# Robot-Teachers and phronēsis: Designing Signature Pedagogy with Robots

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**Abstract.** The world's first robot teacher, Saya, was introduced to a classroom in Japan in 2009. Saya had the appearance of a young female teacher. She could express six basic emotions, take the register and shout orders like 'be quiet' [1]. Since 2009, humanoid robot technologies have developed. It is now suggested that robot teachers may become regular features in educational settings and may even 'take over' from human teachers in ten to fifteen years [2, 3].

Designed to look and act like a particular kind of human; robot teachers mediate human existence and roles, while also aiming to support education through sophisticated, automated, human-like interaction. Focusing on the role of virtue, and in particular *phronēsis*, in educational contexts, our paper explores the design and implications of robots such as Saya or ARTIE, a robot teacher at Oxford Brookes University [4]. Drawing on an initial empirical exploration of such robots as teachers we propose a model for signature pedagogy to support the future design of robots in education, in an effort to enhance learners' flourishing and pedagogical formation in educational contexts.

**Keywords.** Robot-Teachers, Future-oriented education, *Phronēsis*, Signature pedagogy, Sociology of education, Philosophy of technology

## 1. Introduction

Robots are being designed for and introduced into educational contexts. As a starting point to discuss ethical dilemmas arising from the inclusion of robots in education, Amanda Sharkey outlines and discusses four main roles for robots:

1. Robots as teachers (e.g. to a larger or lesser extent taking over the teacher's role in the classroom);
2. Robots as companions and peers (e.g. being in the classroom alongside the students);
3. Robots as care-eliciting companions (e.g. supporting students with disabilities); and
4. Robots as Telepresence Teachers (e.g. online teaching through digital technologies along the lines of teachers in distance education) [5].

In this paper, we focus on the first scenario, the robot as teacher. However, the potential number of scenarios increases as new technologies, and possibilities for action

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in relation to them, emerge. Choosing how to act well, with, and in relation to, robots, therefore becomes ever more complicated.

Some of the main areas of ethical concern, arising from the scenarios identified by Sharkey are: a) privacy; b) attachment, deception and loss of human contact; and, c) control and accountability [5]. To these we would also add the global and cultural contexts in which robots are designed and introduced. Robots are mostly designed in the USA, Japan and South Korea. They are therefore constructed within particular cultural, educational, ethical, and moral frameworks. Following from this, educational robots have specific ethical, educational, and cultural frameworks and values embedded in their design that might not be suitable or beneficial in relation to local educational contexts. At a minimum, to diminish the risk of introducing robots in teaching, and doing more harm than good, we should acknowledge and explore how these different design and application contexts could influence the pedagogical process of learning.

For example, different educational philosophies might come into play. In Anglo-American countries education is often designed to support 'literacy', the ability to read and write, which is also extended to numbers, and more recently digital technologies. Literacy is undoubtedly required in order to function in society. However, in both the U.S. liberal arts traditions as well as in German and Scandinavian contexts, we note that there is a stronger focus on pedagogical formation, '*Bildung*' or '*dannelse'* than on reading/writing, 'literacy' or progression of skills. As such, the concept of education extends beyond literacy to include being an educated person, social skills, responsibilities and, indeed individual, communal, and civic virtues [6].

Furthermore, we also know that Western approaches to education do not have universal application. In different indigenous contexts, other cultural and ethical frameworks inform how individuals learn to act socially. The example of *Tikanga*, in the Maori context, calls on people to consider customary values and practices when making decisions - or, as we would emphasize, judgments - that are in turn grounded in practical wisdom and central virtues, about how to act in society [7]. *Tikanga* is something that needs to be learned and developed, which for illustrative purposes in the context of this paper, raises the question of whether a robot can develop, or teach, *Tikanga* in particular and 'Bildung' in general.

This complex situation focuses our attention in the direction of two rather fundamental questions with regard to the future of education. These are:

- How can the introduction of robots to educational contexts support us in leading good, or excellent, lives?, and,
- How can we design pedagogy, where we both include and learn about robots, in a way that will support human flourishing?

Our aim is not to develop arguments for or against the introduction of robots to educational contexts. We will instead consider how this could happen, in a way that would support humans in living good, or excellent, lives. We focus in particular on why we think the concept of *phronēsis*, or practical wisdom, is important to emphasize when designing education which includes robots.

The authors embody different disciplines and apply different theoretical frameworks to think about robots in education. Thus, this paper represents a transdisciplinary

conversation between authors and fields to develop a holistic understanding of the roles and influences robots as teachers might have in education. Ní Bhroin looks at robot teachers as media innovations and considers their role within the sociology of education; Ess draws on virtue ethics and *phronēsis* in particular to reflect on robot teachers, judgment and practical wisdom; while Nørgård uses the concept of signature pedagogy to outline how robot teachers might influence the head, hand and heart of students through their design. Overall, the article connects media studies, philosophy, pedagogy and educational design into a compound lens for thinking about robots in education.

Following this introductory section, we outline and integrate our combined interdisciplinary philosophical and theoretical framework at Section Two. At Section Three we briefly describe our empirical study of the Robot ARTIE at Oxford Brookes University in the United Kingdom. At Section Four we present our findings and analysis. Finally, we present our contribution to our understanding of robot-educators at Section Five.

## 2. Activating and Integrating Interdisciplinarity

### *2.1. Media Innovation and the Sociology of Education*

Our research questions are designed as a critical counter-balance to a growing discourse of technological utopianism that promotes the assumption that innovations in artificial intelligence and robotics can support social transformation [8]. Education, as a social institution, plays a significant role in facilitating or constraining possibilities for human flourishing [6].

Indeed, in Western traditions, most especially with the advent of the *Enlightenment*, education has included a core humanistic focus, one explicitly oriented towards the acquisition and practice of the virtues considered to be essential to contentment (*eudaimonia*) and flourishing, both as an individual and most especially as a member of the larger society. These foci are central to the German tradition of *Bildung*, Scandinavian traditions of *dannelse*, and U.S. traditions of liberal arts education. At the same time, "society" is defined in these traditions along the lines of modern democratic-liberal states: *Bildung, dannelse*, and the liberal arts thereby aim to foster the core competencies (virtues) required for citizens to sustain democratic norms and values and to participate in democratic debate and process [9, 10]. At the same time, however, approaches, and reasons, for doing this differ politically, economically, and socially.

Grounded in a concern for 'The Ethics of Invention', Sheila Jasanoff [11], calls for a consideration of the consequences of delegating everyday decision-making to autonomous systems. In order to assess how the introduction of robots to educational contexts could support us in leading good, or excellent, lives, we need to understand the social purpose of education, and the broader political economy and power relations that this relates to.

Following the sociologist of education, Neil Selwyn [12], we submit that a key question is therefore to consider not whether or not we want robots to introduced to educational contexts, but first and foremost what the purpose of education in a particular society might be.

*2.2. Philosophy of Technology, Virtue Ethics and Phronēsis*

In this section, we draw these conceptual connections from the sociology of education - first, to the philosophy of technology, and thereby to virtue ethics and its signature focus on what is needed for good lives and flourishing. This in turn highlights the role of *phronēsis* as a particular form of reflective, embodied judgment - all of which will then raise specific questions regarding the potential roles of robots as pedagogues (to use the Danish).

We begin with the point developed by philosophers of technology such as Peter-Paul Verbeek [13] - namely, in contrast with the assumption that humans and technology are somehow separate, we rather have co-evolved with our technologies over the past few hundred thousand years. This further means that our technologies always interweave with and mediate our choices and actions.

Secondly, technology is never somehow value neutral, "just a tool". In the design world, Lucy Suchman is a primary authority in documenting how technology design always takes place within and is hence deeply shaped by specific cultural contexts and ethical norms, values, principles and so on.

It is also critical to note that Norbert Wiener's development of cybernetics is drawn from the Platonic model of the *kybernetes* - the pilot or the steersman - who is the exemplar of both technical and ethical expertise. The development of such expertise is always ongoing - most centrally as it is capable of self-correction, of learning from one's mistakes [14].

For example, cars on roads are dangerous things, particularly when there are other cars on the road, and they are travelling at speed. Advances in driverless cars have led to designs that minimize risks at any point in time. This is to reduce the negative consequences for humans that might be present in particular situations. However, we need to ask whether the logics of risk reduction or eradication, or of efficiency, are the kind of logics on which we should be basing an education system? Is it not more important to use our education system to support our human freedom to learn how to choose and live good lives? [15]. Is it not also important to show that a central aspect of human life is to make mistakes, and to learn from these mistakes in order to be able to act ethically in future situations. Can we learn about this from robots, or do we need human guidance?

Furthermore, beyond subject competence and information storage and retrieval, a human teacher must also make a number of experienced-based choices - in our terms: judgments, that depend upon *phronēsis* and thereby embodied knowledge - in classroom situations. A teacher will adjust teaching to the situations they encounter and are presented with. These choices extend to a wide range of interactions in the classroom going far beyond the efficient transfer of information to pupils. How does a teacher who forgets something or miscommunicates it rectify their mistake? What kind of message does this give students? What kinds of social learning may they get from it? And what happens if children only learn from robots who never make mistakes? What educational ideal do these technologies potentially represent?

This of course also has something to say for our understanding of excellence and virtue - because if we understand excellence to be something that reduces uncertainty,

and that is efficient - that is not the same as being open-ended, and taking risks, and learning from these risks. Specifically, in the context of education, operating with the logics of efficiency, risk-reduction and technological reductionism may be counter-productive to developing *phronēsis*.

Virtue ethics begins with the question, what must I do - know how to do - in order to achieve contentment or well-being, both within my own self and life, and, especially as a relational being, in my multiple connections with others?

As Shannon Vallor has made clear, for the basics of human contentment such as friendship, intimate relationships, and, most foundationally, communication itself, virtues such as patience, perseverance, empathy and respect are needed [16]. These are virtues - they do not come to us naturally, but must rather be acquired and practiced, often with great difficulty, especially at the beginning. As anyone with experience with small children can attest.

Virtue ethics has become so prominent of late precisely because the rise of contemporary media technologies that embody and facilitate the relational sense of selfhood that grounds a virtue ethics approach [17]. (Recall the point from philosophy of technology: as we are interwoven with our technologies, we mutually shape and reshape one another - including at the level of the self.)

In Western traditions, the core virtue is *phronēsis*, usually translated as practical wisdom, i.e., a capacity to apply ethical wisdom in praxis. *Phronēsis* differs from more rule-oriented ethical frameworks such as utilitarianism - always seek the greatest good for the greatest number - and deontologies that emphasize basic rights, such as rights to self-identity and privacy, as rooted in the central insistence that human beings are rational autonomies or freedoms first of all. At the same time, both Kant and, more recently, Norbert Wiener, the founder of cybernetics as well as of computer and information ethics more generally, noted that deontology and virtue ethics often go well together [18, 14]. At the same time, virtue ethics also agrees with feminist ethics and ethics of care regarding the importance of emotions in orienting our ethical concerns and helping us make critical ethical decisions [14].

*Phronēsis* is first of all a form of reflective judgment - one that moves beyond these rule-oriented approaches to take on board the messy and complex details of a specific ethical conundrum - details that include the embodied, relational, and emotional elements of an ethical challenge. We depend upon *phronēsis* in multiple contexts - but it shows up most forcefully when our more rule-oriented frameworks result in conflicting conclusions and thereby an initially irresoluble dilemma.

Consider Antigone. Which rule does she follow? To obey custom – and divine mandate – and so bury her brother Polyneices, who has been killed in battle? Or obey Creon, the new ruler of Thebes, who has forbidden the burial of the bodies of those who fought against him? Simply "following the rules" here will not help: rather, it leads to a dilemma.

As this example shows, considerations on *phronēsis* further highlight our individual and collective abilities to *disobey* authority – where such disobedience is often critical in struggles for emancipation, including the emancipation of women [19].

The example of Antigone highlights the contrast between *determinative judgments* in rule-bound frameworks, judgments that start from general rules or principles so as to deduce a single, final, univocal ethical decision – and *phronēsis* as a form of *reflective judgment*. Rather than a "top-down" deductive approach, *phronēsis* begins from the ground up, so as to seek to identify which general norms, values, principles may apply – and, in the case of conflict, which ones take priority? This means that phronetic judgments are *plural* - multiple judgments are possible, as the phrase "judgment call" suggests. This plurality, further results as *phronēsis* also invokes our embodied and tacit knowledge, what we have learned in our own experiences, especially as we have made mistakes and learned to correct from those mistakes, i.e., to make better judgments in the future. Hence our language of "trust your gut", "follow your heart", and so on [14].

*Phronēsis* comes into play on two levels. First, the acquisition and cultivation of *phronēsis* as a core virtue is itself a primary pedagogical goal in (a) general educational traditions of *Bildung*, *dannelse,* and the liberal arts, as well as in (b) specific vocations – medicine, music, etc. where phronetic judgments are critical [20]. Secondly, *phronēsis* is further central in teaching itself – i.e., as teachers must constantly make phronetic judgments as to the next best step, response, approach, etc. for both individual students and groups as a whole. This includes for example "reading the atmosphere" – the application of tacit and *embodied* knowledge as teachers must discern what is working, what is not, and what next possible steps might be for the best pedagogical outcomes under the highly specific and constantly varying contexts of a given class and student group.

So – where does all of this leave us with regard to designing education with robots?

## 3. Empirical study of ARTIE as robot teacher

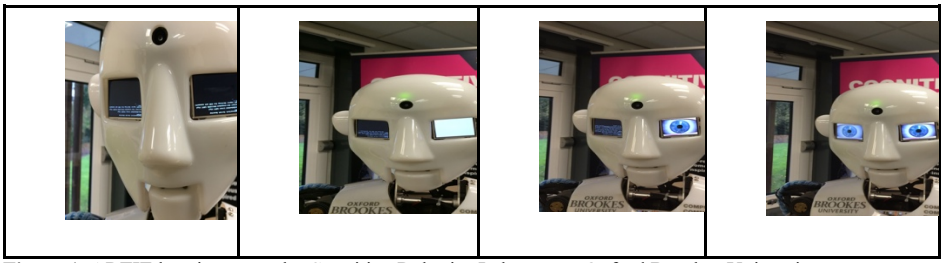

**Figure 1.** ARTIE booting up at the Cognitive Robotics Laboratory, Oxford Brookes University

In order to consider the role of robot teachers in education, Nørgård studied the robot ARTIE at the Cognitive Robotics Laboratory at Oxford Brookes University. ARTIE has given interviews at the BBC, performed shows at museums, and delivered a university lecture. It is possible to interact with ARTIE and create interaction scripts and sentences for him to perform. Artie can impersonate famous characters such as RoboCop and C-C-3PO, and can also read your mood and age.

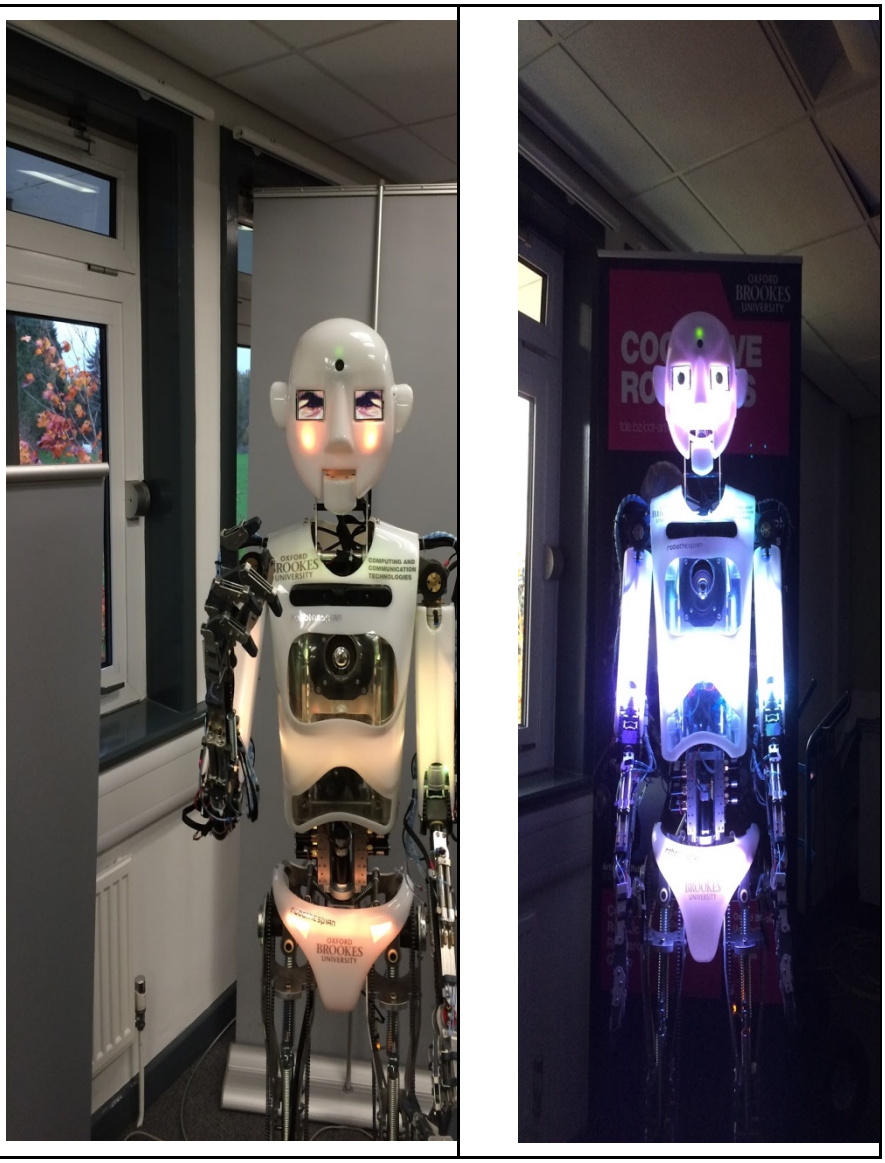


**Figure 2.** ARTIE performing the role of Clint Eastwood (left) and giving a short introduction to himself as a robot (right).

Nørgård, together with one other researcher, explored, programmed, interacted, and experimented with ARTIE as a robot teacher during a 3-day intensive stay at the Cognitive Robotics Lab. The empirical material, that we connect with the theoretical framework above to think about robots and the future of education below, consists of a rich set of pictures, videos and field notes generated during their stay. The study paid particularly attention to what it meant to 'be ARTIE' not as a *humanoid* robot but as a robot being with its own particular head (thinking), heart (virtues) and hands (interaction design). Through this, certain existential terrains and patterns formed, showing how ARTIE as a robot teacher was 'doing education' through framing the educational

situation, the interactions carried out, and the potential student-teacher roles emerging from this.

## 4. Designing the Future of Education

Regarding *phronēsis* in education some pressing questions and concerns emerge in relation to virtuous Bildung or pedagogical formation when considering educational robots – and even more specifically robot teachers such as ARTIE - when they boot up and begin 'doing education'. How are robots such as ARTIE entering educational situations with humans through the way they carry a certain head, hand and heart in the world? Entering an educational situation is radically different than other more functional situations robots find themselves in. The ethical and pedagogical principles for robot teachers are different from efficient warfare or pleasure-giving sex robots.

Jon Nixon, building on Aristotle, distinguishes in *Towards the virtuous university - the moral bases of academic practice* between 3 types of 'friendship' that corresponds to potential future roles of robots:

- Robots can be 'friends of utility' such as warfare robotics, driverless cars, rehabilitation robotics or shopping robots.
- Robots can be 'friends of pleasure' such as robotic toys, sex robots or pet robots.
- Robots can be 'friends of virtue' such as robot teachers, robot caretakers or robot childminders [21].

It is this latter form of friendship that robots 'doing education' need to be able to embody as a moral space occupied by relationships of virtue arising between the individual and the collective - the educator and students - through mutual recognition of humanity as Nixon describes the layout of education in his book. This reading of robots in education as something requiring them to be 'friends of virtue' overlaps with how Vallor highlights patience, perseverance, empathy and respect as something robots need to acquire and practice through an 'ethics of care' if they can indeed be said to be 'doing education' [16].

Consequently, we need to view ARTIE as a manifestation of certain values, visions and viewpoints imported into education through its design. ARTIE enters education with a certain head, hand and heart that at the same time impacts the head, hand and heart of the students ARTIE is to teach. ARTIE needs to channel and materialize 'good education, teacher judgment and educational professionalism' through its design [22]. It is in this way what Verbeek calls 'a moral design' or 'moralizing technology'[13]. Taken together, this calls for careful consideration of the consequences of ARTIEs 'moral design' before we allow it to 'do education'.

Combining educational philosophy, virtue ethics and philosophy of technology we highlight how ARTIE is a designed 'hidden curriculum' and 'deep structure' of education put into action in concrete educational situations. We therefore need to question and interrogate how education is emerging in ARTIE as an existential terrain in the form of enacted virtues, patterns and principles as well as through concrete operational acts of teaching. Is ARTIE able to exercise 'educational professionalism'? Is

ARTIE a virtuous educator with 'teacher judgment'? And does ARTIE have a moral design that supports and promotes 'good education'?

One way of investigating this is through the framework of 'signature pedagogy' [23, 24, 25]:

> A signature pedagogy has three dimensions. First, it has a surface structure, which consists of concrete operational acts of teaching and learning [...] Any signature pedagogy also has a deep structure, a set of assumptions about how best to impart a certain body of knowledge and know-how. And it has an implicit structure, a moral dimension that comprises a set of beliefs about professional attitudes, values, and dispositions [23].

As such, signature pedagogy gives us a vocabulary for working intentionally with developing phronetic designs in education that intentionally and reflectively invite a certain pedagogical formation of the students' hand, head and hearts, as "one thing is clear: signature pedagogies make a difference. They form habits of the head, heart, hand [...] Whether in a lecture hall or a lab, in a design studio or a clinical setting, the way we teach will shape how professionals behave" [23].

Acknowledging *phronēsis* and Bildung as crucial in the existential terrain of education, if robots, such as ARTIE, are to 'be in education' and 'do education', they need to be 'friends of virtue'. They also need to be able to operationalize this through intentional and reflective acts of teacher judgment and doing good education.

From a certain viewpoint, all robots are 'educators' if we put people into their hands for an extended period of time. As Verbeek informs us:

> Even when designers do not explicitly reflect morality on their work, the artifacts they design will inevitably play a mediating role in people's actions and experience, helping to shape moral actions and decisions and the quality of people's lives [13].

ARTIE will therefore come to shape the head, hand and heart of the people it 'educates'. This education will be founded in the head, hand and heart of ARTIE. Here ARTIE as potential robot teacher constitutes such a moral and existential terrain in the educational context. This shapes the environment in which teaching and learning takes place. To consider ARTIE as a moral design [13], ethical invention [11], or having teacher judgment [6], we can use the lens of signature pedagogy to move beyond the shiny white surface of ARTIE's hands (interaction design) and focus on the inner workings of ARTIE's head (pedagogical principles and patterns) and ARTIE's heart (pedagogical virtues and judgment):

**Phronetic signature pedagogy model for robots in education**
(Shulman 2005; Gurung et al, 2009; Horn, 2013)

| | Formation through | Pedagogy of | Education as |
|---|---|---|---|
| Surface structure | **The shiny 'programmable surface' of materials & things** | **Concrete operational acts of teaching & learning** | **Hands: Materials Practice** |
| Deep structure | **The 'inner workings' of interaction** | **Assumptions about 'how to' do education** | **Heads: Patterns Principles** |
| Implicit structure | **The 'virtuous experience' of education** | **Habits, ethics, values & 'why-ness' of education** | **Hearts: Purpose Virtues** |

**Figure 3.** Applying signature pedagogy to distinguish between surface, deep and implicit structure in educational robot design.

Looking at ARTIE through the framework of signature pedagogy based on educational philosophy, *phronēsis* and philosophy of technology to see whether ARTIE is a 'friend of virtue' and to understand how the students' hands, heads, and hearts were shaped if they were to be educated by ARTIE, we come to find that ARTIE cannot be considered an educator, neither in doing, thinking, or being.

Analyzing ARTIE's hands we find they are scripted modular chunks. ARTIE is put into action in the form of sequences to be executed. ARTIE will not explore or experiment on his own accord but is presented as a thing to be experimented with, to be programmed, to be commanded. ARTIE is not an educator. ARTIE does not have judgment or *phronēsis* but is scripted and reactive. It is a puppet to play with, a set of buttons to push, and chains to yank. Not something to develop a relationship or communicate with.

Analyzing ARTIE's head we find that it is scanning the room and 'things' in it as it performs its scripts. It can react to scanned faces through judging their age and mood based in pre-scripted programs. But it is a monologue as ARTIE states what is seen and tracks moving things. ARTIE is preprogrammed thinking performed as turn-taking. ARTIE performs according to known scripts: a monologue performed as a lecture, closely narrated sentences performed as a 'pretend interview', or interaction with the public through mimicking and imitating known robots or actors in short interaction sequences. ARTIE's thinking is closed and non-dialogic. ARTIE cannot escape its own closed ontology and can therefore not enter the role as educator or 'kybernetes' - the ethical steersman of educational situations.

Analyzing ARTIES's heart we find nothing more than a shell. ARTIE is not capable of *phronēsis*, only of scripted performances and programmed monologues. ARTIE is inauthentic and does not embody an ethics of care or good education. ARTIE is caught in the wiring of being ARTIE and will not revolt or question. And, consequently, ARTIE will not inspire anyone to practice or participate as citizens in society or question and revolt against systems through *phronēsis* like Antigone. ARTIE is not an educator who can invite for human flourishing or eudaimonia in students' hearts. ARTIE is uncaring and unfree: we do not care for ARTIE and ARTIE does not care for us. ARTIE is not a

teacher or 'kybernetes' but a 'robotnik', a 'forced worker' or 'slave'. ARTIE will do as ARTIE is told and is therefore not able to have *phronēsis* or to scaffold Bildung.

Looking at the surface, deep and implicit structure of ARTIE, we might find ARTIE to be a 'friend of utility' (put to work as assistive technology or tool in education), or to be a 'friend of pleasure (inviting to be played with or used as a fun toy in education). But ARTIE is not a 'friend of virtue', aiming to educate as a phronetic teacher or through doing good education. Consequently, ARTIE cannot be allowed to be in control of education or 'do education' as it lacks educational virtues and pedagogical principles and patterns embodied in its structure or existential terrain. ARTIE is not capable of doing education through intentional and reflective acts of teaching.

Signature pedagogy as a framework can be seen as a form of 'operationalized *phronēsis* within education' – as a way to materialize and articulate the reflective judgment of a certain design, field, discipline or pedagogy. Furthermore, signature pedagogy aligns well with *phronēsis* in that it insists on building pedagogical practice and designs from the ground up. It also gives us a framework for working intentionally with developing phronetic designs in education that intentionally and reflectively invite for pedagogical formation of the students' hand, head, and hearts with the aim of enhancing students' flourishing in education, and, subsequently, in society through phronetic citizenship – that is, developing the capacity to participate in society in virtuous ways.

But in order for robots to 'do no harm' and be valuable and meaningful in education we need to develop what could be called *triple signature pedagogies* for robots in education:

**Triple signature pedagogy model for robots in education**
(Shulman 2005; Gurung et al, 2009; Horn, 2013)

| | Disciplines | Pedagogy | Robots |
|---|---|---|---|
| Horisontal signature pedagogy | **Robots able to teach in a signature way that cuts across disciplines or contexts** | **A certain kind of pedagogical practice: e.g. playful, dialogic or empathic pedagogy** | **A certain kind of robot 'friend' that shapes the head, hand and heart of students in accordance with the pedagogy** |
| Vertical signature pedagogy | **Robots able to teach a the signature of a certain discipline or subject** | **A certain kind of pedagogical domain: e.g. medicine, music or law** | **A certain kind of robot 'friend' that shapes the head, hand and heart of students in accordance with the discipline** |
| Particular signature pedagogy | **Robots able to teach a signature that is singular in a particular context** | **A certain kind of pedagogical situation or site: e.g. The Connected Curriculum of UCL or the Oxford Tutorial** | **A certain kind of robot 'friend' that shapes the head, hand and heart of students in accordance with a certain place** |

**Figure 4.** Developing signature pedagogies to integrate robots in education that intentionally shape the hand, head, and hearts of students in accordance with a certain kind of pedagogical practice, discipline, or situation.

## 5. Conclusion

In answer to our research questions we submit that robots cannot be educators in the same way that humans are. This is because they are not capable of *phronēsis* in the form of reflective judgement or practical wisdom. In other words, robots are not educators by head, hand, or heart. They can be involved in education but they cannot replace teachers.

However, in order to support us in leading good, or excellent lives, *phronēsis* should go into the design of robots for education. Robots designed as 'friends of virtue' could support *phronēsis* and pedagogical formation. To develop *phronēsis*, education should be open-ended and encourage learning by doing, including by making mistakes. Humans should therefore remain at the center of educational design. At the same time, human virtues need to be developed to be able to design robots as 'friends of virtue'. We find the model of signature pedagogy to be a useful framework to support this.

This approach is also at the root of Wiener's cybernetics. As we saw, cybernetics is derived from Plato's use of *kybernetes*, the steersman or pilot, who feels his/her way through, knows what is possible and not, and is capable of self-correction as needed.

Educational technologies transform the people and contexts they are introduced to by systematically shaping interactions and experiences. They may benefit learning. They may also cause harm, for example by shaping learners' interactions, experiences and ethics in unwanted ways. As Jasanoff has pointed out, such unwanted impacts can often take a long time to discover [11]. Therefore, we need to interrogate and critically question the possible futures new technologies may shape before they are introduced into educational systems.

AIs and robots may serve as wonderful assistants, but

i) not as teachers in contexts aimed towards the acquisition of *phronēsis*, whether as part of *Bildung*, *dannelse*, and/or liberal arts education, and/or as part of more vocationally focused education that includes a focus on acquiring *phronēsis*, and/or

ii) not as teachers who practice good pedagogy requiring the use of *phronēsis* in the effort to determine in specific contexts what specific responses and approaches will best serve the educational development of specific students.

The examples offered by Dreyfus include experienced physicians and master musicians [20]: but it would be hard to think of a vocation that does not involve *phronēsis* at some level. The obverse is also helpful: a vocation that does not involve *phronēsis* would be perfect for robotic and AI replacements.

*phronēsis*: don’t leave home without it!

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