Narrative Didactics for Computer Science - Exploring alternative narratives of computer science and their application for teaching

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ABSTRACT

Storytelling offers many possibilities for teaching, but is only considered a secondary tool in pedagogical practice or not made use of at all, like in the case of computer science. In this paper, a new didactic approach is proposed, in which stories and the fictional worlds that come with them, form the basis of teaching. Central to this approach are alternative narratives for a given subject. If the teaching is based upon such a narrative through storytelling, the learning context of the subject is changed, thereby enabling new teaching methods, tools and resources inherent to the narrative, while at the same time making it more approachable and/or more entertaining to learn.

CS Unplugged already made significant progress in this direction for computer science, however, alternative narratives are only by-products there and the practical application of the findings has been limited. Therefore, a new didactic field is proposed, called narrative didactics, which bases itself on the described narrative approach for teaching and puts the study of narratives at the center of its research without the limitation to non-technical adaptations.

While there are still ethical questions that need to be answered before practical application, the field of narrative didactics could give access to a broad range of new teaching resources and learning environments, and make XR-technologies more applicable for practical teaching by using them along with other learning resources of the same narrative.

1 INTRODUCTION

Humans are narrative beings. They understand the world through stories [2]. Through narratives, humans learned to be able to understand complex and abstract concepts through the telling of stories, anticipate danger and learn about problems that they didn't witness themselves. As seen in other areas of teaching, storytelling holds great potential for education. For example, programming is treated as art in the work with Scratch. It can be observed that children are more motivated and it enables new ways of teaching as well. However, the potentials of this idea have not been sufficiently explored, even with Scratch. In narrative didactics, teaching would be completely surrounded by the alternative narrative, for example, by telling children, that technical devices work through marbles, which roll around inside them with circular marble tracks as loops and branches as conditional statements. Then the teacher could go on to tell them that with marble tracks, they could be able to control those devices/build their own devices and based on this narrative, would teach them programming and computer science knowledge through building marble tracks (analogue, as a computer game or VR-experience). This would, like in Scratch, enable new ways of teaching that would not be possible in the learning context of "regular" programming, it would make it more approachable and potentially also more entertaining. The described narrative is called the marble-narrative, which has not been tested in practice and will be further explained in the latter half of the paper; however, already the work with Scratch shows the potential of alternative narrative as the basis for teaching.

Narrative didactics is about doing further research in this direction to discover new narratives for teaching. CS Unplugged [1] has already made significant progress in finding alternative narratives for computer science (References) however, these narratives are only side-products of this method and there has not yet been found an effective way of applying them in practice; also, it is limited to non-technical adaptions of these narratives. Narrative didactics instead puts the narrative at the center of teaching by building teaching on top of alternative narratives through storytelling thus enabling access to this broad range of new learning resources without limiting itself to non-technical adaptations. A side effect of this could be that XR-technologies could be more easily integrated in practical school lessons if they, too, build on the used narrative of the other learning resources (shared-narrative learning resources). Though there are also some ethic questions that need to be answered before applying it in practice, research in this area could discover new narratives, discuss and research their effectiveness and feasibility in teaching, and apply them for practical use.

In the following, the idea of the new field is described, it is compared to existing fields and then fully defined. After that, practical applications are discussed and the example of the marble-narrative is proposed.

2 IDEA

This paper builds upon the idea that storytelling and alternative narratives can be beneficial for teaching, which is described in the following section. It then goes on to ask, how they can be made use of for actual teaching and finally, it will become clear that a new field for research as well as a new general approach to teaching is needed to apply the full advancements of storytelling to education.

2.1 Why narratives could be beneficial for computer science education

The need for narrative didactics is founded on the simple observation that we do not live in the best universe to teach computer science. Computer science is in this regard fundamentally different from other, purely practical skills like carpentry or engineering,

because it has many theoretical aspects to it. But on the other hand, it has still fundamentally different properties than math, because it can be practically applied in the real world and produce results that have an immediate effect on the real world, while at the same time, the artefact itself cannot be experienced with the senses, which again makes it different from other crafts and also other sciences like engineering and moves it again closer to math. As Donald E. Knuth put it in his paper about programming as an art: it can be seen both as high art and science [3]. With the help of alternative narratives, it might be able to overcome this ambiguous role of computer science between the arts and science by transferring it to a world, in which this ambiguity does not exist. This could for example be a world, in which programming can be directly experienced just like a traditional crafts such as woodworking and could then also be taught that way. Now is programming not the same as computer science, but here the same could be applied: by making the knowledge able to be more actively experienced by explaining it in the context of a fictional world. Now programming cannot be equated with computer science; but the same the idea could also be applied here: by explaining its concepts in the context of a fictional world, in which they can be more actively experiential, they could possibly be better understood.

Another advantage is the reduction of complexity, which is generally a common pedagogical practice. The idea is not to introduce children to large constructs of knowledge all at once, but through different layers, starting with a simple, closed world of knowledge, to which then more and more layers of complexity are added. This can for example be seen in math education. In computer science, on the other hand, it seems that attempts are made to enter the digital world all at once. Narratives could enable to provide such a proto-digital-world, a logically consistent but incomplete analogy of the digital world, which children and teachers could realistically understand in its entirety and derive practical knowledge from it, and which is later expanded with more layers or replaced with a completely different and more realistic understanding of the digital.

2.2 Application of narratives for teaching

Basing teaching with means of immersive technologies in such a fictional universe, could enable new ways of teaching computer science, as seen in Figure 1.

The idea of this paper is to bring the learning context of computer science lessons closer to the world of computer science with stories/narratives. That is, to create a more favourable "starting point" for computer science teaching. Such a narrative could be, for example: "Programming is Music". In the most extreme case, all curriculum and instructional materials would then build on this, and teachers would further bolster the alternative narrative through stories. In this hypothetical example, one question would be whether the skills learned in the context of this narrative would also be applied in reality and, if this is the case, whether this transfer is effective. Both questions were already shown by CS Unplugged research (TODO: add reference). Therefore, alternative narratives could be used as a basis for teaching computer science on any scale.

Based on these argumentation, the question naturally arises, what better narratives for computer science could be and how these

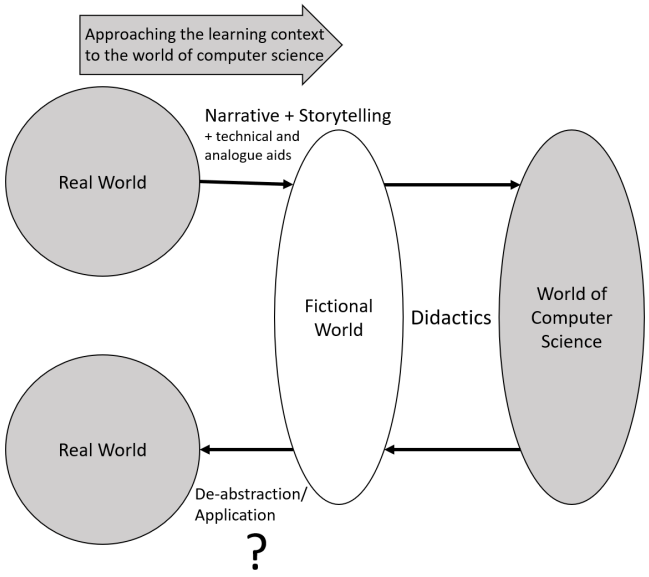

Figure 1: Idea of basing teaching on alternative narrative to provide a better basis for teaching computer science

could be practically made use of for education? Both of these questions will be explored in this paper, as well as some ethical questions regarding them, but before that, an alternative didactic approach is proposed, regarding the of status of narratives in teaching: from a secondary learning tool, to the foundation of learning. It will provide the basis for narrative didactics and make it possible to apply its findings in practice.

2.3 Argumentation for a new didactic approach

In the current tradition of teaching computer science, telling of stories is not practiced, and the agreed upon approach is, to deliver knowledge as directly as possible. To make use of storytelling as a basis for teaching, there would need to be allowed to deliver knowledge less directly and even deliver knowledge in a form, which differs from the one that should be taught according to the subject. For that to be possible, (at least in some cases) alternative versions of knowledge needs to be accepted as being equal to the real knowledge. Along with this, there needs to be a new didactic approach, which allows the telling of alternative versions of knowledge and by that stands less firmly in the tradition of the enlightenment than the didactics of the past decades. Didactic research topic like CS Unplugged are already doing this while not openly admitting to it and still trying to stay fully true to the ideals of the enlightenment, which, however, limits the practical application of their findings.

Storytelling has been used in education for a long time. Partly to discuss societal problems and partly to pass on knowledge to future generations. Only in recent time has society, for good reasons, distanced itself from passing on knowledge along with stories, because often storytelling in the past was accompanied by authoritative hierarchical structure and restrictive thinking. In the course of the last centuries, this approach was therefore, at least in subjects

related to science, replaced by more direct and transparent ways of education.

With the approach of narrative didactics, stories could again play a more active role in teaching. The overall question that has already been hinted in the last section, should therefore be, whether the risk that go along with this should be taken and with which benefits it comes for learners, for which more research needs to be carried out. However, it could be, that in complex subjects, the means are simply necessary to teach it effectively, and since it already is subject of research anyway, it would be better to admit to it, and then control and shape its development, instead of ignoring it. Therefore, in complex cases like that of computer science, it may be possible that the risk should be taken.

However, anti-enlightenment potentials that go along with this need to be taken seriously. They need to be acknowledged, their dangers assessed and for a particular subject, the benefits of applying this approach must always be weighed against the risks. In the sense of narrative didactics, fictional environments are treated just as another learning environment, in which pupils behavior can and should be observed as in any other learning environment. However, because stories always influence the people consuming them, the acquired knowledge will always come along with an influence beyond the acquisition of knowledge. Even if not consciously intended, children will be influenced by the approach without their knowing and the approach could also be abused for indoctrination. However, if a sensible ethical framework will be developed, this new approach, as a slight but not altogether deviation from the enlightenment, could enable great potentials for teaching. This means not a total deviation from the tradition of the enlightenment but a less hard understanding of it. One of these ethical guidelines should be that the narratives are transparent, they are described in a general manner and this documentation is open for everyone to look into. Other possible ethical guidelines will be proposed in section 4.6.1 along with the more detailed description of the field.

To summarize, the new didactic approach allows alternative narratives of learning subjects if it is seen beneficial and certain ethical guidelines are met, but apart from that and also within the alternative narratives, it sticks to the principles of the enlightenment. This new approach would allow basing teaching fully on an alternative, which will from now on be referred to as alternate-narrative-based education and thus form the basis for narrative didactics, because alternative narratives could then be applied in practice and the new didactic field of narrative didactics could be established with practical relevance.

3 RELATED FIELDS AND RESEARCH

As described in the last section, there is the need for a new field of didactics, that dedicates itself to the research of narratives. In the following, intersections and relations to other scientific fields are described in order to demonstrate the topics and methods of the field further. After that, comparisons are made to other didactic topics like CS unplugged, as well as to alternative approaches of computer science and programming.

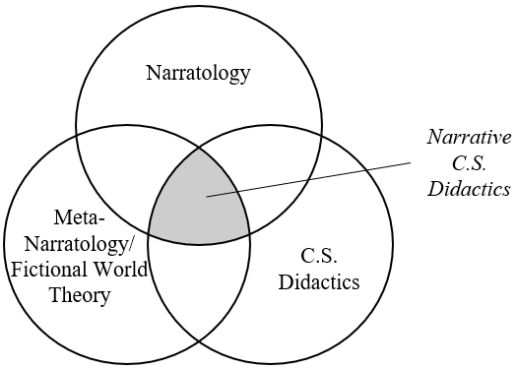

Figure 2: Relation of Narrative C.S. Didactics to other fields

3.1 Relation to other scientific fields

In the following, the relation to the main interrelating fields are described as well as their intersections to one another.

3.1.1 Main interrelating fields. Narrative didactics considers itself with the following topics:

(1) Creation and analysis of the fictional world in relation to teaching C.S. on (meta-narratology)
(2) Creation and analysis of stories such that they serve as basis to teaching (narratology)
(3) Doing research how to carry out teaching in a given fictional world (C.S. didactics)

That means, narrative didactics consists out of the interrelation of the following three disciplines: computer science didactics, narratology and meta-narratology, as seen in Figure 2.

While the intersection between narratology and meta-narratology is obvious and will be omitted, the other two interrelations need to be described as well as the overall picture.

3.1.2 Intersection with Narratology. Humans have used storytelling for education for centuries, and it is also currently today in everyday teaching. From a point of view of narrative didactics, stories form the medium, through which alternative narratives can be experienced.

Their study and comparison is therefore very important, for one because of their potential to make knowledge more accessible and entertaining, but also to understand the responsibility that come from stories and the many intentional as well as unintentional ways that they can have an influence on learners, and the care that must therefore be taken when constructing them.

3.1.3 Intersection with Meta-Narratology. Narratives, as a higher, abstract form of properties of stories, can be studied also, although they are usually not the topic of narratology, because narratology is usually reduced to the comparison of the contents of texts and not of their meaning per se. That is why a new field of study should be introduced, which dedicates itself to the analysis and comparison of stories on a higher level, that is: of their narratives.

Meta-Narratology is a scientific field that has not been defined yet. Its research objects will be defined in Section 4.1 for being able to study narratives in narrative didactics. However, for the moment, meta-narratology can be seen as the analysis and comparison of

narratives, with narratives being alternative version of telling about a certain subject.

Alternative narratives have been used in combination with stories for a long time now to bring knowledge to people and to pass it onto the next generation. This happened earlier often through mythology, in which very abstract concepts very passed onto through oral tradition.

Of course, alternative narratives have almost always been used as an instrument of power, sometimes to convince people to commit crimes against humanity, one of the most severe cases being the antisemitic propaganda of the Nazis, and to threaten democracy, as for example in the form of right-wing conspiracy theories that lead to mass shootings in Germany and contributed to the storm of the capitol in the U.S. Therefore, the analysis and deliberate construction of narratives should in no case be taken lightly and the consequences as well as the potential for abuse should always being analysed as well.

However, in the past, humanity also managed to bring out many positive narratives that drove innovation, stimulated the inventiveness of people and provided a common ground to discuss important societal problems regarding technical innovation, like works of the science fiction genre or even going as far back as greek mythology, in which technical innovation were for example discussed in the story of the trojan horse. In recent times, for example Series like Star Trek provided alternative ways to look at technical advancements and discuss problems about them that also had actual societal relevance.

Allegorical narratives about technical innovation and their deliberate construction are therefore already quite old, but in recent years, it has been put on a new scale seen in the introduction of the term world-building. This came about with the invention of pen and paper role-playing games like Dungeon and Dragons, for which it became necessary to let multiple authors work on the same fictional universe and they needed a common ground for their stories to stay consistent, and for the same reason with the growth of comic universes by DC and Marvel. Therefore, the general description of worlds was introduced, which often can also be seen as the implementation of a certain alternative narrative of reality. In the past decades, world-building has grown into a big field especially in the gaming and filming industry, and will probably continue to grow with the development of virtual worlds and ideas like the Metaverse. However, a scientific field was not yet established. But due to the growing demand of world-building-skills in the next years, this will probably be only a matter of time.

One central way of narratives to convey knowledge is found in fairy tales (or more generally: in mythologies): there, certain moral rules are often elevated to laws of nature. By walking through the world, knowledge is conveyed, thus reducing the margin for understanding. Often the rules (or: the morals) are not even explicitly addressed, but arise of their own accord through the fact that they are anchored as natural laws of the world, are the only way to survive in the world of the fairy tale through learning these very laws, and are thus understood by themselves due to survival instincts.

This means that in narrative didactics, just as stories, narratives are being studied mainly for their application in teaching but always in relation to the ethical questions and societal responsibilities that come along with it.

3.2 Comparison to other related topics of computer science didactics

In the following narrative didactics is set in relation to other topics of computer science didactics.

3.2.1 CS Unplugged. CS Unplugged is also doing research on narratives, however, it does so from another direction. While in CS Unplugged narratives are only a by-product of research, narrative didactics puts them at the center of its research. Therefore, CS Unplugged can be considered a method of narrative didactics to find out new narratives, which can then be studied further. That means that narrative didactics could already build upon the findings of CS unplugged and other similar fields like computer games and XR-technology for didactics.

3.3 Relation to Alternative Views on Computer Science

Programming and computer science are commonly seen as a science. However, in the past, alternative ways to look at computer science have been proposed. Two of them will be discussed in the following and it will be shown, why they are interesting in the context of narrative didactics.

3.3.1 Programming as theory building. Peter Naur defined 1923 in his paper computer science as theory building [4]. He described that every computer scientist builds up a theory when working on a software problem, which changes based on new requirements and so on. However, one could also say that they also build themselves theories about this theory building process. A theory about theory building, which essentially, is a theory about computer science. This theory of a long-working computer scientist would be very useful for educators. The approach of narrative didactics would now be, to describe this theory in a fictional world and then to carry out teaching in this world.

3.3.2 Programming as an art. It was already written before, that new narratives could make use able to overcome the complex role that computer science holds between mathematics and other practical crafts. In the sense of paper from the last paper, one could say that he found a different theory about theory building then most computer scientists and a one, which could prove to be very useful for education.

4 DEFINITION AND METHODS

In the following, the didactic field of narrative didactic and its methods will be defined as a new research field of didactics.

4.1 Definition of the research objects: narratives, stories and fictional universes/worlds

Narrative didactics is first of all a better way to do research on narratives for didactics. The research-objects of narrative didactics are therefore as follows:

- **Narratives**: Alternative way to talk about/view the topics of a learning subject
- **Stories**: The way to experience a narrative

- **Fictional universes**: can be used interchangeable with narratives, while narratives should preferable be used for more general descriptions of fictional universes

In the following, the research-objects will be fully defined and after that, narrative didactics itself and its methods. Because as described in the last section, narrative didactics has big overlaps with the undefined field of meta-narratology, the in the following defined research object of narratives can be just as well seen as it would be defined in meta-narratology.

4.1.1 Narratives/Fictional Universes. Narratives are understood as alternative views on a subject different from the one it is commonly spoken about in society or science. However, the question quickly arises what is the difference between a fictional universe and a narrative. For example a narrative could be very broadly defined for example in a mechanic that describes the way marbles move. However, the same could also be part of the description of a fictional universe. In a sense, narratives in itself also describe an alternate reality and can therefore also be described in fictional worlds. Therefore, in meta-narratology, narratives and fictional worlds are basically considered the same, every fictional universe can be considered as a narrative and vice versa, however, for matters of distinction, narratives should be used to call more general descriptions of fictional world or of parts of them, or treated as their instantiations.

That means that meta-narratology basically defines narratives in relation to fictional universes. This will become important later when making narratives empirically observable. In general, it is advisable to use the two terms in a productive way to make it easier to understand what is being tried to say instead of using them at free will.

The term for all possible works of fiction is the "multiverse of all fiction", in which the research objects of meta-narratology reside and in combination with computer science, are to be searched for useful worlds that can be used for teaching computer science.

4.1.2 Stories. In narrative didactics, stories are seen as the primary way to experience narratives (story always means all types of fiction, in all types of media). They are the medium to look at a narrative. While every narrative in general contains subjective opinions, it can be described from a objective point of view, while stories are primly subjective. While fictional worlds/narratives are static and can be generally described, stories are dynamic and show a narrative from a more subjective view point. Therefore, the view on a fictional universe through a story is always distorted, and it is basically impossible to understand a universe in its entirety only through stories.

4.1.3 Relation between Stories and Narratives. Every story can come in infinitely many variants, while for a narrative, theoretically, one general description of it would be sufficient to describe it in its entirety.

Every narrative can be told by infinitely many stories. Every story has at least one narrative behind it, meaning it plays in at least one fictional universe. However, a story can also have/belong to potentially infinite many narratives behind it and will do so in the general case. However, a story usually attributes itself to/is written for one specific fictional universe.

The smallest possible narrative is therefore: "there exists something" and a corresponding story could be: "Once upon a time, there was something". Meaning in this case, the story belongs to the narrative, but it also belongs to the narrative: "there exists an element named A". That means, even in this example, there could be many narratives to which the story belongs just as there could be many other stories, which belong to the narrative. However, while different stories can hold the same information, narratives must always hold to some degree distinct information to all other existing narratives.

4.2 Making narratives empirically observable through stories

For narrative didactics to become a discipline and relevant for didactic research, its research objects have to become empiric. Therefore, narratives are made empiric based on the following chain of conclusions:

(1) **Narratives can be indirectly observed through fiction**: Narratives are not itself empirical researchable. Because narratives are abstract constructs, they cannot be observed by humans with their senses. Humans interaction with them can only be empirically observed by integrating them first in a consumable piece of media and then observing the interaction between this piece of media and a human. The observation is always influenced by the story and the technical means, through which the narrative is told in the piece of media. Without total immersion in a story, the inaccuracy becomes too high. Results depend too high on the story.
(2) **A separation of story and fictional worlds is necessary for comparable results**: the general description of a fictional world, independent of the story about it, can make the research more independent of the medium to explore the narrative (the stories). By then researching different stories of the same fictional world, results can be verified and stabilized. Every story describes a fictional world and just as a narrative can be integrated in a story, it can just as well be integrated in a fictional world, e.g. by declaring it natural law and building the world based on this assumption. Therefore, no narrative is "lost" in this transission from stories to fictional worlds. Because every fictional world can be host to many stories, the step can be seen as a reduction of research objects, which is not necessarily a bad thing. Every narrative, however, can still spawn multiple fictional universes, which means that it can still only be observed indirectly.
(3) **For research, the description of the fictional worlds has to be described in detail, as well as the media through which it is being experienced**: Another condition for comparability of results is that descriptions of fictional worlds become standardized, or at least described thoroughly. In the future, it would be good to establish some guidelines and maybe even standards how to describe a fictional world and the media through which it is experienced. A consequence of this is, that there needs to be standardized ways how to describe and categorize fictional

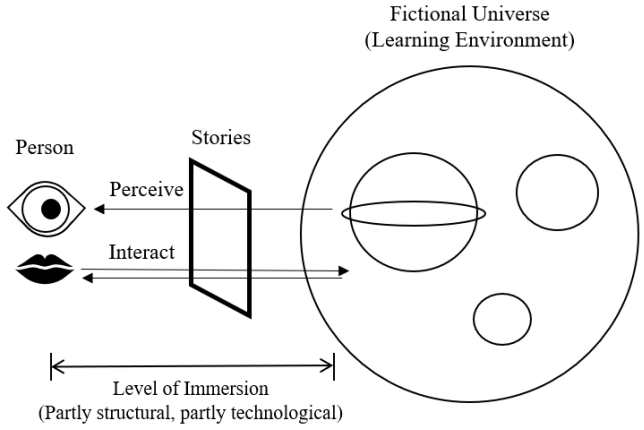

Figure 3: Concept of alternate-universe-based education

worlds. The same holds for the media through which the world is being experienced (more on this will be described in the next section).

Based on these three principles, serious scientific research could be carried out on fictional worlds and in consequence, conclusions could be drawn about their underlying narratives, in which they were integrated. This could enable a much more effective and stable way of researching narratives than in current research and make them accessible for scientific areas like didactics.

And a side effect of this would be, that if observable results of a fictional world can be stabilized, they could be considered as learning environments, in which teaching can be carried out. This new approach of learning wil be called "alternative-universe-based education" from now on.

4.3 Definition of Narrative Didactics

Based on the definitions of the last sections, narrative didactics can now be defined.

The key principle behind narrative-didactics is that of alternate-narrative-based (or: alternate-universe-based) education. As described in the last sections, immersion is in narrative defined through stories as seen in Figure 3.

In alternative-narrative-based education, as described in the last section, alternative narratives are now made the basis for teaching by treating them just as another learning environment. In this sense, teaching in reality, would look like in Figure 4 to see. Traditional teaching is therefore basically only seen as teaching in a world with total immersion, of course with the additional information, that this world happens to be the world experienced by most people on Earth as reality. It is therefore still considered the first choice for teaching, even in narrative didactics.

That means if the fictional universe and the story to view it are described fully in a standardized format, narratives can be empirically observed. However, because a fictional universe can always only be observed with high inaccuracy, observations in reality should always be preferred. Additionally, observations are always only true for a fictional universe and not necessarily in reality, which

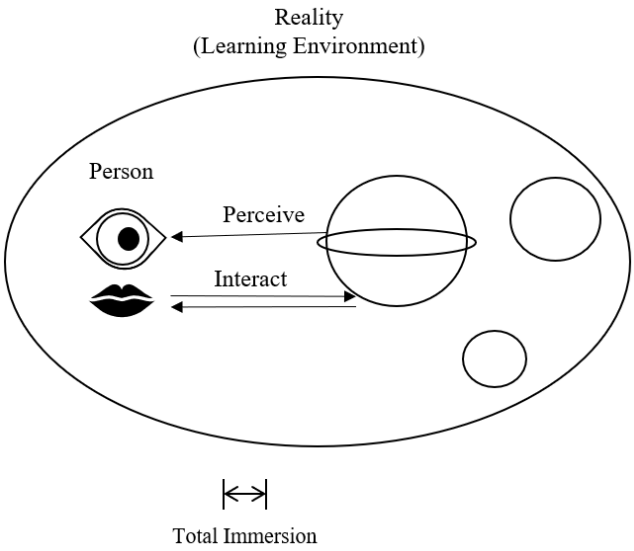

Figure 4: Traditional, reality-based education

further limits the use of an observation made in a fictional universe, however, it might be useful for doing teaching there.

With traditional didactics, we have only access to the learning environments based in reality. Through narrative didactics, we can explore many new learning environments, in which of some of them, teaching might be easier for a certain subject.

4.4 Definition of Immersion

As already declared in the last sections, narrative didactics is based on the following main principle: immersion happens through stories. This is further elaborated on in this section.

The main immersion-aspect of stories are defined as the level of interaction, which is defined as follows:

- **Fully interactive**: almost same interaction level as reality
- **Highly interactive**: role-playing with certain constraints
- **Semi-Interactive**: narrator allows limited choices
- **Fully Passive**: no interaction

The level of interaction is connected to certain story telling techniques, however, it does not necessarily change what the story is about, it just enables different ways to experience it. Therefore, there has to be a stable model behind the way, how a story is told, which stays the same, even so the art und weise how a story is told is changed. This is the fictional world, which is described by the story. Stories cannot change a fictional world, they are the way to experience them. That means, every fictional universe of story can be adapted for every level of interactibility without changing the fictional universe.

For example, in a flight simulation, one could think, that no storytelling happens. However, when playing the simulation, one initially assumed to be the pilot of the plane. Therefore, the simulation is based on the story, that the player is the pilot of the plane. However, the fictional universe is the same or almost the same as

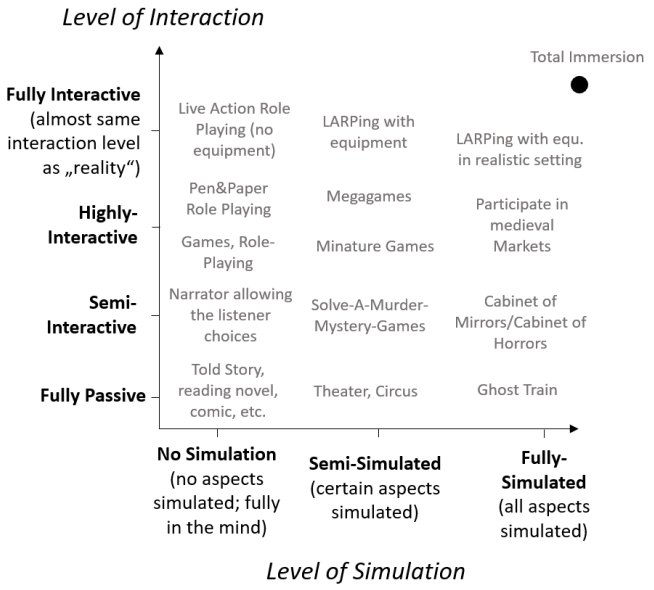

Figure 5: Immersion-Dimensions of stories in narrative didactics

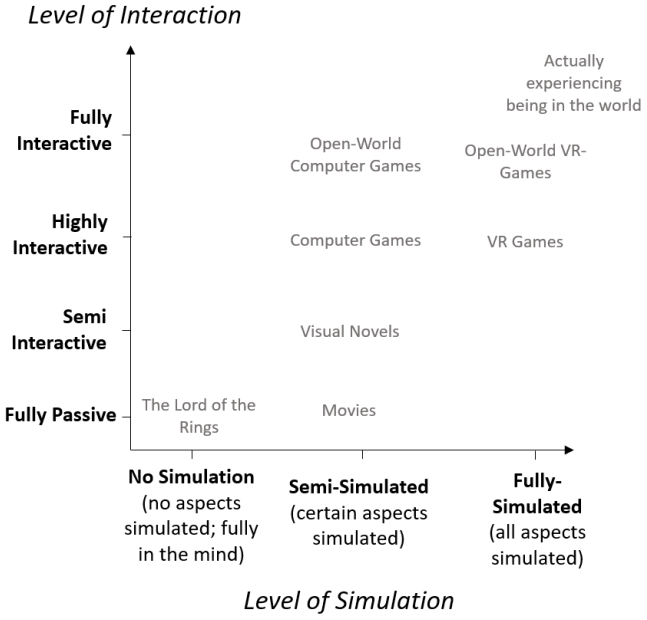

Figure 6: Digitally realized stories of The Lord of the Rings in the immersion-coordinate system

our reality. On the other hand, if that plane would be a spaceship, it would be in a universe, in which spaceships exist.

The other aspect of immersion is the level of simulation, which, without support, is done only by imagination, however, it can be supported and build upon with technical means. This means that immersive technologies (or general techniques of immersion) do not enable anything fundamentally new in the sense of storytelling techniques but can merely take over what imagination is doing and by this, make immersion more quicker and easier and apply storytelling techniques better to fictional universes much more different than our one. The primary advancement of immersive technology is therefore that of simulation and being able to simulate much more worlds much more easily. The types of stories will stay the same as in the last decades and partly even centuries.

Figure 5 shows the two dimensions of the immersion level of a story. Inside the coordinate systems are examples of story types of the respective interaction- and simulation-level. As can be observed, only analogue story types were listed, which shows that all of the coordinate could at least basically already be traveled to in recent decades and centuries ago. This can mean that technical means are used to support imagination but it does not has to be. However, digital simulation is also possible and can enable higher levels of immersions for worlds completely different from our own.

While it would be increasingly hard to tell highly immersive stories with analogue means for fictional worlds like The Lord of the Rings, digital immersive technologies allow to simulate them much more easily and quicker and to a much higher degree as seen in Figure 6. However, immersive technologies do not allow to access more sections of the coordinate system in general, they just do so for specific universes like that of The Lord of the Rings. In terms of story telling techniques, however, they enable nothing generally new. With the digital it just becomes possible to apply those techniques much more easily and to much more fictional worlds. Immersive technology can therefore be seen mainly as an advancement in simulation while the storytelling techniques exist for decades and most of them even for centuries. But because due to the current approach in didactics most of these techniques are not made use of for didactics, the simulation-potentials of immersive technology for education cannot be made use of as well.

This categorization of stories helps to get a complete view on the stories that could be possible for education. Because simulation is only a parameter, that can be adjusted, books, comics and games, as well as analogue and digital means are treated the same (or at least in the same coordinate system), they just offers different degrees of immersion and interaction.

4.5 Methods

Narrative didactics now analyses and compares the described research objects to one another in relation to their use for the didactics of a specific field, e.g. computer science. Possible research questions lie in the following areas:

- Investigating universes/narratives for a specific subject.
- Comparing universes/narratives for a specific subject.
- Trying to find regularities among universes/narratives or their variants for a particular subject.
- Trying to find the best universe-/narrative-variant for a given subject

A research question could be for example, whether certain aspects of a world description are present in many universes of the same narrative, or if there are even whole modules, which are the same in many universes of the same narrative. Another could be to try to find the best narrative variants for a certain subject and by finding patterns that can be found among those best narrative

variants, for example, a certain analogy for programming, certain constraints to natural law, etc.

To come up with new narratives for research, there are methods that could help to do so:

- Thinking about a way a subject could be represented in a world different from the way we see it in reality. How would teaching in this world would look like?
- Asking oneself the question: "What would the best possible world to teach a certain subject?"

These methods could be accompanied by established creative techniques.

4.6 When to and when not to do narrartive didactics, or: the recommended use-cases and limits of the field

The question with the above learned methods is, when to apply them and when to stick to traditional didactics.

It is easy to see that narrative didactics are not sensible to use in every case and come to their limits. For example regarding the ambiguity of the defintion of narratives, one could think about many examples, in which it is not clear whether it is a narrative or not. For example: playing deck-building card games is programming. This could very well be considered a narrative, however, it could also just be seen as trying out a new game mechanic for programming.

This shows that narrative didactic is just a different approach that can be useful in some cases. In some cases, it is useful to see a certain subject as a narrative or convert it into one, in most cases, it is sufficient to observe it just the way it shows itself in the common understanding. Narrative didactics is only useful if it gives new understanding of a subject.

To try it out, it can always be a good idea to ask, what would happen if a new idea for a given subject would declared natural law in a fictional universe and how then teaching would look like there.

4.6.1 Ethical Questions. Narrative didactics are not to be used outside the borders of the ethical guidelines that should be established in the near future. For the methods of narratives didactics, narratives should always be described in a generally formulated, open document. In the next section, the topic of ethical questions is deepened with a focus on the practical usage of narrative didactics and its research objects. In general, methods of narrative didactics should never be used to consciously do harm to single people or groups of people and stick to the general ethical rules of science.

5 EXEMPLARY NARRATIVES AND RESEARCH QUESTIONS

This section describes some example narratives and shows possible research questions about them.

5.1 Existing Narratives

Many alternative narratives for computer science have already been researched. For example that Computer Science is

- Alchemy/Chemistry (TODO: references)
- Music (TODO: references)

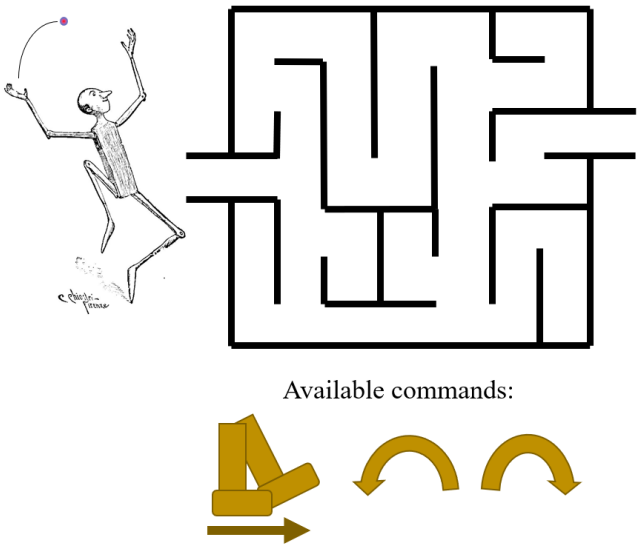

Figure 7: Labyrinth problem

- the Creation of Life (TODO: references)
- the Creation of Art (Videos, Stories, etc.) (TODO: references)
- Dancing (TODO: references)

It can also be observed in the references that the different narratives result in distinct mechanics and tools for teaching computer science.

5.2 The Marble-Narrative

To show the application of narrative didactics from scratch, in the following another narrative is proposed, which is called the "marble-narrative". In its world, all technical devices work through marbles, that run on tracks in their insides. The general description of the world would be something like "technical devices work through marbles". Now this narrative could be used to do narrative didactic research on it.

5.2.1 The Marble-Track-Narrative. First, the narrative needs to be defined further. One possible way to further define the marble-narrative would be through marble-tracks, called "the Marble-Track-Narrative". The marble-track-variant does not reduce itself to a limited area of space but the tracks can be freely constructed as seen in Figure 8. In this metapher, the marble is the program pointer, moving through the different commands of the program doing something.

As a first example for an exercise that could later be used in schools, in Figure 7.

Of course, would need to be accompanied by means of storytelling to bring this idea to the children. For that, the narrative would need to be adapted (further defined) into a fictional world, which is described in the next section.

5.2.2 The Marble-Pinball-Narrative. It could already be done research on the marble-narrative, for example, how the narratives

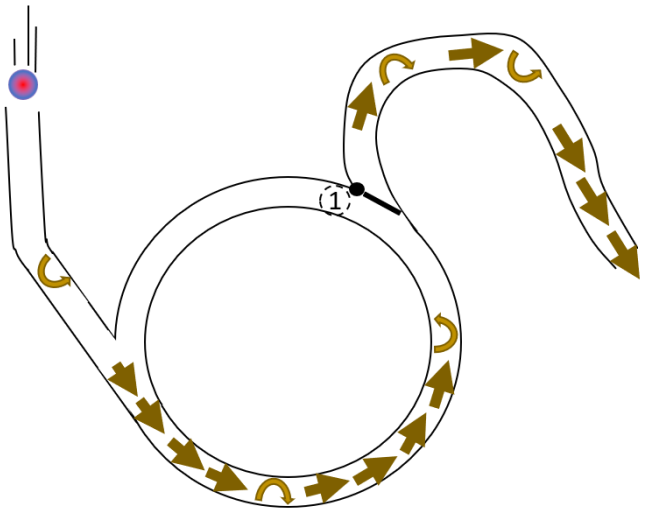

Figure 8: Solution with a hand-drawn marble track

in general works in practical teaching and so on, which actions should be enabled, which puzzles are well suited, etc.

Another research question is the comparison between different narratives or the comparison between different narratives of the same type. To do this kind of research on the marble narrative, another variant of this narrative is proposed, of which then the more fitted narrative for teaching could be found out through research. The related research question would be, which one would be better suited for teaching computer science.

This narrative-variant is called the marble-pinball-narrative. In it, marbles run on be a more limited area of space, like a pinball-machine, in which the marbles run around and activate certain actions. This would end up in a world that could on the surface look very similar to the first narrative, but would result in completely different teaching materials.

The idea behind the mechanic is then that it works with a so-called "marble-board" as seen in Figure 9. It could in class later be used easily in form of a chess-board. While the triangular-pieces are used to change the course of the marble, the transparent triangle with the 2 written on it will only become solid when the marble has two times passed over it from above. The actions work the same as for the marble-track-narrative. This way, the puzzle could be solved with a configuration of the marble-board.

5.2.3 Conclusions for Narrative Didactics in General. It became clear in the this section, that the declaration of these mechanics in a general world-independent manner enables new ways to think about teaching material. Without immediately thinking about how the mechanic of a narrative can be realized, one can come up with new ideas some of which may not (yet) be able to be applied in practice, but some of which might open completely new ways of teaching and encourage out-of-the-box-thinking. The above examples of the marble tracks and the board could be seen as using a Raspberry Pi in schools but without the complicated setup and error-proneness by making use of the children's imagination. Another way of looking at it is through visual programming. The

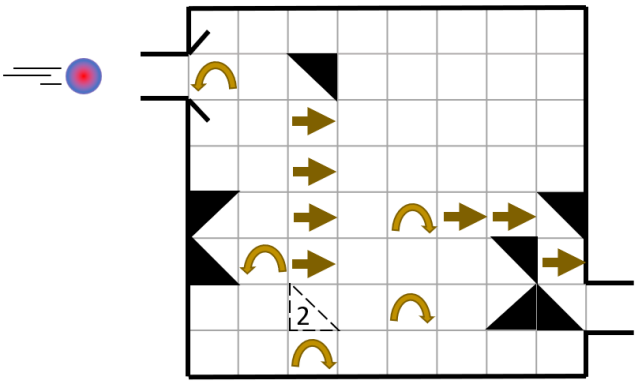

Figure 9: Solution with the marble-board (chess-board with cut-out pieces)

elements that can be selected in visual programming programs are taken out of the program to form analogue elements, which the kids then use and in their imagination run the programs.

Another advantage of this is that learning resources would be developed much more long-lasting and stable resources, because fictional universes are not dependent on the changes of tech and devices. This could lead to much more matured resources, because they can be developed and improved over long time, and would also make more effectively use of the effort put into them.

6 APPLICATION FOR TEACHING

In this section is explained, how narratives could be used for class and which ethical questions have to be answered for that.

6.1 Application of the Marble Narrative

After finding out the better marble-narrative, it could be thought of how to use it in class. The application of the marble mechanics itself could be thought of easily. Maybe the teacher would start by playing simple marble-games with the children and later, show them marble tracks/marble boards and how they can build machines with them in the fictional world. Then they would start themselves to play with the marble boards/hand-drawn marble-tracks to solve a certain defined problem.

In the case of the marble-track-narrative, for that an unplugged version would be possible, in which the children actually put together tracks, however, this would be very expensive. Therefore, for class they should be either hand-drawn or created in form of a computer game or XR-experience, in which children could actually build up the marble-slides and see their execution (however, the narrative and the mechanics of the world, of course, would for any medium stay be the same).

To apply the marble-pinball-narrative in class, the approach would be to make use of mixed reality in the sense that the board can be scanned via tablet by the teacher and the pupil can then look how the marble runs through the marble-board and whether it solves the problem or not. After they arranged the pieces on the board and decided for themselves to having solved the problem, they could scan their setup by the teacher and see on the tablet, whether their marble board/track solves the problem at hand.

However, to being able to explain the usage of the proposed learning tools better, it would be helpful to explain them through stories. For that, it would be useful to further define the respective narrative in a fictional universe and then build the teaching resources based on this universe. The lessons would then be build around this fictional world.

6.2 Creation of fictional universes for class: world-building, or: declaring a narrative natural law

After seeing how the marble narrative is used in class, the question is, how it could be integrated in teaching, how its working are explained to the children and how they understand the exercises. Of course, in narrative didactics this happens through stories and a fictional universe of the narrative. Therefore, to create a common ground for the stories that are told in class and the teaching materials that are build on them, a further description of the narrative, which in the case of computer science often holds rather technical mechanics, it is useful to create a fictional universe based on them. For this, the skill of world-building is needed. The question is how the creation of fictional universe for class could look like. For the creation of a fictional world for class, the skill of world-building is needed.

How could it work to integrate a narrative into a fictional world. As explained in Section 3.1.3 one way to do so is by declaring the narrative natural law. This thought is not in itself problematic but depends on the narrative and the actual implementation and later usage. But it needs to certainly be applied with care. But if so, it could be the most effective way to bring narrative to people through a fictional world.

In the case of the marble-narrative this would be a universe, in which all technical devices run with marbles running in them. The world could therefore be something like Steam Punk world but with engines powered by marbles instead of steam. For an exemplary universe, this could look like the following: one could for example integrate the narrative into the universe of Pinocchio, however, with the twist that Pinocchio has to eat Marbles now and then, because his “father” constructed him with marble tracks running inside of him. One could start by telling this story, however, in this variant of the story, Pinocchio and his father at some point tell other people how the magic of Pinocchio works and together, they build great machines based on it to take work from them and have time for other things. One then would show the children the marble-board/marble-track and show them how they can build their own machines with them.

6.3 Creating fictional universes in class: shared universes and shared-narrative-learning-resources

What remains is the problem of inconsistency when multiple authors start working on the same narrative.

When using a narrative in class the question would be how to effectively create learning resources for this narrative. The main problem is here that inconstancy can occur quickly if multiple authors work on the same narrative, which will happen inevitable, because not all learning resources for all type of learning mediums can be created by a single person. This could be solved by describing the universe generally in a fictional universe and then working independently on this definition. Such a fictional universe is called a shared universe and could be effective solution for preventing grave problems of inconsistency.

That means on the universe from the last section, for example called the Pinocchioverse, would then books, exercises and games be based. Even multiple authors could then work independently on creating learning resources without running into great fundamental consistency problems. The resulting learning resources are called shared-narrative-learning-resources, because they build upon the same shared narrative, and the narrative itself, together with all the learning resources that are picked for using in class, is called the shared-narrative-learning-environment. A crucial step in using an alternative narrative in a school would therefore be to create such a shared-narrative-learning-environment by selecting the shared universe and the appropriate learning resources to be used.

6.4 Advantages for integrating XR-Technologies in teaching

What also became clear with the creation of the different marble narrative variants is, that one can also immediately see that it is fairly easy to describe the mechanics of the different narrative-variants in a general manner and that this is independent of the way it is implemented. And for both variants, the game could easily be thought of to be implemented in various ways - in the form of a computer game, but also as an unplugged project or XR-experience. This point will be further explained in the next section, which is about the practical application and creation about these narratives in schools.

Shared universes could also be beneficial for integrating XR-technologies more flexible into the daily teaching routine.

A shared narrative as basis for learning resources could make it much easier to integrate XR-technologies in teaching, because if they use the same narrative as the other learning resources, the threshold to use them in the class will be much lower. Instead of being separate from the rest of the teaching resources, they would become part of the same ecosystem and switching between resources of different technological levels would become much easier.

6.5 Ethical questions

First is the question of the risks of using narratives in education itself and the responsibility that come with it. Because the view on fictional universes happens through stories, which are always blurred and come with their own integrated views on things. Also, one should always be conscious that every story influences the listener and that every narrative influences its stories, too. Narratives determine which stories will be easy to be told in them and therefore, in the usual case, also be told. For example in the case of The Lord of the Rings, it would be easy to create stories on one’s own, however, the racist and colonialist world views that are present in its world would probably find its way into most of these stories or have to be consciously overcome. Therefore, care must be applied when creating stories as well as narratives, and

the creators must always be conscious of their responsibility to inevitable influence the reader one way or the others. At the same time, if stories influence the listener anyways one way or the other, the question is raised, which influences this should be; and specifically, which moral values regarding computer science should be taught to the children through the stories, which has not yet been acknowledged in current computer science didactics. This is also true for the behavior of the children in the fictional universe: should for example a child, which builds a marble-robot with a weapon be praised for their inventiveness or not? These and other questions need to be answered when creating narratives and stories, as well as when using them in class. Probably it could also be thought of, whether this type of behavior should openly be discussed in class and lead to a broader discussion of the responsibility of innovation.

Another point is free-choice of narrative. Generally regarding use of immersion in teaching, there should be a general agreed upon degree of immersion that should not be superseded. Obvious deconstruction should for an average intelligent human always be possible. Meaning people should always be able to recognize that they are in an artificial learning environment. Fictional universes already contain an interpretation of its universe and in contrast to immersive devices, narratives cannot just be taken off. Therefore, there needs to be a free choice of universe - every pupil (their parent) has the right to be educated in the universe they chooses. No one is forced to be educated in a certain universe (except for reality) and parents who don't want their kids to participate in narrative didactic-based teaching should be offered alternatives. Therefore, the school should always be offering the possibility for pupils to switch to another shared-narrative-universe for attending class. Maybe the narrative itself to a certain level might be mandatory.

Related to this is the matter whether stories should be told in a way that they are true or not. Because in any case, deconstruction is necessary - at some point, the narrative needs to be broken, because pupils that continue to believe in alternative narratives could shape wrong believes about the world, giving way to wrong conclusions and conspiracy theories. To prevent this worst case of risking that someone continues to believe in the alternative narrative, it would be best to make clear from the beginning by the teacher that the stories are only meant metaphorical and are not actually true; that means, to provide a transparency in terms of the used narratives to the children. For example, if a pupil asks whether technical devices in our world also run on marbles, the teacher should always say no. This could be further bolstered by letting the stories play in a fantastic world where it is obvious that it is not real.

In general, a sufficient teaching of critical thinking as part of the general curriculum is a pre-condition for applying means and techniques of narrative didactics in teaching, which minimum standard should grow potentially with the level of immersion. Together with a transparency of narrative, this will make sure that pupils will ask questions like whether the stories are actually true, and they should never be discouraged in doing so.

7 OUTLOOK

This section will describe the idea of letting pupils participate in the creation of fictional universes and give an outlook on the future of the field of narrative didactics.

7.1 World-Building as a collaborative experience/didactic tool

Another aspect to this, which has not yet been discussed is the one about collaboration. An idea could be to not treat fictional universes just as another learning environment but instead making use of their flexible nature and letting pupils participate in their creation. In this sense, people in the past were more advanced in this then we are. Stories were told from generation to generation, while today, most people are consumers and stories are only told by a few. It should be thought of whether pupils should also participate in the process of world building and story telling or not. This could also have benefits for society in general to discuss, anticipate and ultimately solve future problems.

Story-Telling and learning also happens through the collaborative telling of stories. Maybe another idea would be that the universe is not fully developed and given to the pupils but that they themselves can take part in it.

7.2 Future Development of Narrative Didactics

The field of narrative didactics will need to be further specified in the future, regarding its theoretical definition and methods, its actual application, meaning the creation of fictional universes (and the description and improvement of this process) and doing research on them, and the application of its findings for teaching. There could also be research about the process of creating fictional universes, world-buildings and methods regarding this to be able to apply it more effectively in educational practice by publishers and so on.

8 CONCLUSION

Narrative didactics could give the research of narratives new methods and once the ethical questions have been answered, enable to apply it to actual teaching to make fictional world applicable for teaching and enable new ways of teaching complex subjects like computer science.

The widespread usage of alternative narratives in didactics could lead to societies thinking of computer science mostly through these alternative narratives, which would probably be better than not doing it at all, but as explained earlier, also poses certain dangers. But while for many scientific subjects as seen in pop-cultural products like Star Trek and the works of Jule Verne, this has in some way always been the case, for computer science it has not (at least not sufficiently). The search for alternative narratives for computer science is therefore not primarily the task of didactics, but one of society in general and potentially many other scientific fields.

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