

## Exploring the Effect of Student Backgrounds, Learning Approaches, and AI Use on Learning Outcomes in a Systems Thinking MOOC

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### Abstract

This article presents findings from a massive, free-of-charge online extension course titled Systems Thinking, which was conducted in Brazil in May and June 2024. The course engaged 345 participants. The research aimed to analyse how students' backgrounds, learning methods, and use of AI tools influenced learning outcomes. A mixed-method approach was employed, using electronic questionnaires to collect both quantitative and qualitative data. Quantitative data was analysed with descriptive statistics, while qualitative data was assessed using AI detection software (GPTZero) and a structured rubric. The main findings were: (i) most of the people interested in taking the course were seasoned educators and mid-career professionals, interested not only in the course content, but also in improving their skills and employability; (ii) most students learned by watching the video lectures and doing the modelling exercises proposed in the case studies—few learned from interacting with their peers; (iii) almost all of the students used AI to answer the exam questions, to varying degrees. However, the majority used AI in quite limited ways, and their learning was very effective.

**Keywords:** MOOCs; learning outcomes; AI detector; rubric; persona

### Introduction

Nowadays, there is growing interest in systems thinking, a methodology that helps us to understand and find solutions to complex problems. Educational programmes that focus on using this methodology are increasing. However, access to systems thinking courses in Brazil remains quite limited. To address this gap, a massive open online course (MOOC) titled “Systems Thinking” was developed and delivered. The goal was to offer a free course primarily to educators, while also welcoming anyone interested in the subject. This study aims to explore the learning outcomes of the course participants by examining how their backgrounds, learning methods, and use of artificial intelligence (AI) tools influenced their learning.

Specifically, the study investigated:

1. How participants' backgrounds affected their engagement and learning outcomes
2. The effectiveness of different learning methods used in the course
3. The impact of AI tool usage on the learning process and assessment outcomes.

### The context

Professors at the Federal University of São Paulo, Brazil, are encouraged to offer extension activities that provide educational opportunities to the broader community. These activities can take various forms, such as workshops, online seminars, community projects, panel discussions,

or online courses. To gain approval for an extension activity, professors must submit a formal proposal to a committee. If approved, they are free to develop the activity.

This article discusses the lessons learned from delivering a 5-week MOOC extension course. The course, titled “Systems Thinking”, was an introductory 30-credit course with no prerequisites and was open to anyone who was interested. It was designed and taught by a single professor, without the assistance of teaching assistants or IT technicians. The professor was responsible for creating the learning environment, producing video lectures, advertising the course, delivering the content, assessing student performance, and issuing certificates. The university provided an IT system for student enrolment and certificate issuance. The course was offered in May and June 2024 and was advertised through university and K–12 Facebook groups, as well as via email to extension departments across the country.

Because the university provided no IT support for extension courses, the professor used a combination of free tools to build the MOOC platform: Google Sites for hosting content, Google Groups for email management, Facebook for collaborative learning, and YouTube for hosting video lectures. Creating the course required significant effort, with the professor spending approximately 35 hours producing the video lectures and setting up the learning environment.

The course had a website with short video lectures (10 minutes each) and a book, specifically tailored to the course, that contained several case studies with modelling exercises. The course had six modules. The first module presented videos with definitions of systems, systems thinking, and systems characteristics (such as feedback loops, counterintuitive behaviour, and nonlinearity). The second module introduced the concept of mental models; the third presented the concepts of causal relationships, feedback loops, and systemic maps. The fourth module included several modelling exercises based on the book’s case studies. The fifth module covered the concepts of systems archetypes. The sixth module presented the concepts of stocks and flows and the main principles of system dynamics.

Every week, the professor sent a detailed email to all students with instructions about the learning goals for the week and the tasks to be completed. The course also had a private Facebook group where students could post questions and share knowledge. The professor visited the group multiple times daily, answering students’ questions and encouraging participation.

At the beginning of the final week of the course, students received an exam with six open-ended questions, each of which related to one course module. The students had one week to answer the exam questions. They were asked to not use artificial intelligence (AI) to answer the questions. The professor then analysed their answers using AI detector software (GPTZero) and a rubric specifically tailored to the course to consider the use of AI.

## Theoretical review

Systems thinking can be understood as a methodology for understanding and addressing complex problems. It enables the comprehension of systems’ structures and their patterns of behaviour (Meadows, 2008), and it helps us to understand the relationships between variables, feedback loops, and the nonlinearity present in complex systems (Cabrera & Cabrera, 2023). This knowledge is highly useful for decision-making (Cechvala, 2024), problem-solving, and organisational learning and development.

Systems thinking can be applied in diverse fields such as management (Sterman, 2002), engineering (Bossel, 2007), environmental science and ecology (Meadows, 2008; Ford, 2010), health (World Health Organization, 2009), and education (Senge et al., 2000).

Systems thinking has been taught in several graduate and undergraduate courses around the world (Bozkurt, 2023). In Brazil, there are currently only a few courses that cover this methodology, most of them taught in paid MBA programmes (Ibmec, 2024), in graduate courses (Arantes do Amaral & Gonçalves, 2015; USP, 2024), undergraduate courses (Hildebrandt-Stramann, 2021; UNIFESP, 2024), and on YouTube channels (Arantes do Amaral & Hess, 2017). In other words, the opportunities to study systems thinking in Brazil today are still quite limited.

To address this issue, a free massive open online course (MOOC) on systems thinking was offered. This course aims to provide learning opportunities primarily for teachers and educators, but also for anyone else interested in learning about the subject. The goal is to contribute to the creation of a community of systems thinkers who can bring these concepts to schools and universities.

Researchers (Guerrero-Quiñonez et al., 2023) point out several benefits of MOOCs. They are accessible, allowing anyone with internet connection to access them. More than that, they are flexible, allowing students to learn at their own pace (Papadakis, 2023). Scholars (Tan & Tazir, 2024) also pointed out that MOOCs provide lifelong learning opportunities, allowing individuals to improve their skills.

However, the challenges involved in designing and delivering MOOCs were well recognised. For example, MOOCs generally have high dropout rates (Psathas et al., 2023), and they require students to be disciplined and motivated to learn (Çakiroğlu et al., 2024).

Researchers (Wei et al., 2024; Yu et al., 2024) pointed out that several factors (such as academic background, professional experience, socio-economic status, and motivation) affect learning outcomes in MOOCs.

Scholars (Papadimitriou, 2023; Zubkov, 2023) highlighted that learning methods traditionally used in MOOCs (such as video lectures, quizzes, discussion forums, and gamification) can enhance learning outcomes. However, these methods rely on the quality of their design and integration within the course to be effective.

It is also recognised that students today use AI to generate answers for written assignments in various ways (Májovský et al., 2023). Scholars (Herbold et al., 2023) have pointed out that students may generate complete essays using tools such as ChatGPT. Researchers (Elali & Rachid, 2023) have also noted that students may use AI tools to paraphrase content from articles, books, and websites. Additionally, AI may be used as a writing assistant (Imran & Almusharraf, 2023), with students inputting partial responses and asking the tools to expand their thoughts. Furthermore, students may use AI to incorporate emotions and sentiments in AI-generated texts, making detection more difficult (Ayub et al., 2024). Researchers (Zhou et al., 2024) have also highlighted that students may use AI tools that are specifically designed to alter sentences generated by AI to make detection more challenging.

Scholars (Bašić et al., 2023) have pointed out that while AI tools can help students to structure their answers, these tools may also contribute to shallowing their learning.

Because resources and facilities are limited, the course was designed to be completely online, with no face-to-face meetings. As a result, online exams were relied on to evaluate students' learning. Multiple-choice quizzes were not created, because students can easily use artificial intelligence to answer them (Morreel et al., 2023). Instead, students' learning was assessed through open-ended questions, with instructions not to use AI to answer them. The professor believed that using AI would undermine learning, as it would prevent students from engaging critically with the material and developing a deeper understanding. Students were informed that

AI detector software would be used to help identify those who violated this rule, and that course certificates would not be issued to them.

Although several articles examine the learning experience in MOOCs and the use of AI in education, there appears to be a lack of understanding of how students' backgrounds, learning methods, and use of AI tools influence learning outcomes and engagement in a MOOC on systems thinking. This research aims to address this gap.

## **Method**

### **Research design**

A mixed-method approach was followed. Quantitative and qualitative data were collected using electronic questionnaires. The quantitative data were analysed using descriptive statistics, while the qualitative data were analysed using AI detector software (GPTZero) and a rubric.

### **Participants**

Three hundred and thirty-four people enrolled in the course. Students from all 26 Brazilian states participated, with the majority (59.9%) from the state of São Paulo. Each of the other 25 states and the Federal District contributed less than 5% of the participants. Most of the students were female (55.7%). More than half (52.1%) identified as white, 36.2% as mixed race, 8.7% as black, 2.4% as Asian, and 0.6% as indigenous. The oldest was 76 years old, and the youngest was 11. The average age was 38.6 years, with a standard deviation of 11.8 years.

### **Data collection procedures**

Two questionnaires were sent to the students: one in the first week of the course and the other at the end of the course. The first survey aimed to understand the demographics of the students. Questions were asked about their place of residence (states of Brazil), race, age, gender, social status, field of work, academic background, years of work experience, and previous knowledge in the subject.

The second survey had two parts: the first part was an exam with six open-ended questions, each corresponding to a course module. Students were asked to describe, in complete sentences, what they had learned in each module, with the goal of understanding the depth of their comprehension of the main concepts of systems thinking. They were instructed to not use AI to answer these questions. The second part was a course evaluation in which students were asked to answer closed questions on a Likert scale about their motivation to learn, their effort in learning, and whether the course met their expectations.

### **Data analysis procedures**

The data collected from the surveys was analysed using two methods. Descriptive statistics were used to analyse the quantitative data from the first survey, focusing on students' demographics. R software was developed specifically to perform this analysis, and a design-thinking tool called Persona was applied to gain a deeper understanding of the students.

The qualitative data from the first part of the second survey (students' answers to the exam questions) was processed as follows: Answers to the six questions were collected from each student. AI detector software (GPTZero) was then employed to assess the likelihood of AI use in these answers. It is acknowledged that no AI detector is currently fully accurate (Elkhatat et al., 2023) or entirely reliable (Weber-Wulff et al., 2023). Nevertheless, despite these limitations, the software was used as a preliminary assessment tool to flag potentially AI-generated content.

The AI detector software classified the answers in three groups: AI-generated, mixed (human and AI), or human-generated. Following this initial classification, all students' answers were carefully reviewed and graded using a rubric (Table 1). Supplementary evidence from GPTZero was taken into consideration.

The rubric guided a qualitative analysis and evaluation of the texts created by the students. The extent to which the key points of the course were addressed, and the depth of their responses, were analysed for each student's answer. The analysis also examined whether students effectively connected the course content with real-life examples and presented their answers logically, providing clear evidence of their learning.

For the data from the second part of the survey (regarding motivation to learn and learning methods), R software was developed to calculate and present the results from the five-point Likert scale questions.

**Table 1** Rubric used to grade the students' answers

Rubric	Description
Very good	All key points are addressed accurately. The student provides detailed and meaningful examples. The ideas and concepts presented are logically connected, showing that the student has a deep understanding of the content. <b>The use of AI appears to be minimal, probably used to fix the grammar.</b>
Good	The student covers some of the most important points accurately, presenting a few examples. The student presents their ideas in a logical way, sometimes with a few flaws and minor errors. <b>The use of AI appears to be moderate, probably used to fix and improve the text.</b>
Fair	The student demonstrates a reasonable understanding of some of the key points, with some minor inaccuracies, flaws, or omissions. The ideas and arguments are not very well connected but are still understandable. <b>The use of AI appears to be moderate; it was probably used to generate a few phrases and content that complemented the text generated by the student.</b>
Poor	The student shows limited comprehension of the key points and misses important elements. The text is written in a confusing way, making it difficult to follow; the ideas do not appear to be logically connected. <b>AI was probably heavily used to add text that summarises some of the course content (from the website, video lectures, and book) by combining sentences and paragraphs.</b>
Very poor	The students' responses are difficult to understand and sometimes completely off topic. <b>Or most of the text was likely generated by AI, which, although well-written, was unrelated to the topic.</b>

## Results

### Persona

Based on the analysis of the students' demographic data, three personas were identified.

**Table 2** The personas discovered

Persona	Characteristics
<b>Educators (45.5%)</b>	The mean age is 42.5 years. Sixty-three percent work in São Paulo State, and the majority (72%) have finished or are currently enrolled in postgraduate courses. Many (41%) have more than 15 years of work experience. The majority are female (57%). More than half (52%) are white. Seventy-one percent declared that they had very little knowledge of systems thinking at the beginning of the course. The majority (62%) are K-12 teachers. Almost half (47%) are married, 45% have no children, 23% have one child, and 24% have two children.
<b>Mid-career professionals (42.5%)</b>	The mean age is 38.6 years. Sixty-three point eight percent work in São Paulo State, and almost half (42%) have completed undergraduate studies or are still finishing their undergraduate studies (23%). Twenty-seven percent have postgraduate certificates (MBA or specialisation courses). Almost half (49.4%) have less than 10 years' work experience. Forty-three percent work in the fields of health, IT (13.8%), and self-employment (10.5%). The remaining participants work in other fields (engineering, business and finance, law, art and design, services, science and technology, logistics and transport, construction, public safety, agriculture, commerce, communication and media, homecare), with each field comprising less than 5% of the participants. The majority (51%) are female. More than half (51.3%) are white. Sixty-five percent declared that they had very little knowledge of systems thinking at the beginning of the course. More than half (58%) are single; 63% have no children, 15% have one child, and 17% have two children.
<b>Undergraduate students (12%)</b>	The mean age is 24.5 years. Many study in São Paulo State (32.5%) and Rio Grande do Norte State (25%). The majority (72.5%) are still taking undergraduate courses. Almost all (97.5%) have no work experience. The majority (65%) are female. More than half (52.5%) are white. Eighty-two percent declared that they had very little knowledge of systems thinking at the beginning of the course. The majority (90%) are single, and many have no children (87.5%).

### The motivation to learn

Figure 1 presents a stacked flow graph of the students' answers to five questions relating to their motivation to learn. Dark green shows the percentage of students who answered "totally agree" to each question. Light green represents "agree", grey represents "neither agree nor disagree," light brown represents "disagree," and dark brown represents "totally disagree".

The quantitative analysis revealed that ninety-eight percent of the students acknowledged that their main motivation for learning was the course content and the opportunity to develop their problem-solving skills. Ninety-three percent reported that their primary motivation was to

improve their job readiness, and 91% cited employability. Fifty-six percent stated that their main motivation was the need for approval.

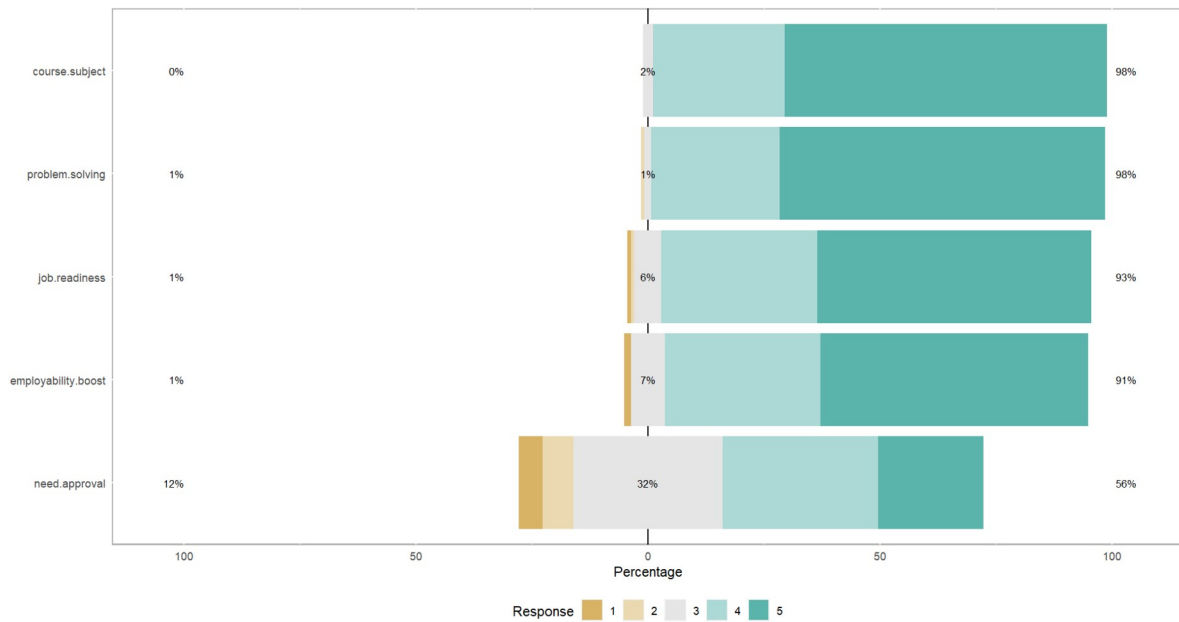


Figure 1 Students' answers related to their motivation to learn

### The learning methods

Figure 2 illustrates that most students (90%) acknowledged learning by watching the video lectures, while 79% reported also learning by completing the modelling exercises proposed in the case studies. Additionally, 64% indicated learning from reading the book, and 60% learned from the professor's feedback. In contrast, only 32% acknowledged learning from the comments of their peers in the Facebook discussion group.

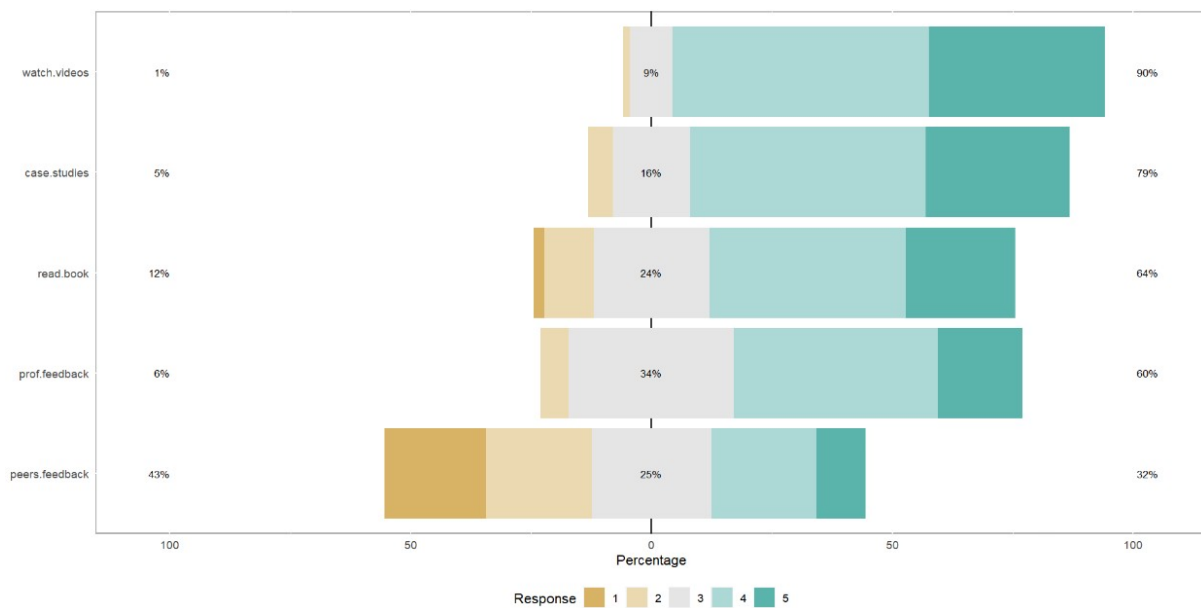


Figure 2 Students' answers in relation to their learning method

## Using AI to answer the open-ended exam questions

The AI detector software (GPTZero) indicated that all students probably used AI to answer the exam to some degree (Table 3). According to the AI detector report, 39 students (21.3% of the total) appeared to rely entirely on AI to answer the exam questions, 14 students (7.7%) possibly submitted a text that was mixed (partly generated by humans and partly by AI), and 130 students (70%) probably submitted a text with little or no use of AI.

However, despite the usefulness of AI detection tools, the results from Table 3 should be viewed with reservation. The AI tool relies on algorithms that assess patterns and structures in text, but it may not always accurately distinguish between human-written and AI-generated content. As a result, false positives (genuine responses flagged as AI-generated) and false negatives (AI-generated text that has not been identified) may have occurred.

**Table 3** The potential use of AI to answer open-ended exam questions

Response type	Number of students (%)
AI-generated	39 (21.3%)
Mixed (human and AI)	14(7.7%)
Human-generated	130 (70%)

## Academic performance

The students' exam answers were analysed and classified according to a rubric (see Table 1). Table 4 presents the percentages of answers classified as "Very good", "Good," Fair", "Poor", and "Very poor".

**Table 4** Percentages of grades by response type

Grade category	Human-generated	Mixed (human and AI)	AI-generated
Very good	31.6%	7.1%	0
Good	24.6%	28.6%	0
Fair	10%	7.1%	0
Poor	11.5%	21.4%	0
Very poor	22.3%	35.8%	100%

## Discussion

The use of personas provided a better understanding of the individuals interested in taking the course on systems thinking. All personas indicated that most students were from the State of São Paulo, which was expected because the Federal University of São Paulo is located there, and São Paulo has the largest population of any Brazilian state.

The data in Table 2 shows that almost half (45.5%) of the participants were educators. The data also revealed that the educators were seasoned, with extensive work experience and advanced educational degrees. The data also showed that many (42.5%) were mid-career professionals, and that a small percentage (12%) of participants were undergraduate students. The data also revealed that the participants enrolled not only because they were interested in the course content, but also to improve their job skills and employability (see Fig. 1).

This led to the first finding.

Most of the people interested in taking the course were seasoned educators and mid-career professionals, interested not only in the course content, but also in improving their skills and employability.

This finding aligns with the findings of researchers (Aman, 2024) who pointed out that MOOCs attract people who are interested in improving their employability skills. It also aligns with the findings of other scholars (Seaton et al., 2014; Gonçalves & Osório, 2018) who point out the significant participation of teachers in MOOCs.

This finding provided valuable insights for improving future course content to better address the needs of each persona. The course should include challenges and exercises that educators can apply with their students—real examples from health, IT, and business to engage mid-career professionals, and interactive content designed to spark students' interest in systems thinking.

The data revealed (Fig. 2) that most students acknowledged that they learned by watching the video lectures and by doing the modelling exercises proposed in the case studies. The data also revealed they learned by reading the book content and from the professor's feedback. However, it also showed that they didn't learn much from their peers (32%). Therefore, the use of the Facebook group as a space for sharing knowledge can be considered ineffective.

This resulted in the second finding.

The majority of the students learned by watching the video lectures and doing the modeling exercises proposed in the case studies; few learned from interacting with their peers.

This finding aligns with the findings of other researchers (Chiu et al., 2018; Miladi et al., 2023) who pointed out the challenges of promoting student interaction in MOOCs.

In relation to the use of AI to answer the open-ended questions of the exam, the preliminary assessment obtained using AI detector software (Table 3) suggested that almost all students used it, disregarding the course rule about not using AI to answer the exam questions. It also estimated that a small percentage of the students (21.3%) cheated by relying entirely on AI to answer the questions. Additionally, the assessment suggested that a small percentage (7.7%) of the students combined their own answers with AI-generated answers, making it difficult to quantify how much they truly learned. However, the data (Table 3) also revealed that most of the students (70%) probably used AI in a limited way.

The AI detector information was used judiciously, primarily to flag suspicious text that required further investigation. The application of the rubric enabled a more in-depth analysis. The results of this analysis (Table 4) revealed that students' answers previously flagged as "AI-generated" were evaluated as "very poor" because most of the answers were off topic or generic. Thus, it can be concluded that the AI detector software was efficient in classifying the AI-generated answers.

For the answers classified by the AI detector as “Mixed”, the use of the rubric (Table 4) graded 28.8% of the responses as “Good,” 7.1% as “Very good,” and 7.1% as “Fair.” These percentages suggest that the learning of nearly half of the students in the Mixed category was reasonable. However, the extent to which students relied on AI to create their answers remains unclear. This uncertainty makes it difficult to determine whether students in the Mixed group genuinely learned. Nonetheless, the number of students in this category was relatively small, representing only 7.7% of the total (Table 3).

The number of answers classified by the AI detector as “Human-generated” corresponds to 70% of the total student responses (Table 3). The rubric helped us to grade most of these responses (Table 4) as “Good” (28.6%) or “Very good” (31.6%). It can be concluded that students in this category effectively learned and made minimal use of AI in their answers. In addition to that, 10% were classified as “Fair”. Therefore, the learning of 66.2% of the students, who clearly did not use AI to answer the questions, was classified as fair and above. Based on that it can be inferred that the learning of 70% of the students was very effective.

In short, the AI detector insights, combined with the rubric, led us to deduce that probably only a small percentage (21.3%) of the students cheated by using AI to answer all the questions. Seventy percent of the students probably did not use AI to answer their questions, and most of their learning was classified as fair (10%) and above fair (56.2%). For a small percentage of the students (7.7%) it was not clear if they genuinely learned or not. Therefore, we may consider that majority of the students learned, and their learning was very effective.

This led to the third finding.

Almost all the students used AI to answer the exam questions to varying degrees. However, the majority used AI in quite limited ways, and their learning was very effective.

## Conclusion

What can be learned from this experience?

Returning to the three research questions, it can be concluded that the participants’ backgrounds—seasoned educators with extensive work experience, and mid-career professionals—positively influenced their learning. They sought to improve not only their knowledge but also their employability.

It was also found that the course design (combining short video lectures with modelling case studies) was very effective. However, the use of the Facebook group to promote participation was not effective. It is speculated that using grading as a motivation for participation could have made it more effective.

Additionally, it was found that the rule instructing students to not use AI to answer the exam questions was ineffective, as almost all students did not follow it. However, the use of AI detector software, combined with a rubric that considered AI use, proved to be very effective. This approach revealed that most students used AI in a limited way, yet their learning remained effective. It was also found that, in the following courses, the rule about using AI should be more flexible, clarifying that the students could use AI for fixing the grammar but not to answer the questions.

Based on the evidence presented, it can be affirmed that the course achieved its goals, which was providing systems thinking learning opportunities—mainly for educators. A substantial number of educators participated, and it is speculated that they will apply what they have learned in the

courses they teach in the future, therefore creating even more systems thinking learning opportunities in Brazil.

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