of LLMs in mathematics education, they have been shown to be capable of solving some mathematical problems (Schorcht et al., 2024). Tools such as ChatGPT could be very useful for primary school teachers to develop competence in solving mathematical tasks (Noster et al., 2024).

AI prompting techniques

- Prompting techniques can be classified according to the amount of instructions provided to the AI:
  - *Zero-shot*: the task to be solved is presented without providing further details, providing a direct and precise instruction
  - *Few-shot* technique involves giving the LLM some prior instructions to improve its response
  - *Chain-of-thought* prompting involves deco… reasoned intermediate steps b…
  - *Output custom…*

…questions or

Few studies have explored the competence of pre-service teachers using AI tools for mathematical problem-solving (Noster et al., 2024), but no detailed analysis has been undertaken to characterise the prompts formulated by pre-service teachers to solve a modelling problem.

Method: participants & data gathering

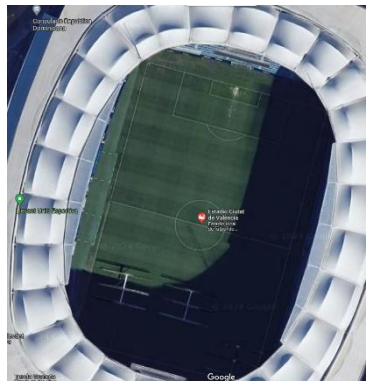
The participants were N=94 pre-service teachers from the Faculty of Education at the University of Valencia in their last (4th) year of their undergraduate studies.
22,2 years old, 67% women.

All the participants had working with a sequence of 4 Fermi problems

2 hour session

Problem-solving in the classroom with ChatGPT assistance

Interaction with ChatGPT + Written solutions

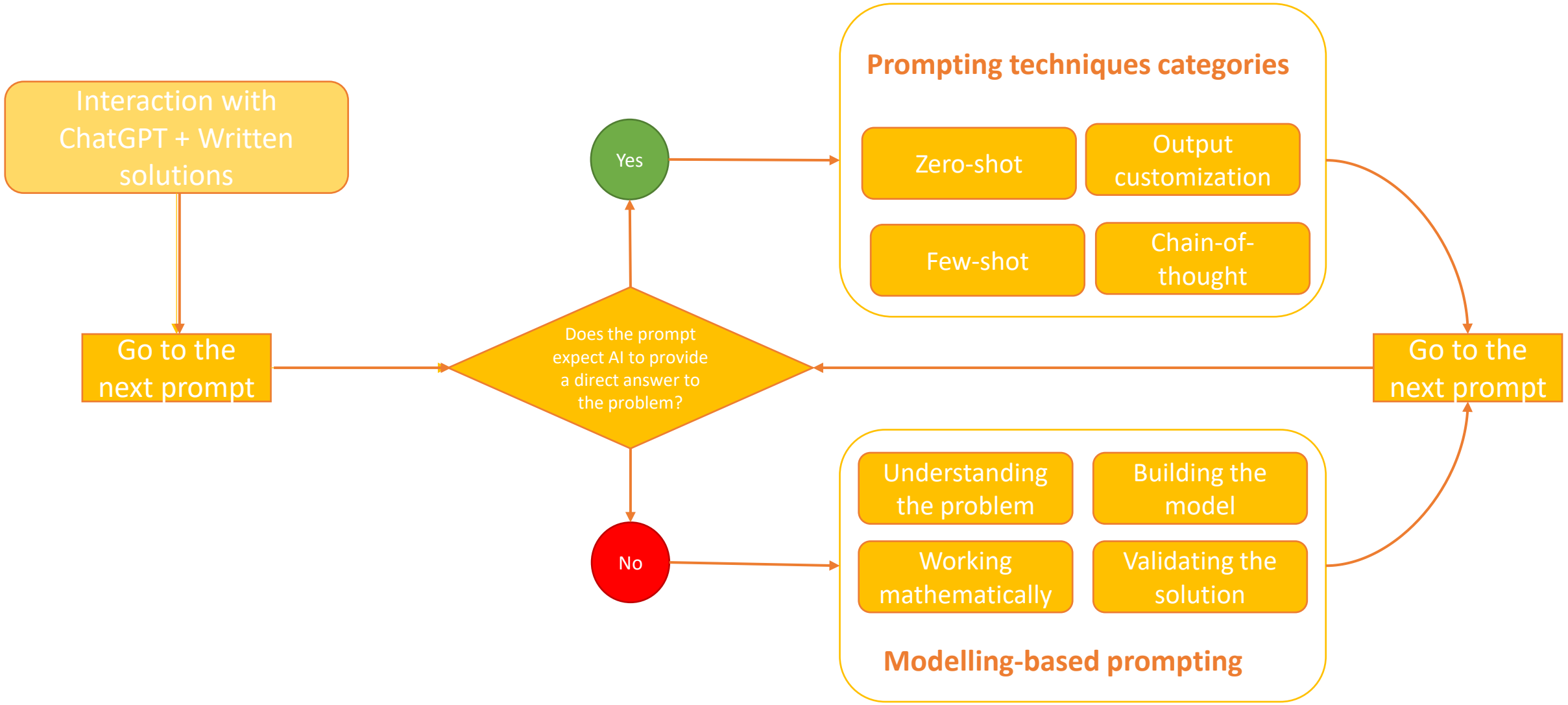


P5. How many people can fit in the Levante football field as audience (only in the grass area) if we want to use this space for a concert of a famous artist?



P6. How many people can fit inside the IKEA shop in Valencia at the time of maximum influx of customers?

Method: data analysis of the prompts



You
¿Cuanta gente cabe en el campo de futbol del Levante como público (solo en la zona del césped) si queremos utilizar este espacio para realizar un concierto de un artista famoso?

ChatGPT
La capacidad del campo de fú
alrededor de 26,354 espectado
concierto, la capacidad podría ser diferente debido a la distribución del escen
producción y otros elementos necesarios para el evento.

Zero-shot

How many people can fit on the Levante stadium as audience (only on the grass area) if we want to use this space for a concert of a famous artist?

The capacity of the Levante UD football ground is around 26354 spectators. However, if you wish to use only the grass area for a concert, the capacity might be different due to the layout of the stage, production equipment and other elements.

Por lo general, en eventos como conciertos en estadios de fú
puede ser menor que la capacidad total del estadio debido a
las luces, el sonido, las áreas de seguridad, entre otros.

La capacidad final en la zona del césped dependerá de factores como la disposición del escenario, las regulaciones de seguridad y el diseño del evento en sí mismo. Podría variar significativamente dependiendo de cómo se planifique el concierto. Es posible que desees consultar con expertos en eventos o con el personal del estadio para obtener una estimación más precisa.

You
Quiero ur

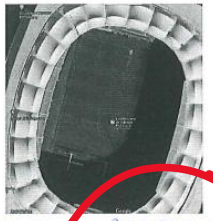
Output customization

I want an estimate, an approximate number

ChatGPT
Dado que el Estadi Ciutat de València tiene una capaci
considerando que un concierto en la zona del césped r
equipo de producción y las áreas de seguridad, una es
20,000 personas en la zona del césped. Esta cifra podr
evento y de las regulaciones de seguridad aplicables. E
eventos y autoridades locales para obtener una estima
todas las normativas pertinentes.

Given that the stadium has a capacity of 26354 spectators and, considering that a concert on the lawn requires space for the stage, security areas and production equipment, a conservative estimate could be around 20000 people on the lawn. This number could vary depending on the design of the event and security regulations.

Problema 5 ¿Cuánta gente cabe en el campo de fútbol del Levante como público (solo en la zona de césped) si queremos utilizar este espacio para realizar un concierto de un artista famoso?



~~Teniendo en cuenta el espacio del césped (100 x 70 m)~~
Habría que tener en cuenta la medida del césped del estadio (100 x 70 m ±)
Al restar el espacio para el escenario y según protocolos, unas 20.000 personas

You
¿Cuánto mide un campo de fútbol 11?

Understanding the problem

What are the dimensions of an 11-a-side football pitch?

ChatGPT
Un campo de fútbol 11, también conocido como campo de fútbol de tamaño completo, tiene dimensiones estándar definidas por la FIFA. Las medidas oficiales son las siguientes:

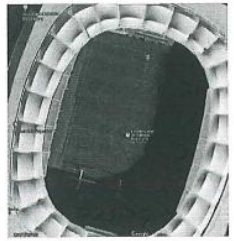
- Longitud: Entre 100 y 110 metros (109.7 - 120.1 yard
- Ancho: Entre 64 y 75 metros (70 - 82.3 yardas).

Estas medidas pueden variar ligeramente dependien
federación de fútbol correspondiente, pero en gener
dimensiones.

An 11-a-side football pitch, also known as a full-size football pitch, has standard dimensions defined by FIFA. The official measurements are:
- Length: between 100 and 110 metres
- Width: between 64 and 75 metres.

These measurements may vary slightly depending on local regulations or football federation.

Problema 5 ¿Cuánta gente cabe en el campo de fútbol del Levante como público (solo en la zona de césped) si queremos utilizar este espacio para realizar un concierto de un artista famoso?



Un campo de fútbol 11 mide 105 metros de largo y 70 m de ancho. Dividimos 5 m por 2'5 m a los laterales y 5m de ancho por 2'5 detras de cada 105 m largo y 75 ancho

Escenario → 70 largo y 30 ancho

En 70 m → 140 personas (0'5 m x pers)
30 m → 60 pers
→ 8400 personas

110 m → 220 personas
75 m → 150 personas
} 220 x 150 = 33.000

33.000 - 8400 = 24.600 personas

8400 personas que debemos restar por lo que ocupa el escenario

Results: characterisation of the use of ChatGPT in Fermi problem-solving process

ChatGPT as PS-Expert

The solver assigns the responsibility for solving the problem to the AI, as an expert solver (the AI is expected to complete the modelling cycle successfully).
The prompt technique is used to directly find the solution to the problem, always including a zero-shot or few-shot question.
The written solution reproduces the answer obtained by ChatGPT without any justification.

26%

ChatGPT as PS-Assistant

The solver breaks down the real, complex problem into sub-problems associated with the different stages of the modelling cycle, but gives the AI responsibility for solving each of these sub-problems (making assumptions and chaining reasoning and calculations).
Direct response prompting techniques are combined with some prompting techniques based on the modelling cycle.
Some participants initially use a zero-shot instruction, but when faced with an unsatisfactory qualitative response, they formulate specific prompts on the modelling phases to define subproblems that they solve with few-shot instructions.
The written solution includes ChatGPT partial answer so that the development of the model is done by the AI, but guided phase by phase by solver interactions with AI.

43%

ChatGPT as PS-Support

Solvers decompose the problem into sub-problems linked to the stages of the modelling cycle, which they solve with occasional support from AI to justify their assumptions, quantification of variables, reasoning or calculations.
Solvers only use specific prompts to support the different stages of the modelling cycle, which they complete independently.
Solvers write their own solution to the problem, incorporating the ChatGPT prompts into their autonomous development of the model.

31%

Thanks for your attention!
¡Muchas gracias!

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