

# From Automaton to AI Robot: the Added Value for Learning

Marie Martin, Thomas Deneux and Morgane Chevalier

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## From automaton to AI robot: the added value for learning.<sup> $\star$ </sup>

 $\begin{array}{l} \text{Marie Martin}^{1,2[0000-0001-5981-3696]}, \text{ Thomas Deneux}^{1[0000-0002-9330-7655]}, \\ \text{ and Morgane Chevalier}^{4[0000-0002-9115-1992]} \end{array}$ 

 <sup>1</sup> Université Paris-Saclay, CNRS, Institut de Neurosciences Paris-Saclay, France {marie.martin.2,thomas.deneux}@cnrs.fr
 <sup>2</sup> Université Paris Cité, Paris, France marie.martin@cri-paris.org
 <sup>3</sup> Haute École Pédagogique du canton de Vaud (HEP-VD), Lausanne, Switzerland {morgane.chevalier}@hepl.ch

**Abstract.** Since educational robotics has been integrated into school curricula, the number of robots on the market has continued to grow. Today, it is even possible to increase the degree of autonomy of some of these ground robots by connecting them to artificial intelligence software. However, the use of these new functionalities raises the question of their added value for learning. In this position paper, we compare the potential of each category of robot (traditional robot versus AI robot) to promote learning. As a result, we present scenarios where self-learning robots enable students to reflect on their cognitive processes and learn how to learn.

**Keywords:** Educational Robotics · Artificial Intelligence Education · Machine Learning · Metacognition · Primary School.

#### 1 Introduction

The use of robots in education is not new. Numerous studies have confirmed the relevance of educational robotics learning activities (ERLA) in fostering essential skills for academic success, such as computational thinking (CT) [5] [10] [6] [3] and metacognition [12] [17] [8], as early as elementary school. However, with the increasing prevalence of artificial intelligence (AI) in our daily lives, some educational robot programming platforms now incorporate machine learning (ML) systems. Some offer training of a ML model that can later be used in a Scratch or Scratch-like programming interface (MachineLearningForKids.co.uk; Google's Teachable Machine; MIT's Cognimate; Vittascience, France). Others, such as the AlphAI software, allow the training of learning robots and the visualization of AI algorithms (developed at the CNRS, France [12], and commercialized by Learning Robots, France). A large number of other AI robot initiatives have been

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proposed in the science education field [21]. This development of robots linked to AI software raises the question of the added value of using AI robots over more traditional robots. This question follows the pedagogical concerns raised by Tedre and colleagues [18], who compared the traditional approach to programming (CT 1.0) with the data-driven approach to programming through ML (CT 2.0). Indeed, the growing complexity of computer science (CS) leads us to rethink the way in which CS is taught at school, introducing new knowledge (version CT 2.0 according to [18]) without replacing the basic knowledge (CT 1.0). In addition to this increase in CS knowledge, the teaching of ML seems to offer the possibility of approaching metacognition through learning activities that compare ML and human learning. Therefore, in this paper, we explore the added value of ERLA and ERLA embedding an AI algorithm (AI-ERLA), with a particular focus on the development of metacognition in primary school students.

#### 2 From automaton to event-based programming robots

As Papert [14] has written, robots are objects to 'think with', because being able to manipulate them accompanies thought in action, as a mediating tool. In fact, from the very first years of school, such tools for mediating thought are essential for overall learning (communication, problem solving, etc.).

For more than 40 years now, robots have been entering the educational sphere in an evolutionary manner, moving from automaton that the student controls to robots equipped with sensors that can adapt their behaviour according to the data collected in their environment. While the former operate in an open loop, the latter operate in a closed loop or sensory-motor loop, which only gives the latter the status of robot [1]. In addition to the machines themselves, it is their programming paradigm (sequential vs. event-based) and problem solving approach (deductive according to [18]) that helps or hinders their entry into schools. Sequential programming seems to be better suited to young students, as sequentiality is dealt with at the start of schooling in the activities involved in learning to read and write. [7]. In addition, human-computer interaction is also at stake. In this respect, visual programming interfaces have the advantage of being able to make the language accessible to young students, by enforcing the correct coding syntax and making it visually explicit [11]. Moreover, some engineers and researchers go so far as to make the programming interface tangible too in order to make robot programming accessible to even younger students and reduce the mental load [16].

Using "objects to think with" (the robot and its tangible programming interface), allows to leverage children's embodied experiences in the world in order to better help them enter the new universe of computer code and digital artifacts [9]. Thus, through the use of automaton and robots to be programmed, students are encouraged to develop 21st century skills [19] such as communication, collaboration, creativity and critical thinking. Added to this are 'information, media and technology skills', particularly knowledge of machines (sensors, actuators, etc.) and knowledge of the languages used to program these machines. In the context of an ERLA, debugging skills are also at stake. Consequently, the three CT components [2] are likely to be mobilised during an ERLA: computational perspectives, computational concepts, computational practices. Of course, certain conditions favour the emergence of CT, such as the teacher temporarily blocking access to programming [5] or delayed feedback for the student on the execution of the program by the robot [4]. These two interventions refer to the metacognitive pause [15] and, besides, some researchers associate the CT skill with metacognitive skills [20]. However, all this knowledge about ERLA from the state of the art is only valid in the CT 1.0 version [18], i.e. under the deductive problem-solving approach. This changes when the problem-solving approach is inductive (CT 2.0), i.e. based on data-driven approach to programming.

#### 3 Shift towards AI robots

AI robots open up a new form of human-machine interaction and thus a new learning relationship in the classroom between student and robot. These robots incorporate a ML algorithm (supervised or reinforcement learning) which, on one hand, impacts on the problem solving approach (inductive, [18]) and, on the other hand, gives them more autonomy than traditional robots (section 2). Indeed, traditionally, in computational problem solving (CT 1.0), the problem is solved by the human and the solution of the problem is then executed by the machine [5] whereas in data-driven approach to programming (CT 2.0, fostered by generative AI [18]) both the problem solving and the solution are generated by the machine. The role of the student has therefore changed and he-she needs to understand how the machine learns, whether in supervised or reinforcement mode, by expanding the scope of his-her knowledge developed in traditional programming to that of ML[18].

Supervised learning is "applicable when we know what output is expected for a set of inputs" [1] (p. 214) whereas, in reinforcement learning, "we do not specify the exact output value in each situation; instead, we simply tell the network if the output it computes is good or not" (ibid.). Through this game of rewards (positive or negative), the robot is obliged to take account of its previous actions, i.e. it learns from delayed feedback, which makes the learning process iterative.

In the case of reinforcement learning, we can clearly see the transition to autonomy of the machine, which solves and executes the given problem itself. This calls into question the role of the student in the problem-solving task. At first sight, this seems to run counter to Papert's constructivist approach [14] (section 2). Nevertheless, some authors [13] posit this as an opportunity to revisit the work of Papert and his colleagues, who have already highlighted the gain in metacognitive knowledge and skills for student (even young ones) in AI context. Based on the idea of "contrastive learning" [13] (p.22), these authors support the value of highlighting the "relationship between AI and education, not only looking at AI as an applied tool to advance education but also investigating its value as an analogy to human intelligence" (p.1).

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In this regard, [12] recently showed that students aged 8 to 11, subjected to an ERLA embedding an AI algorithm (AI-ERLA), significantly improved their metacognitive knowledge, compared with those not subjected to the AI-ERLA. The educational value of AI robots is thus well-founded, but there are still differences in the way they are used. For instance, [12] proposes a teaching scenario in which students i) explore and manipulate the robot in traditional mode, but also ii) observe the AI robot in reinforcement learning mode. The switch from the traditional robot to the AI robot involves a change of task (from exploration/manipulation to observation), with the student being asked to focus more on metacognitive aspects. This change leads to different learning objectives.

#### 4 Four learning scenarios with increasing robot autonomy

As mentioned in the introduction, we have identified 4 main types of scenarios that can be set using different types of robots, with or without embedded AI. Table 1 in Appendix summarizes these 4 scenarios and discusses their respective advantages. We focus our discussion in particular on how students engage in the proposed activities. Indeed, while the ideas of Papert's constructionism imply that the student is the actor or actress of his-her learning and concretely in action in his-her learning environment, the shift to the use of AI robots could run somewhat counter to this idea. In fact, with traditional use of educational robots (columns 2 and 3 in Table 1), the autonomy of the machine is low and the power of the student to program and therefore to reflect and act (computational perspectives and practices) is high. But what happens when the machine becomes increasingly autonomous?

In the first scenario, students simply control robots remotely and learn to associate commands (e.g. buttons) with robot actions and to plan a sequence of actions. Student engagement is high as they are involved in every moment of the robot course, but at the same time this interaction remains trivial, so intellectual engagement may be low as students get older.

The second scenario corresponds to the mainstream use of educational robots, where students are engaged in programming the robot's response to its environment. Their engagement is high as they iteratively i) plan how the robot should behave, code, then ii) observe the robot behaving according to its code and correct the code (debugging, etc.). Among these coding activities, we can distinguish those that are simpler for the younger ones, do not involve sensors, and where students only program an open-loop sequence of actions.

The third scenario is an extension of the second, but involving AI, or more precisely "supervised learning". Here, students no longer program their robots with code, but train them with data thanks to an ML model for a classification task: in the case of image recognition, for example, they need to provide relevant example images associated with given categories in order to train an image recognition model. In the case of an AlphAI robot, students collect data by remotely controlling their robot, and each image from the robot's camera is directly associated with an action that the robot should perform, so that the robot can be switched to autonomous driving as soon as this training is complete: using such an AI robot can be simpler than traditional robot programming and therefore more accessible to young students. In fact, the underlying task is different because the approach to solving the problem changes from deductive to inductive. In this context, data collection leads to an understanding of what is relevant data. For instance, in the case of platforms such as machinelearning-forkids.com, students integrate their trained model to a Scratch code, therefore they manage to program their robot using both code (scenario #2) and data (scenario #3). Altogether, despite the high degree of autonomy available to the AI robot in scenario #3 and the AI model's ability to learn and memorize, the student's power to act remains high (similar to scenario #2, i.e. action of iterative debugging). It is noteworthy also that such activities are more accessible to young students, and that they allow the programming more "exciting" robot behaviours, such as circuit racing.

In the fourth scenario, the robot learns 'on its own' by trial and error. Its goal during learning is to maximise a score or 'reward' that it receives after each action it performs. The activities become more subtle because they include waiting periods during which the robot learns by accumulating experience. The power of the student to act seems to be reduced, since it is the AI robot that solves the problem on its own. Nevertheless, it is possible for the student to manipulate: he she can help the robot to learn faster by forcing it to make certain explorations [12]; he she can also manipulate the reward given to the robot to adjust the learning goals, as is the case in the study by Zhang and colleagues [21]. The task proposed in this study is designed according to constructionist principles, and the results of the study show a high level of student engagement and learning, similar to what was described in scenarios #2, #3 and #4 in Table 1 (understanding AI and CT concepts). Moreover, the students' engagement may also lie in the transition from manipulation to critical observation, as the analysis of how the robot learns is useful for learning about one's own learning: in scenario #4, the students observe that the robot, like humans, needs time, curiosity, acceptance of mistakes and thus perseverance to learn successfully. This use follows the recommendation of Ojeda and colleagues [13] to use reinforcement learning as a tool for metacognitive reflection, allowing children to "reflect on their own thinking and learning".

#### 5 Conclusion, Limitations, and Perspectives

The purpose of the present paper was to explore the added value of educational robotics and AI in the learning process, with a particular focus on the development of metacognition in primary school students.

Based on the state of the art and on practitioners'feedback, we built and proposed a synoptic table regarding 4 different scenarios with robots and AI. It shows the added value of AI robots compared with traditional robots in primary schools. It emerges that the 4 scenarios identified with robots do not all offer the 6 M. Martin et al.

same level of i) robot autonomy in solving the problem, ii) type of student's engagement in learning, iii) targeted educational objective, iv) teacher intervention during learning.

In this paper, continuing Tedre and colleagues's pedagogical concerns about CT versioning [18], we argue that all different types of robots represent an opportunity for learning. The challenge, therefore, is to train teachers in this area. In the previous sections, we recalled the recognized benefits of the tangible aspect of robots for learning and showed how data visualization, a neural network, and the *in situ* behavior of an AI robot also contribute to student learning. Consistent with the work of Ojeda and colleagues [13], this analysis highlights the need to use AI robots not as a replacement for traditional robots, but as a complement to them. Constructed learning is simply not the same and depends more on the scenarios, the nature of the task, and how the tool is mediated by the teacher than on the level of autonomy of the robot. This shift in students' agency needs to be understood by teachers so that they can make good use of each of these tools according to their pedagogical objectives.

#### References

- 1. Ben-Ari, M., Mondada, F.: Elements of robotics. Springer Nature (2017)
- Brennan, K., Resnick, M.: New frameworks for studying and assessing the development of computational thinking. In: Proceedings of the 2012 annual meeting of the American educational research association, Vancouver, Canada. vol. 1, p. 25 (2012)
- Catlin, D., Woollard, J.: Educational robots and computational thinking. In: Proceedings of 4th International workshop teaching robotics, teaching with robotics & 5th International conference robotics in education. pp. 144–151 (2014)
- Chevalier, M., Giang, C., El-Hamamsy, L., Bonnet, E., Papaspyros, V., Pellet, J.P., Audrin, C., Romero, M., Baumberger, B., Mondada, F.: The role of feedback and guidance as intervention methods to foster computational thinking in educational robotics learning activities for primary school. Computers & Education 180, 104431 (2022)
- Chevalier, M., Giang, C., Piatti, A., Mondada, F.: Fostering computational thinking through educational robotics: A model for creative computational problem solving. International Journal of STEM Education 7(1), 1–18 (2020)
- Eguchi, A.: Ai-powered educational robotics as a learning tool to promote artificial intelligence and computer science education. In: International Conference on Robotics in Education (RiE). pp. 279–287. Springer (2022)
- Greff, É.: Le jeu de l'enfant-robot: une démarche et une réflexion en vue du développement de la pensée algorithmique chez les très jeunes enfants. Ph.D. thesis, Paris VII (1996)
- Havenga, M., Jordaan, T.: Introducing coding and robotics: Prospective mathematics teachers' metacognitive thinking in scratch. In: International Conference on Robotics in Education (RiE). pp. 17–26. Springer (2023)
- 9. Horn, M., Bers, M., et al.: Tangible computing. The Cambridge handbook of computing education research 1, 663–678 (2019)
- Hsu, T.C., Chang, S.C., Hung, Y.T.: How to learn and how to teach computational thinking: Suggestions based on a review of the literature. Computers & Education 126, 296–310 (2018)

- Magnenat, S., Shin, J., Riedo, F., Siegwart, R., Ben-Ari, M.: Teaching a core cs concept through robotics. In: Proceedings of the 2014 conference on Innovation & technology in computer science education. pp. 315–320 (2014)
- Martin, M., Chevalier, M., Burton, S., Bonvin, G., Besançon, M., Deneux, T.: Effects of introducing a learning robot on the metacognitive knowledge of students aged 8–11. In: International Conference on Robotics in Education (RiE). pp. 169– 183. Springer (2023)
- 13. Ojeda-Ramirez, S., Rismanchian, S., Doroudi, S.: Learning about ai to learn about learning: Artificial intelligence as a tool for metacognitive reflection (2023)
- 14. Papert, S.A.: Mindstorms: Children, computers, and powerful ideas. Basic books (1980)
- Romainville, M.: Conscience, métacognition, apprentissage: le cas des compétences méthodologiques. In: La conscience: perspectives pédagogiques et psychologiques. Presses de l'université du Québec (2007)
- Sapounidis, T., Demetriadis, S.: Tangible versus graphical user interfaces for robot programming: exploring cross-age children's preferences. Personal and ubiquitous computing 17, 1775–1786 (2013)
- 17. Socratous, C., Ioannou, A.: Using educational robotics as tools for metacognition: an empirical study in elementary stem education. In: Immersive Learning Research Network Conference, UK. pp. 64–75 (2019)
- Tedre, M., Denning, P., Toivonen, T.: Ct 2.0. In: Proceedings of the 21st Koli Calling International Conference on Computing Education Research. pp. 1–8 (2021)
- Voogt, J., Roblin, N.P.: A comparative analysis of international frameworks for 21st century competences: Implications for national curriculum policies. Journal of curriculum studies 44(3), 299–321 (2012)
- Yadav, A., Ocak, C., Oliver, A.: Computational thinking and metacognition. TechTrends 66(3), 405–411 (2022)
- Zhang, Z., Lavigne, K., Church, W., Sinapov, J., Rogers, C.: Introducing reinforcement learning to k-12 students with robots and augmented reality. In: International Conference on Robotics in Education (RiE). pp. 351–365. Springer (2023)

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### Appendix

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Type of tacher's minipulate the mediation)         Help students with the programming language and identification of all cases.         Help students identify all the cases and relevant examples needed.         Help the student 1) identify the strategies the robot uses to solve the problem, 2) and the way the robot learns and the way the student           Ievel of complexity of the task for the student         Very low Interaction is step by the difficulty liss in the intropation.         Help the student 1) identify the strategies the robot uses to solve the problem, 2) the difficulty liss in the programming language (computational concepts) <sup>1</sup> .         Help the difficulty liss in the intropation and knowledge of the programming language (computational concepts) <sup>1</sup> .         Help the difficulty liss in the programming language (computational concepts) <sup>1</sup> .         Help the student 1) identify the strategies the robot learns and having enough distance obstacle for students.           What does the robot do?         It exercutes orders a countered in its ervironment (closed loop). These situations encountered in the vectore a program according to the students         It learns form labeled examples to make decisions students         It learns form labeled examples to make decisions students         It learns form labeled examples to experiences, thanks to the reward system provided by humans.           Can we talk about A? Why students         No         No         No         No         No           Links with everyday objects used by students			program, based on the CCPS		robot and drawing conclusions.
Type of tracher's intervention (reacher's mediation)         Help students within the task for the student         Help students manipulate the programming language and identification of all cases.         Help students melvant examples needed.         Help the student 1 identify the trobuses to solve the problem, 2) draw parallels and differences between the vary the robot learns and the way the student learns.           Iver low complexity of student         Very low interaction is step by step (low anticipation).         Help the students with the programming language. Ivery low of the state learns and the way the student learns.         Help the students of the way the robot learns and the way the student learns.           What does the robot do?         It executes orders regardless of its environment (open loop).         It executes the program. It executes the program. according to the situations environment (open loop).         It executes the program. according to the situations including generalizing decisions to new, unlabeled data, decisions autonnously, including generalizing is his knowledge to make decisions autonnously, including generalizing is knowledge to make decisions autonnously, including generalizing decisions to new, unlabeled data.         Yes 			model [5] for instance.		
teacher's mediation)         manupuate the remote control.         programming inguage and dentification of all cases.         relevant examples needed.         the root uses to solve the produtem, 2/ draw parallels and differences between the way the nobol learns and the way the student           Ievel of complexity of student         Very low interaction is step by step (low anticipation).         Very low interaction is step by step (low anticipation).         High requires anticipation and knowledge of the programming task, which requires anticipation and knowledge of the programming inguage (computational concepts).         Hedium         No need to know the programming anticipation.         High root users and having enough distance (more difficul because it is mpossible to show why a neural network has generated an output [19].         High root users and having enough distance (more difficul because it is mpossible to show has needed.         High root users and having enough distance (more difficul because it is mpossible to show has needed.         High root users and having enough distance (more difficul because it is mpossible to more difficul because it is mpossible to show has needed dop). These situations root dop to users it is moved and the reparates and the secure secure secure to make decisions automomusly, including generatizing decisions to new, unababled data.         It learns by thiad and error. It learns continuely on its environment (pen loop).           Can we talk about AP? *         No because the robot executes when asked to do so. *         No because the robot executes automomusly, including generatizing decisions to new, unababled data.         Yes because the machine explores and thave been defined.         Yes because what is called	Type of	Help students	Help students with the	Help students identify all the cases and	Help the student 1) identify the strategies
Intervention mediation         Definition of a loades.         Definition of a loades.           Index parales and uniferations         Usery low interaction is step by student         Very low interaction is step by step (iow anticipation).         High The difficulty lies in the programming language.         Medium No need to know the programming regardless of its environment (open involved per of the student         Medium The difficulty lies in the programming language.         Medium No need to know the programming regardless of its environment (open involved per of the student         The difficulty lies in knowing how the requires anticipation and knowledge of the programming language.         Medium No need to know the programming regardless of its environment (open involved in the situations environment (open loop).         The difficulty lies in knowing how the regardless of its environment (open involved in the situations environment (open loop).         The difficulty lies in knowing how the robot learns and howing encupt students.           What does the robot do?         It executes orders environment (open loop).         It executes is provided by the student. It analyzes the case the knowledge of the relationships between inputs and outper studing generalized an output [18].         It earns by the and error. It learns provided by humans.           Can we talk about AI? Why reclass the robot executes the nasked to do so. It is not autonomous the nasket net robot executes when asket do do so. It is not autonomous the nasket net robot.         No         Yes because the machine explores and involves "machine learning".           Links with everyday students         Remote-controlled car.         Coefte	teacher's	manipulate the	programming language and	relevant examples needed.	the robot uses to solve the problem, 2)
Iterediation's mediation's mediatio	(Teacher's	remote control.	identification of all cases.		the way the relief learne and the way the
Interaction is level of complexity of the task for the student         Very low Interaction is step by anticipation).         High The difficulty lies in the programming task, which requires anticipation and knowledge of the programming language (computational concepts).         Medium Medium         Medium No need to know the programming and upge. However debugging is made more difficult because it is imposible to generated an output [18].         High The difficulty lies in knowing how the robot lears and having encupt distance (maturity) form one's own way of learning as a student.           What does the robot do?         It executes orders regardless of its environment (open loop).         It executes the program according to the situations environment (open loop).         It executes where program according to the situations environment (open loop).         It learns to the reward system provided by the student. It analyzes that add error. It learns continuously 'on its own' from its experiences, thanks to the reward system provided by humans.         It learns by that and derror. It learns continuously 'on its own' from its experiences, thanks to the reward system provided by humans.         Yes because the robot make decisions autonomously, including generalizing decisions to new, unlabeled data.         Yes because the machine explores and fumbles around in order to implement a programmed. It may be autonomous, but it is not off the beaten track.         Industrial robots using computer vision. Self-driving cars.         A robot like Dreame* that adapts the way it walks according to the state of the ground.           Knowledge at takes         Technical aspects of the machine + CT 1.0 (including CS)         Technical aspects of the machine + CT 1.0 (including CS) <td< th=""><th>(Teacher S</th><th></th><th></th><th></th><th>the way the robot learns and the way the</th></td<>	(Teacher S				the way the robot learns and the way the
level or complexity of the task for the student       Very low interaction is step by anticipation).       Frigh Hafficulty lies in the programming task, which mowledge of the programming language (computational concepts).       No need to know the programming language. However debugging is made movel difficult because it is impossible discern why a neural network has generated an output [18].       Frigh The difficulty lies in knowing how the robot lacars and having enough distance (maturity) from one's own way of learning as a student.         What does the robot do?       It executes orders environment (open loop).       It executes the program continuous of learning and continuous of not its encountered in its environment have been defined.       It learns from labeled examples encountered in its environment have been defined.       It learns from labeled examples to understand the relationships between inputs and outputs, and then uses this knowledge to make decisions autonomously, including generalizing decisions to new, unlabeled data.       It learns from its executes orders when asked to do so. It is not autonomous, unlabeled data.       Yes because what is called At today involves "machine learning". here, the procise situations programmed. It may be autonomous, but is not off the beaten track.       No       No      because what is called At today involves "machine learning".       A robot like Dreamer <sup>2</sup> that adapts the way it walks according to the state of the ground.         Links with everyday objects used by students       Technical aspects of the machine + CT 1.0 (including CS)       Fechnical aspects of the machine + CT 1.0 (including CS)       Alconcepts + MK + CT 2.0       Alconcomy Memory Learning       Alconcepts + MK + CT 2.0			18.1		
Comparison         No	level of	Very low	High The difficulty lice in the	Medium	High
International student       anticipation).       programming lask, which in any genomical basined and knowledge of the programming language (computational concepts).       more difficult because it is impossible to discert with a neural network has generated an output [18].       modulation labring encount way of learning as a student.         What does the robot do?       It executes orders regardless of its environment (open loop).       It executes the program according to the situations encountered in its environment (according to the situations encountered in its environment (open loop).       It learns from labeled examples to understand the relationships between inputs and outputs, and then uses this knowledge to make decisions autonomous, have been defined.       It learns from its experiences, thanks to the reward system provided by the student. It analyzes these examples to understand the robot executes are program.       It learns from its experiences, thanks to the reward system provided by thumans.         Can we talk about AI? Why every day been asked to do so, It is not autonomous, but it is not off the beaten track.       No       Yes      because the mobility from one's own and from its exportences, thanks to the reward system provided by thumans.      because the mobility from one's own and from its exportences and functions autonomous, but it is not off the beaten track.       Yes      because the mobility from one's own and from its exportences.         Links with every day bigsts used by students       Remote-controlled car.       Coffee machine, automatic exportences.       Yes      because the mobility from one's own and functions envice exportence.       A cobot like Dreamer <sup>2</sup> that adapt	the task for the	stop (low	programming task which	language. However debugging is made	robot learns and having enough distance
and participation in all independents.       Independents.       Independents.       Independents.         What does the robot do?       It executes orders in environment (open loop).       It executes the programment (closed loop). These situations environment (closed loop). These situations have been defined.       It learns from labeled examples to understand the relationships between inputs and outputs, and then uses this knowledge to make decisions autonomously, including generalizing decisions to new, unlabeled data.       It learns by trial and error. It learns continuously 'on its own' from its experiences, thanks to the reward system provided by the unans.         Can we talk about AI? Why environment (open loop).       No      because the robot executes a program according to the programmed. It may be autonomous, but it is not autonatic car.       Industrial robust and programmed. It may be autonatic car.       Industrial robust and programmed. It may be autonatic car.       Industrial robust and programmed. It may be autonatic car.       Industrial robust and programmed. It may be autonatic car.       Industrial robust and programmed. It may be autonatic car.       Industrial robust and programmed. It may be autonatic car.       Industrial robust and programmed. It may be autonatic car.       Indust	student	anticination)	requires anticipation and	more difficult because it is impossible to	(maturity) from one's own way of learning
What does the robot do?         It executes orders environment (open loop).         It executes the orders according to the situations environment (open loop).         It executes the orders according to the situations environment (open loop).         It learns from labeled examples provided by the student.         Putting things into words can be an obstacle for students.           Can we talk about AI? Why ?         No         No         No         No         Yes          because the robot executes orders when asked to do so. It is not autonomous, bit is not autonomou tautonomy au	Student	anticipation).	knowledge of the	discern why a neural network has	as a student
Image: state of the s			programming language	denerated an output [18].	Putting things into words can be an
What does the robot do?         It executes orders regardless of its executes the program according to the situations encountered in its environment. It enaryzes these examples to understand the uses this knowledge to make decisions autonomously, including generalizing decisions to new, unlabeled data.         It learns from labeled examples to understand the experiences, thanks to the reward system provided by the students autonomously, including generalizing decisions to new, unlabeled data.         It learns from labeled data.         Yes           Can we talk about AI? Why         No        because the robot executes were situations arogenerating the situations program according to the process situations arogenerating decisions autonomously, including generalizing decisions to new, unlabeled data.         Yes        because the robot executes are program according to the process situations programmed. It may be autonomous, but it is not off the beaten track.         Yes        because the rachine examples it memorized.           Links with everyday objects used by students         Remote-controlled car.         Coffee machine, automatic car wash, domestic machines.         Industrial robots using computer vision.         A robot like Dreamer <sup>2</sup> that adapts the way it wask according to the state of the ground.           Knowledge at autonomy         Technical aspects of the machine + CT 1.0 (including CS)         Als such as ChatGPT and other chatbots and audio assistants that have been trained using both supervised and reinforcement learning.         Alconomy Merrory Learning         Alconomy Merrory Learning           Knowledge at autonomy         Technical aspects of the machine + CT 1.0 (including CS			(computational concepts) <sup>1</sup> .	3	obstacle for students.
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loop).       (closed loop). These situations have been defined.       relationships between inputs and outputs, and then uses this knowledge to make decisions autonomously, including generalizing decisions to new, unlabeled data.       provided by humans.         Can we talk about AI? Why ?       No       No       No       No       Yes       Secause the robot executes orders when asked to do so. It is not autonomous, but it is not autonomous       No       Yes       Yes         Links with everyday objects used by students       Remote-controlled car.       Coffee machine, automatic car wash, domestic machines.       Industrial robots using computer vision. Als such as ChatGPT and other chatbots and audio assistants that have been trained using both supervised and reinforce- ment learning.       A robot like Dreamer <sup>2</sup> that adapts the way it walks according to the state of the ground.         Knowledge at autonomy       Technical aspects of the machine + CT 1.0 (including CS)       Al concepts, especially the importance of data in modern life + CT 2.0       Al concepts + MK + CT 2.0         Level of robot autonomy       No autonomy       Autonomy No learning       Autonomy No learning       Autonomy No learning       Autonomy Nemory Learning (a more difficult onel) Exploration       High Active observation during the time robot learning (a more difficult onel) Exploration       High Active observation during the time robot learning (a more difficult neotot learning (a more difficult neot learning		environment (open	encountered in its environment	these examples to understand the	experiences, thanks to the reward system
Image: series of the machine     have been defined.     outputs, and them uses this knowledge to make decisions autonomously, including generalizing decisions to new, unlabeled data.       Can we talk about AI? Why about AI? Why?     No     No     Yes       ?     No autonomous.    because the robot executes a program according to the procise situations programmed. It may be autonomous, but it is not autonomous.     Yes    because what is called AI today involves "machine learning": here, the procise situations programmed. It may be autonomous, but it is not off the beaten track.     Industrial robots using computer vision.     A robot like Dreamer <sup>2</sup> that adapts the way it walks according to the state of the ground.       Links with everyday objects used by students     Remote-controlled car.     Coffee machine, automatic car wash, domestic machines.     Industrial robots using computer vision.     A robot like Dreamer <sup>2</sup> that adapts the way it walks according to the state of the ground.       Knowledge at stakes     Technical aspects of the machine     Technical aspects of the machine + CT 1.0 (including CS).     Al concepts, especially the importance of data in modern life + CT 2.0     Al concepts + MK + CT 2.0       Level of robot autonomy     No autonomy     Autonomy     Autonomy     Autonomy     Autonomy       No learning     High     Direct handling + CT 1.0     High     High     High       Direct handling     High     Direct handling + CT 1.0     Procise site of the machine robot learning + regulation + CT 2.0		loop).	(closed loop). These situations	relationships between inputs and	provided by humans.
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Can we talk about AI? Why ?       No       No       Yes       Yes        because the robot executes orders when asked to do.s. It is not autonomous.      because the robot executes a program according to the precise situations programmed. It may be autonomous, but it is not off the beaten track.      because what is called AI today involves "machine learning": here, the robot learns from the examples it memorized.       Yes because the machine explores and fumbles around in order to implement a structure wash, domestic machines.         Links with everyday objects used by students       Remote-controlled car.       Coffee machine, automatic car wash, domestic machines.       Industrial robots using computer vision. Self-driving cars.       A robot like Dreamer <sup>2</sup> that adapts the way it walks according to the state of the ground.         Knowledge at stakes       Technical aspects of the machine + CT 1.0 (including CS)       Als such as ChatGPT and other chatbots and audio assistants that have been trained using both supervised and reinforce-ment learning.       Al concepts + MK + CT 2.0         Level of robot autonomy       No autonomy       Autonomy No learning       Autonomy Memory Learning       Autonomy Memory Learning       Autonomy Memory Learning (a more difficult one!) Exploration         Student's engagement       High Direct handling + CT 1.0       High Direct handling + regulation + CT 2.0       High Active observation during the time robot learns, reflection, and metacognition + CT 2.0				to make decisions autonomously,	
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about NFF Why ?      becades the foot excluses when asked to do so. It is not autonomous. It is not autonomous. Links with everyday objects used by students      becades the foot excluses when asked to do so. It is not autonomous. Links with everyday objects used by students      becades the foot excluses involves "machine learning". here, the robot learns from the examples it molves "machine learning". here, the robot learns from the examples it memorized.      becades the foot explores and strategy to achieve the set goal. This also involves "machine learning".         Links with everyday objects used by students       Remote-controlled car.       Coffee machine, automatic car wash, domestic machines.       Industrial robots using computer vision. Self-driving cars.       A robot like Dreamer <sup>2</sup> that adapts the way it walks according to the state of the ground.         Knowledge at stakes       Technical aspects of the machine       Technical aspects of the machine + CT 1.0 (including CS)       Al concepts, especially the importance of data in modern life + CT 2.0       Al concepts + MK + CT 2.0         Level of robot autonomy       No autonomy No learning       Autonomy No learning       Autonomy Memory Learning       Autonomy Memory Learning       Autonomy Memory Learning (a more difficult one!) Exploration         Student's engagement       High Direct handling + CT 1.0       High Direct handling + CT 1.0       High Direct handling + regulation + CT 2.0       High Active observation during the time robot learns, reflection, and metacognition + CT 2.0	can we talk	NU bosouse the rebet	NO	res	tes
Products of data is not autonomous.       a programmed. It may be autonomous. but it is not off the beaten track.       industrial robot learns from the examples it memorized.       industrial robot learns from the examples it memorized.       industrial robot learns from the examples it memorized.       strategy to achieve the set goal. This also involves "machine learning".         Links with everyday objects used by students       Remote-controlled car.       Coffee machine, automatic car wash, domestic machines.       Industrial robots using computer vision.       A robot like Dreamer <sup>2</sup> that adapts the way it walks according to the state of the ground.         Knowledge at stakes       Technical aspects of the machine + CT 1.0 (including CS)       Technical aspects of the machine + CT 1.0 (including CS)       Al concepts, especially the importance of data in modern life + CT 2.0       Al concepts + MK + CT 2.0         Level of robot autonomy       No autonomy       Autonomy       Autonomy       Autonomy       Autonomy         student's engagement       High       High       Direct handling + CT 1.0       Direct handling + CT 1.0       High       High		because the tobot	because the tobol executes	involves "mashing lograping": here, the	fumbles around in order to implement a
It is not autonomous.       process matubins       process matubins       mode names from the oxamples it is not not oxamples it is not off the beaten track.       industrial robots using computer vision.       A robot like Dreamer <sup>2</sup> that adapts the way it walks according to the state of the ground.         Links with everyday objects used by students       Remote-controlled car.       Coffee machine, automatic car wash, domestic machines.       Industrial robots using computer vision.       A robot like Dreamer <sup>2</sup> that adapts the way it walks according to the state of the ground.         Knowledge at stakes       Technical aspects of the machine       Technical aspects of the machine + CT 1.0 (including CS)       Als such as ChatGPT and other chatbots and audio assistants that have been trained using both supervised and reinforcement learning.       Al concepts, especially the importance of data in modern life + CT 2.0       Al concepts + MK + CT 2.0         Level of robot autonomy       No autonomy       Autonomy       Autonomy       Autonomy       Autonomy         No learning       Memory       Learning       Exploration       Autonomy       Autonomy       Exploration         Student's engagement       High       Direct handling + CT 1.0       High       Direct handling + CT 1.0       Direct handling + regulation + CT 2.0       Active observation during the time robot learning + CT 2.0	•	when asked to do so	a program according to the	robot learns from the examples it	strategy to achieve the set goal. This also
Instruction of the destruction of the state of the beaten track.       Instruction of the beaten track.       Instruction of the beaten track.         Links with everyday objects used by students       Remote-controlled car.       Coffee machine, automatic car wash, domestic machines.       Industrial robots using computer vision.       A robot like Dreamer <sup>2</sup> that adapts the way it walks according to the state of the ground.         knowledge at stakes       Technical aspects of the machine       Technical aspects of the machine + CT 1.0 (including CS)       Al such as ChatGPT and other chatbots and audio assistants that have been trained using both supervised and reinforcement learning.         Level of robot autonomy       No autonomy       Autonomy       Autonomy       Autonomy       Autonomy         Student's engagement       High       High       High       High       High       High       High         Direct handling       Creatending + CT 1.0       Direct handling + CT 1.0       High       High       High       High         Direct handling       High       Direct handling + CT 1.0       High       High       High       High		It is not autonomous	programmed. It may be	memorized	involves "machine learning"
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everyday objects used by students       car.       wash, domestic machines.       Self-driving cars.       it walks according to the state of the ground.         Als such as ChatGPT and other chatbots and audio assistants that have been trained using both supervised and reinforcement learning.       Als such as ChatGPT and other chatbots and audio assistants that have been trained using both supervised and reinforcement learning.         Knowledge at stakes       Technical aspects of the machine       Technical aspects of the machine + CT 1.0 (including CS)       Al concepts, especially the importance of data in modern life + CT 2.0       Al concepts + MK + CT 2.0         Level of robot autonomy       No autonomy       Autonomy No learning       Autonomy Memory Learning       Autonomy Memory Learning (a more difficult one!) Exploration         Student's engagement       High Direct handling       High Direct handling + CT 1.0       High Direct handling + regulation + CT 2.0       High Active observation during the time robot learns, reflection, and metacognition + CT 2.0	Links with	Remote-controlled	Coffee machine, automatic car	Industrial robots using computer vision.	A robot like Dreamer <sup>2</sup> that adapts the way
objects used by students         Ferrit Properties         ground.           Knowledge at stakes         Technical aspects of the machine         Technical aspects of the machine + CT 1.0 (including CS)         Al souch as ChatGPT and other chatbots and audio assistants that have been trained using both supervised and reinforcement learning.         Al concepts, especially the importance of data in modern life + CT 2.0         Al concepts + MK + CT 2.0           Level of robot autonomy         No autonomy         Autonomy No learning         Autonomy Memory Learning         Autonomy Memory Learning (a more difficult one!) Exploration           Student's engagement         High Direct handling         High Direct handling + CT 1.0         High Direct handling + CT 1.0         High Direct handling + regulation + CT 2.0         High Active observation during the time robot learning, reflection, and metacognition + CT 2.0	everyday	car.	wash, domestic machines.	Self-driving cars.	it walks according to the state of the
students         Image: Figure Fi	objects used by				ground.
Knowledge at stakes       Technical aspects of the machine       Technical aspects of the machine + CT 1.0 (including CS)       Al concepts, especially the importance of data in modern life + CT 2.0       Al concepts + MK + CT 2.0         Level of robot autonomy       No autonomy       Autonomy       Autonomy       Autonomy         Image: None of the engagement       High Direct handling       High Direct handling + CT 1.0	students				
Knowledge at stakes     Technical aspects of the machine     Technical aspects of machine + CT 1.0 (including CS)     Al concepts, especially the importance of data in modern life + CT 2.0     Al concepts + MK + CT 2.0       Level of robot autonomy     No autonomy     Autonomy     Autonomy     Autonomy       No autonomy     Autonomy     Autonomy     Autonomy       No learning     Memory Learning     Learning (a more difficult one!) Exploration       Student's engagement     High Direct handling + CT 1.0     High Direct handling + CT 1.0					
Image: marking autonomy         Technical aspects of the machine         Technical aspects of the machine + CT 1.0 (including CS)         Al concepts, especially the importance of data in modern life + CT 2.0         Al concepts + MK + CT 2.0           Level of robot autonomy         No autonomy         Autonomy         Autonomy         Autonomy         Autonomy         Autonomy         Autonomy         Earning         Memory         Learning (a more difficult one!)         Exploration           Student's engagement         High         High         Direct handling + CT 1.0         High         High         High         Active observation during the time robot learning the time robot				Als such as ChatGPT and other chatbots and audio assistants that have been	
Knowledge at stakes         Technical aspects of the machine         Technical aspects of the machine         Technical aspects of machine + CT 1.0 (including CS)         Al concepts, especially the importance of data in modern life + CT 2.0         Al concepts + MK + CT 2.0           Level of robot autonomy         No autonomy         Autonomy         Autonomy         Autonomy           No learning         Memory Learning         Memory Learning         Memory Learning (a more difficult one!) Exploration           Student's engagement         High Direct handling         High Direct handling + CT 1.0         High Direct handling + CT 1.0         High Direct handling + regulation + CT 2.0         High Active observation during the time robot learns, reflection, and metacognition + CT 2.0				trained using both supervised and reinforcement learning.	
stakes     the machine     machine + CT 1.0 (including CS)     of data in modern life + CT 2.0       Level of robot autonomy     No autonomy     Autonomy     Autonomy       No learning     Autonomy     Memory Learning     Memory Learning (a more difficult one!) Exploration       Student's engagement     High Direct handling     High Direct handling + CT 1.0     High Direct handling + CT 1.0     High Direct handling + regulation + CT 2.0	Knowledge at	Technical aspects of	Technical aspects of the	Al concepts, especially the importance	AI concepts + MK + CT 2.0
Level of robot autonomy         No autonomy         Autonomy         Autonomy         Autonomy         Memory         Memory         Memory         Learning         Memory         Learning         Exploration         Memory         Learning (a more difficult one!)         Exploration           Student's engagement         High Direct handling         High Direct handling + CT 1.0         High Direct handling + regulation + CT 2.0         High Active observation during the time robot learns, reflection, and metacognition + CT 2.0	stakes	the machine	machine + CT 1.0 (including	of data in modern life + CT 2.0	
Level of robot autonomy     No autonomy     Autonomy     Autonomy     Autonomy       autonomy     No learning     Memory     Memory       Learning     Learning     Memory       Employer     Learning     Exploration       Student's engagement     High Direct handling     High Direct handling + CT 1.0     High Direct handling + regulation + CT 2.0     High Active observation during the time robot learns, reflection, and metacognition + CT 2.0			CS)		
autonomy     No learning     Memory Learning     Memory Learning     Memory Learning       Student's engagement     High Direct handling     High Direct handling + CT 1.0     High Direct handling + regulation + CT 2.0     High Active observation during the time robot learns, reflection, and metacognition + CT 2.0	Level of robot	No autonomy	Autonomy	Autonomy	Autonomy
Student's engagement     High Direct handling     High Direct handling + CT 1.0     High Direct handling + regulation + CT 2.0     High Learning (a more difficult one!) Exploration       Student's engagement     High Direct handling + CT 1.0     High Direct handling + regulation + CT 2.0     High Active observation during the time robot learns, reflection, and metacognition + CT 2.0	autonomy		No learning	Memory	Memory
Student's engagement         High         High         High         High         Direct handling + CT 1.0         High         Active observation during the time robot         learns, reflection, and metacognition + CT         2.0				Learning	Learning (a more difficult one!)
Student's engagement         High         High         High         High         High           Direct handling         Direct handling + CT 1.0         Direct handling + regulation + CT 2.0         High         Active observation during the time robot learns, reflection, and metacognition + CT 2.0					Exploration
engagement Direct nanoling + CT1.0 Direct handling + regulation + CT2.0 Active observation during the time robot learns, reflection, and metacognition + CT 2.0 2.0	Student's	High	High	High	High
learns, reflection, and metacognition + CI	engagement	Direct nandling	Direct nandling + C1 1.0	Direct nandling + regulation + C1 2.0	Active observation during the time robot
					earns, reflection, and metacognition + CT

Table 1: Comparison of the 4 robotics scenarios (with and without AI).

<sup>1</sup> An intermediate level of difficulty consists in programming only sequences of actions, without using any sensor.
<sup>2</sup> See at <https://danijar.com/project/daydreamer/>.