Designing Digital Literacy Activities: An Interdisciplinary and Collaborative Approach

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***Abstract*—This WIP presents an innovative collaborative and interdisciplinary approach integrating computer science literacy and digital media literacy to build a critical citizenship-oriented digital education. This approach is inspired by design-oriented research methodology. Designing an activity aimed at digital education has four stages: appropriating of the subject matter, stepping back oneself from the expert knowledge, defining the sequence of the activity, and creating educational materials. It is carried out collaboratively between researchers (activity designers), practitioners (teachers and children), and experts in media and computer science. This approach takes shape through two research projects aimed at 10 to 15-year-old children: a first project targeting artificial intelligence literacy and a second one, Internet security literacy. The AI literacy project is tested with 75 teachers-in-training, five teachers, and 85 children aged 10 to 15. The critical analysis of the approach is at interdisciplinarity and collaboration levels. The alliance of computer science education and digital media education makes it possible to give meaning to educational activities. "Turnkey" educational materials corresponding to the expectations of teachers, and the reality of a classroom, are created. However, the balance between the two axes is difficult to find. Moreover, this approach takes time and makes project management difficult.**

***Index Terms*—Design-based research, Interdisciplinarity, Collaboration, Digital media education, Computer science education, Methodology, Approach**

I. Introduction

Digital education is a growing concern in contemporary education policies [1]. In particular, the "Pacte pour un enseignement d'excellence", a wide-ranging reform of education in French-speaking Belgium affecting pupils aged 3 to 15, seeks to support the integration of digital literacy in schools and to strengthen children' digital skills. This approach is accompanied by a new digital competence framework built based on the DigComp 2.0 framework [2] and the media skills matrix of the "Conseil Supérieur de l'Éducation aux Médias" [3].

The economic and societal stakes of these policies are high. Companies cite a lack of workers trained in digital tools and experts in various fields related to information and communication technologies. At a more global societal level, media environments are now largely digitized and permeate most of our practices, whether informational, cultural, or political. Faced with these challenges, three perspectives of digital education are identified: teaching computer science as a fundamental discipline, modifying the representations of digital among young people to encourage their integration into recruitment channels, and aiming at a civic education to enable them to be autonomous and reflective in their digital practices. To meet these various challenges, Henry and Collard [4] propose an interdisciplinary model of digital education (approached by pedagogues and didacticians) that integrates the two perspectives of computer science education (discussed with experts in computer science) and digital media education (discussed with experts in media), to train critical and digitally competent workers and citizens. The relationship between all the disciplines brought together by this model considerably enriches the approaches and solutions by encouraging creativity and serendipity.

While the digital competence framework specifies what needs to teach and the levels of education involved, Henry and Collard [4], [5]'s interdisciplinary model identifies what is at stake and why. Based on this work, the present contribution aims to formulate a proposal on how to build digital literacy according to the design-based research methodology [6]–[9].

According to this method which recommends a team combining different areas of expertise depending on the theme and the nature of the educational activity [9], the proposed approach seeks to integrate computer literacy and digital media literacy for critical citizenship education in schools. This approach takes shape through two research projects aimed at 10 to 15-year-old children: the first project aims at education in artificial intelligence; the second addresses the issue of Internet security.

We begin by briefly describing these two projects. We then formalize the approach to designing digital literacy activities. Finally, a critical analysis of this formalization allows us to identify the highlights and possible improvements.

II. Our Research Projects of Critical Citizenship Education in School

A. Artificial Intelligence Activity

Artificial Intelligence (AI) activity [5] is an unplugged role-playing game based on the "Who's Who?" game. Children will take on the role of a developer and the role of a tester or AI in succession. The mission is to create, test, and optimize an AI capable of identifying an animal-based on simple questions. The answers to these questions must be either yes or no.

The activity takes place in four phases: contextualization, development (and test), optimization, debriefing. The first phase aims to bring out the children's representations of AI. This phase based on the use of press cuttings, images from films or novels.

The second phase divided into two parts. First, children play the roles of developers. They work in groups of 4-5. Each group creates a data set consisting of ID cards for animals. These animals are selected so that similarities in pairs could appear: lion, dog, panda, zebra, giraffe, ostrich, parrot, and crow. The ID cards are constructed by the answers to 6 imposed questions that deliberately do not allow animals to be differentiated.

- is the animal herbivorous?
- does the animal have four legs?
- is the animal taller than me?
- does the animal have hair?
- does the animal have vertebrae?
- does the animal have lungs?

Then, the children take the role of testers, except one who will take on the role of an AI. Each group tests the AI of another group. Testers choose an animal that the AI tries to identify using the answers on the ID cards. The AI has to ask the questions in random order and not exclude questions once they asked. There is, therefore, an intended redundancy. The AI obviously cannot speak and understands only yes/no answers.

The third phase begins with a short debriefing on what was problematic in the previous phase: errors in the data set, difficulty in differentiating between certain animals, or absence of a learning algorithm. Children take on the role of developers again and solve these problems by correcting the data set, adding questions, optimizing the operating algorithm (e.g. no redundancy, respect an order for the questions), and thinking about a learning algorithm. An instruction added: the AIs must keep records of the different game parts played. Children test again the revised AIs.

The last phase compares the different traces collected by AIs. The predictive models that emerge from these traces are discussed. To introduce the notion of generalization, a new animal is added.

Through this activity, we target two complementary learning levels. At the technical level, children will discover the notion of machine learning and become aware of how AI works. At the critical level, children will lead to questioning themselves on the representations they have of an AI, largely nourished by the media and cultural productions and the place of this one in their daily life. They also become aware of the subjectivity and "non-neutrality" of each AI built by a (group of) developer(s), an aspect often made invisible.

B. Internet Security Activity

Internet security activity also based on the principles of an unplugged role-playing game. It inspired by the game "Les Loups-Garous de Thiercelieux". The game plays in teams composed of friends (between four and six), hackers (two or three), and at least one router. The teams compete against each other.

In a team, the friends try to send each other (and view) as many messages (with digital content) as possible. The hackers have specific missions: they try to trap the friends of an opposing team. The router ensures that messages reach the right people. He/She must also send advertising messages according to a schedule that is imposed on him/her. The game ends after each friend sent 10 messages.

A sent message consists of :

- a simple text to contextualize the exchange (optional)
- digital content: an image, an invitation to click on a URL link, an invitation to view an online video, a URL link to a game to download, etc.

When they receive a message, friends can choose to view the content (after previewing it) or place it in the recycle bin. Only messages viewed to allow the team's score to increase.

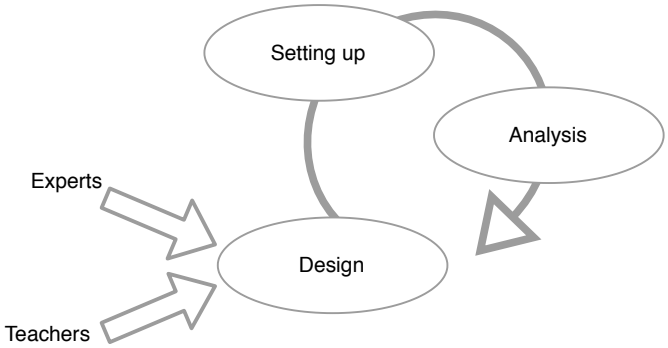

Fig. 1: Design-oriented research methodology

Each friend has a specific profile given to him/her, with a first name and a personality (what he/she likes and dislikes).

The missions of the three hackers are precise.

- Peggy is a phisher. She manipulates to obtain personal data.
- Oscar is a malicious hacker. He can modify or substitute messages.
- Eve is an eavesdropper. She can listen to messages but cannot modify them.

A successful mission by a hacker equals penalty points for the opposing team. Thus, a hacked content viewed or an infected game downloaded lowers the score.

The debriefing begins with the calculation of each team's score and the discovery of successful attacks. Hackers introduce themselves. Discussions can then take place about the hackers' intentions, the value of the data, the threats encountered during the game, etc.

This activity is designed to help children understand cyber-attacks. Through play, they understand how different threats on the Internet work, and that these threats are carried out by people (not machines) with certain intentions. They also evaluate the value of stolen or damaged data. Children identify

the conditions and social context in which threats can succeed (and become attacks) or fail.

III. Our Approach to Design Digital Literacy Activities

The design-oriented research methodology [6]–[9] consists of conducting an iterative process that articulates phases of designing educational interventions, implementing them at various levels, and analyzing the results of these educational practices carried out collaboratively between researchers (who design the interventions) and practitioners (who will later put in place the interventions in a real context - teachers -, or who will experience it - children) (Fig. 1). In the approach presented here, collaboration is not only between researchers and practitioners but also between researchers and experts in the field [9] (Fig. 2).

The approach used to design an activity aimed at digital education has four stages: the researchers have to appropriate of the subject matter, step back themselves from the expert knowledge, define the sequence of the activity, and create educational material (Fig. 2). The last three stages are iterative and could be characterized by "research through mistakes" [8].

The purpose of the **appropriation** stage is the acquisition of computer knowledge related to the object taught, namely AI or Internet security in the case of this contribution. This appropriation is essentially based on resources validated by experts, taking into account the public for which the activity intended, and the digital skills announced by the competence framework. For the projects analyzed, our team already includes expertise in media literacy. So computer experts collaborate.

Then follows the **step back**. Computer science education requires the identification of the key concepts and principles of the target object to extract the knowledge and know-how to teach. Digital media education involves anchoring the activity in contemporary media practices and societal issues. Considering the integration of these two educational perspectives, the aim is to develop a critical reflection on the object taught and the digital practices linked to it. For AI activity, particular attention is paid to the discourse to be held with children, especially concerning the risks linked to the human metaphor of intelligence [X]. For Internet security activity, attention is paid to the role of the social context in the understanding of the risks linked to attacks.

Concerning its **sequence**, each activity is envisaged in three essential phases: contextualization, experiencing, and debriefing. Several cycles can be organized, each time including a new action and a debriefing, to deepen the materials and the reflection. The contextualization starts with the children's representations and clings to the situations they experience daily. This phase is nourished both by the analysis of the children's practices and by the tests carried out in a real context. Through action, the children will "reason and act as", in the manner of a role-playing game. The aim is to give them a tangible experience, in a reflective spatial environment, from which more abstract concepts and more general reflections can be constructed. Teaching in unplugged mode is encouraged to ensure that the children keep their distance from the tool [X], thus opening the "black box" it constitutes and thus guaranteeing a better understanding of its functioning. This choice also ensures better control of the situation for the teacher. Finally, the debriefing consists of feedback on the context, on the initial representations, and the game experience, as well as a broadening of the questioning to contemporary societal issues. In this phase, it is advisable to get out of the game and become more abstract. The sequence thus developed is presented to experts in the field to ensure that the possible learning in terms of computer or digital media literacy (according to the experts consulted) is correct.

Finally, the **educational material** is created, including the documentation to help the teachers to implement the activity at the pedagogical, didactic or organizational level. This documentation is the result of collaborative work with the teachers [9]. The educational material is submitted to them who give feedback on usability, general understanding, shortcomings, etc. This should allow any teacher, whatever his/her digital skills, to take charge of the activity in total autonomy.

Aspects arising from the exchanges with teachers concern the possible adaptation of the activity to different training contexts (school or not, within the framework of a disciplinary or non-disciplinary course, ages of the children, etc.). The appropriation of the activity by these teachers is also analyzed.

The implementation of the activity is replicated in different contexts and with various audiences, depending on the desired results (for the analysis phase - Fig. 1). For AI activity, tests were first conducted with 75 future teachers-in-training: science, mathematics, physical education, and elementary school teachers. Afterward, tests were conducted in five classes with 85 children. Concerning data collection, children's representations were collected via (pre- and post-) questionnaires. Observations and debriefings were also analyzed to identify issues. Five teachers gave us feedback via a questionnaire about documentation, via interviews before and after the activity, and via exchanges during the tests.

Internet security activity is still in a beta version. No test is carried out at the time of writing this paper.

IV. Analysis of the Design Approach

Based on the two activities designed with the collaborative and interdisciplinary approach, a critical analysis of the formalized approach can be made.

At the level of the **interdisciplinarity**, it appears that the alliance of computer science education and digital media education makes it possible to give meaning to the educational activity. On the one hand, the two activities contextualize in a problematic related to media practices (defined in a broad sense). On the other hand, the activities provide a framework for a sufficiently in-depth understanding of digital technologies allowing children to develop a reflective approach to these media practices. For the particular example of the activity about AI, the teachers understand the interest of carrying out the activity in their class, beyond the obligation to teach

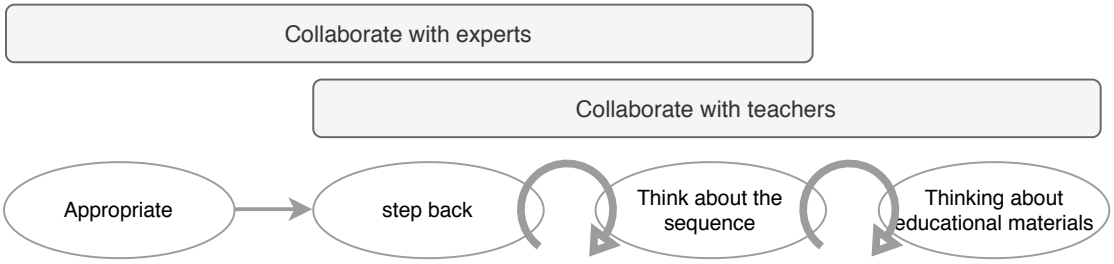

Fig. 2: Design approach

this or that technical concept "indicated in the competence framework". However, the balance between the two axes is difficult to find. Indeed, the purpose of digital media education tends to take a back seat due to the complexity of the technical subject matter addressed and the time devoting to it. Furthermore, it is difficult to identify the core computer science concepts and principles in the whole field and to sort out between those that should be brought to the attention of everyone, and those that belong rather to an expert level.

At the level of **collaboration with practitioners**, this approach makes it possible to arrive at "turnkey" educational materials corresponding to the expectations of teachers and the reality of a classroom. For the AI activity, the desired learning objectives are achieved by the children, taking into account the comparison of their representations in the pre- and post-questionnaires [X]. However, this approach takes time and makes project management difficult. As the dynamics of designing the activity take place in parallel with the analysis of the research project, one constantly modifies the other.

In this collaborative and iterative approach, one difficulty is pointed out : when deciding the end of the project? after which iteration? It seems that closure can occur when the teachers feel able to perform the activity alone and the educational objectives achieved. As the activity evolves through the iterations and modifies the target of the observations, we encountered difficulties in developing a systematic evaluation method and in analyzing the data collected.

Finally, two biases need to be mentioned. First, the teachers who participated in the projects were already aware of digital literacy, had a certain level of expertise in computer science and were a priori motivated to innovate in their teaching. New iterations with a less "acquired" audience should be organized. Second, collaborating based on opportunities did not always serve the purposes of the analysis and led to carry out more iterations. In the future, we would like to develop a more systematic method of recruitment.

V. Conclusion

A proposal on how to build digital literacy according to the design-based research methodology is the core of this contribution. We formalized a collaborative approach integrating computer literacy and digital media literacy and aiming at a critical citizenship education at school.

The design-based research methodology consists of conducting an iterative process that articulates phases of designing educational interventions, implementing them at various levels, and analyzing the results of these educational practices carried out collaboratively between researchers and practitioners. In the approach presented here, collaboration is not only between researchers and teachers but also between researchers and experts in the field.

Our approach to design an activity aimed at digital education has four stages: appropriating of the subject matter, stepping back oneself from the expert knowledge, defining the sequence of the activity, and creating educational material. It is developed through two research projects: two educational activities on artificial intelligence and Internet security aimed at 10 to 15-year-old children.

These projects are still ongoing and the approach still needs to be tested, especially for the project on Internet security. However, this first attempt at formalization could provide a basis for reflection when designing digital literacy activities. In particular, this approach highlighted the value of crossing different disciplines to develop both technical understanding and critical thinking on digital issues. It also highlighted the value of working with practitioners and experts in an iterative process. However, we are aware that it is currently taking place in a very specific context: specific research projects, specific school settings, an imposed competence framework, and a well-defined educational goal.

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