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# The Political Dimension of Problematizing ICT-related Sustainability Issues

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**Abstract**—This paper discusses to what extent researchers explicitly justify their views on the relationship between ICT and sustainability (ICT/S) in papers published at the ICT4S conference. We argue that this would help clarify the nature of the disagreements that underlie conflicting views. We first describe various ways in which ICT/S research has a political dimension. We then conduct an analysis of research papers published in ICT4S since 2020, reading abstracts and introductions. From this, we derive 1) a typology of the chains of justification used to relate research questions to sustainability; 2) a model of the problematization process in ICT4S papers; and 3) an evaluation of the extent to which views on ICT/S are explicitly justified in the analyzed corpus. Results show recurring patterns of justification, and a lack of justification regarding views on sustainability. We conclude by discussing actions the ICT4S community can take to address this.

**Index Terms**—didactics, problematization, literature review

## I. INTRODUCTION

### A. Context and motivation

This paper originates from our interest in teaching sustainability related issues in computer science classes. Indeed, in their systematic literature review [1] on sustainability in computing higher education, Peters et al. point out a diversity of representations, in the numerous teaching experiments that have been described in scientific publications, regarding notions that are key to teaching sustainability in computing, namely 1) sustainability; 2) the relationship between Information and Communication Technology (ICT) and sustainability (denoted ICT/S in the rest of the paper); and 3) the purpose of ICT-related sustainability education. According to the authors, views on sustainability vary across several dimensions (e.g., weak vs strong sustainability). Perspectives on ICT/S range from incremental (adjustments are needed to reduce the footprint of computing) to enabling (ICT as a transformational force towards sustainability) to disruptive (major changes are required to IT norms, practices and processes). Views on the purpose of education oppose training and emancipation.

We argue that the observed diversity of representations regarding sustainability and ICT/S in higher education reflects the diversity that exists in scientific research at the intersection of ICT and sustainability. As an illustration, one can find in publications at the ICT4S conference various critics of ICT/S research, e.g., about some norms of computer science,

software design and ICT/S [2]–[6], or about specific views on sustainability (and a proposal for new frameworks to understand ICT/S) [7]–[11].

Such a diversity of views may prove problematic for teachers who want to address sustainability issues linked to ICT in computer science classes, because these views are incompatible. The authors of [1] identify in particular “*conflicting views about the nature and future of IT and indicate potential tensions about what it would mean for computing education to contribute to a societal transformation toward sustainable and just societies.*” (p.4) This raises the obvious question of how a teacher is meant to choose. Indeed, the standard way to identify what knowledge should be taught in class is to identify stabilized reference knowledge produced by scientific research, and to negotiate its transposition according to the level of students, expectations of the educational institution etc. This process is called *didactic transposition* [12], and it cannot take place for ICT/S related issues.

### B. Contributions

We argue that these *conflicting views* of ICT/S research problems can at least partially be explained by their political dimension, meaning that they cannot be resolved through a purely scientific debate, as they reflect divergent social values (i.e., views on what is important, good and just) and/or divergent interests in the matter. In this paper, we specifically focus on how divergent social values held by researchers in the ICT/S field can lead to different views on sustainability and ICT/S, and therefore different choices of research topics and methods. To the best of our knowledge, this question has not been studied before at ICT4S<sup>1</sup> (cf. Section II).

We are particularly interested in this question because we adopt an emancipatory perspective on education as described in [1], characterized by “*understandings of education that go beyond reproduction.*” (p.13) In practical terms, this means for us constructing the pedagogical conditions that allow students

<sup>1</sup>An approach focusing on disagreements between stakeholders regarding ICT/S has been discussed at the LIMITS workshop, in particular by [13] which explains that “*technology development can be understood as ‘politics by other means’*” (p.1), and how “*technologists can contribute to sustainability by working through and with institutions.*” (p.1) They however do not focus on the choices made during the definition of research questions.

to build their own representation of political problems, while acknowledging the central role played by social values and interests at stake, without falling into relativism. We see this approach as a cornerstone of education for democracy [14] as well as a useful way to handle the existence of the above mentioned conflicting views in scientific research. To follow such an approach, we need a clear understanding of the conflicting views on sustainability and on ICT/S in research. More precisely, we see a need to understand how these views are justified, in order to build, using Michel Fabre’s (a French philosopher of education<sup>2</sup>) terminology [15], not only a *map* of disagreements, but also a *compass* pointing to the roots of these disagreements.

In this paper, we specifically focus on the ICT4S research community. We first argue (Section III) that choices made regarding the definition of sustainability and of ICT/S are (not only, but also) political. To support our claim, we mostly rely on literature from the Science and Technology Studies (STS) field. We then investigate whether these choices are explicitly justified in recent papers published at ICT4S. For this purpose, we propose in Section IV a model for the problematization process of ICT/S research papers in the ICT4S community. Section V describes our systematic review of the introductions of all papers published at ICT4S since 2020 to study the level of explicit justification in their problematization process. We observe that most papers are justified in similar ways, usually matching what one could call Green IT and Green by IT approaches. We also observe that many papers do not justify at all their view of sustainability.

While our work was motivated by the need to help teachers better navigate the state of the art in ICT/S education, we believe it is relevant for the ICT4S community itself, as a better understanding of how our own values influence the research we do in the ICT/S field would represent a first step towards an improved relationship between science and society. Section VI discusses possible actions the ICT4S research community and ICT/S teachers can take in light of our findings.

## II. RELATED WORK

We identify as related work particularly relevant for us the following types of papers:

- Literature surveys on the ICT/S research landscape which systematically study published papers in order to provide an overview of the research field.
- Papers that focus on the wicked, political, systemic, holistic, nonneutral aspects of ICT/S research in a broad sense, and provide a critical view on the standard framing of research in ICT/S related research communities.

To build this related work, we identified relevant papers by analyzing proceedings of ICT4S conferences since 2018, and of the LIMITS workshops since 2020. We added papers from the Sustainable Human-Computer Interaction (SHCI)

<sup>2</sup>Numerous references used in the present article are in French, due to a better familiarity we had with this literature, and the existence of an active French speaking research community in educational sciences and science and technology studies. We reference English translations when available.

landscape, and older ICT4S papers, that we knew from prior research to be relevant. Note that more discussions regarding political aspects of ICT/S exist in the Sustainable Human-Computer Interaction (SHCI) landscape, e.g., [16], [17], which might represent relevant related work to investigate further.

### A. Previous literature reviews

There have been over the years several surveys analyzing the diversity of approaches in some ICT/S-related research fields. These surveys focus on how researchers conceptualize sustainability [7], or on their view of the relationship between ICT and sustainability and related leverage points [8], [10], [18]–[20]. The present article differs from these works in that we do not provide a thematic analysis of the various stances on ICT/S in the ICT4S community. What we seek is to analyze the process by which these positionings are justified.

In [7], the authors analyze, like us, how ICT4S papers published before 2018 justify their research. One major difference with our work (apart from the fact that the paper was written some time ago) is that it ranks justifications over a normative scale that is meant to reflect the authors’ motivations (e.g., if sustainability is only used as an opportunity for research, if it is the premise of the research, ...). We, on the other hand, focus on the extent to which authors explicitly acknowledge their choices, rather than their motivations.

Finally, [16] provides an analysis of the debates that have taken place over time within the SHCI landscape. Our focus is different, as we are interested in regular papers, in which positioning is more easily implicit, rather than position papers.

### B. Related work related to the wicked nature of ICT/S

Calls have been made in ICT/S research to tackle ICT/S-related problems through systemic and holistic approaches, as identified in SHCI by [16]. We found similar calls in the ICT4S community, asking for epistemologic shifts [2], changes in professional practices [4], and alternative environmental evaluation methods<sup>3</sup> [3], [5]. To better assess the systemic effects of technology, [5] recommends involving various stakeholders in the design process. This approach is also promoted by [22], and in the LIMITS community, e.g., in [23]<sup>4</sup>.

As we will argue in Section III, analysis through systems thinking and involvement of stakeholders can help addressing wicked problems such as those related to ICT/S. But they do not provide specific means to understand and/or handle the conflicting aspect of decision-making. This is acknowledged explicitly in [23] for example: “*Finally, our proposal doesn’t address issues related to ideological beliefs. Indeed, even if decision makers have a holistic view of [...] impacts, the final decision can privilege economic profits over environmental and/or social sustainability.*” (p.8)

<sup>3</sup>Note that, while part of this literature disputes the relevance of using ICT to tackle wicked problems, some argue that under certain conditions ICT can still prove useful [21].

<sup>4</sup>In the LIMITS community, the extension of this practice to include other-than-humans in the process has also been called for [24].

### III. ICT/S AS A POLITICAL PROBLEM

Let us now clarify what we call politics and justify why ICT/S as a research field holds a political dimension. Our objective here is not to cover the topic, or even to provide an overview of how ICT/S can be political. We merely intend to show that there is a political dimension to ICT/S as a research problem, that researchers from the ICT4S community cannot escape, and that they should not ignore.

#### A. Concepts for analyzing the political dimension of ICT/S

While the concept of ‘politics’ itself is the subject of an involved academic debate [25], we adopt here, based on [14], the following definition: is political what is involved in conflicts between stakeholders during a decision-making process about common life matters. These conflicts come from disagreements over values, missing knowledge, diverging interests, existing power relations, and so on.

To better understand the relationship between ICT/S research and politics, we found the following concepts useful: *wicked problems*, and *controversies*.

1) *Wicked problems*: The concept of *wicked problem* [26] emerged in systems theory planning and policy sciences in the 70s, to describe problems that are difficult to handle, in particular because of their complexity, their uncertainty, their ambiguity, and because of strong disagreements between stakeholders [27]. They can be approached in different ways, as problems for which knowledge is lacking, as problems that one needs to understand through systemic thinking, or as problems with deep stakeholder disagreement [27].

2) *Controversies*: Science and Technology Studies (STS), which focus on “*the entanglement through history between what we know about the world, what we want to do in it, and how we govern it*” [28, our translation] (p.3), have studied such disagreements via the notion of controversy [25]: “*A controversy is a moment in which a disagreement between multiple stakeholders – each party involving specialized knowledge and none managing to impose certainties – is performed in front of a third party. A controversy is characterized by a tangled web of various interests, facts and values, and moreover are at stake definitions of what is technology and what is social.*” [29, our translation] (introduction, p.6)

#### B. The political dimension of sustainability

As stated in [30], which provides a review of the definitions of sustainable development and sustainability, “*the debate about the meaning of sustainability is far from being closed.*” (p.10) In the economic field, for example, two notions of sustainability coexist, referred to as weak and strong sustainability resp., depending on “*whether one believes that natural capital [...] should be afforded special protection, or whether it can be substituted by other forms of capital.*” [31] (p.3). Social values play here a significant role in this debate. Another example of the political dimension of sustainability is the two degree climate target, which is “*the outcome of a scientifico-political coproduction [...]. Incidentally, the focus on a unique number raises a few problems, as the number represents a “black box”*

*that hides the power struggles and the scientific controversies of its construction.*” [32, our translation] (p.151)

More generally, sustainability-related issues are widely considered *wicked problems* in sustainability sciences and environmental policy making<sup>5</sup> [34]. In other words, choosing a specific definition of sustainability in research cannot be based on scientific criteria alone, and holds a political dimension.

#### C. The political dimension of ICT

How does ICT fit into this debate? Let us start by recalling the political dimension of ICT itself, which is clear from a philosophy of technics perspective. As Langdon Winner<sup>6</sup> puts it in his article entitled *Do artifacts have politics?* [37]: “*The issues that divide or unite people in society are settled not only in the institutions and practices of politics proper, but also, and less obviously, in tangible arrangements of steel and concrete, wires and semiconductors, nuts and bolts.*” (p.128)

STS have analyzed various political dimensions of ICT. For example, Jatón and Vinck [38] have done so using work by Bruno Latour [25] which presents five meanings of *politics*, corresponding to different levels of controversy. Based on this definition, *algorithms* (meant here in a very broad sense, including e.g., programs, ICT, artificial intelligence ...) can be considered as political in various ways:

- They are *political*<sup>(1)</sup> objects, that through their existence change our view of the world and our ways to interact;
- They are constructed following *political*<sup>(5)</sup> norms, i.e., normalized habits; e.g., the use of computational thinking to tackle problems [2] is one such norm;
- They create *political*<sup>(2)</sup> issues, e.g., algorithmic bias, raising concerns among certain groups of people;
- Governments regulate them with *political*<sup>(4)</sup> procedures (e.g., the Algorithmic Accountability Act or the AI Act), that is, using democratic rules to address problems;
- The political dimension that they are missing according to Latour’s typology is the *political*<sup>(3)</sup> agonistic moments that would have clarified allies and adversaries in the controversy.

#### D. The political dimension of scientific research

We have so far addressed the political dimension of the notion of sustainability, and that of ICT. A third political dimension of ICT/S as a research problem is epistemologic.

It is well known in philosophy of science that social values play a role in the construction of scientific knowledge, thus influencing how science contributes to society. This is acknowledged for example by the IPCC regarding climate science: “*Social values may enter climate change research on many levels, such as setting the aim or purpose of studies, formulating research questions, constructing and evaluating models and communicating results. [...] Different sets of choices may prioritize and thereby benefit the interests of some*

<sup>5</sup>Climate change-related policies have even been named a *super wicked problem* [33].

<sup>6</sup>Although some of Langdon Winner’s work has been criticized [35], the quote that we use here clearly represents a view widely shared in STS. For a general introduction to the field, see [36].

stakeholder groups over others.” [39] (p.2) In other words, science is not neutral. And in fact, “given that science, especially through the technologies it enables, has a tremendous impact on society and nature, that it disrupts ways of life and living arrangements in a manner that is more revolutionary than any political revolution, should we not consider it as a political force, or at least as a social force in the melee? [40, our translation] (p.133)

In this paper, we restrict our focus to the problematization phase of the research process, i.e., the choice of research topic and questions. In that regard, the concept of *undone science* [41] emphasizes the political nature of that phase in relation to what we choose, as researchers, to study, and what we choose to ignore. Examples of undone computer science in relation to sustainability have been presented at a dedicated conference in 2024 [42], e.g., [43], [44].

#### E. The political dimension of ICT/S

It should be clear from the previous discussion that there is a political dimension to the ICT/S research problems. STS have recently started studying it<sup>7</sup>, e.g., regarding the interaction between (green) energy production and digital infrastructures [46], [47], the use of ICT in agriculture [48], or conflicts surrounding the establishment of data centers in urban areas [49]. As mentioned in Section II, we believe that this dimension is missing in the ICT4S community, at least when considered through the lens of potential conflicts between viewpoints. The present paper is an attempt at introducing it into the ICT4S community.

### IV. PROBLEMATIZATION IN THE ICT4S COMMUNITY

Now that we have clarified the political dimension of the ICT/S-related problems, we want to focus on the ICT4S research community. Specifically, we are interested in how recent ICT4S papers justify (or not) their research questions with respect to sustainability in general, and ICT/S in particular. For this purpose, we build upon Fabre’s problematization theory [50], and draw inspiration from Hilty and Aebischer’s seminal paper [51] on the emergence of the ICT4S research field to propose a model of the problematization process of ICT/S research papers in the ICT4S community.

#### A. What does problematization mean?

We rely on Michel Fabre’s problematization theory [15], [50] which is mainly an interpretation of John Dewey’s theory of inquiry in the context of didactics and education sciences.

What Fabre calls problematization is “a) the study of a question; b) through thinking that articulates data and conditions relative to the problem, in a specific framework; c) through thinking that watches itself; d) from a heuristic perspective.” [50, our translation] (p.18) More specifically, a problem is built in 3 non-sequential steps (Fig. 1):

<sup>7</sup>See e.g., the CIS-PEN [45] working group, whose research program states: “The relationships between digital technologies and the environment are political, in the sense that they are linked to technical and economical choices made in the name of values such as availability, security, speed, profit...”

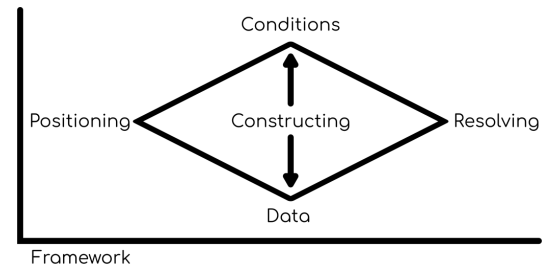


Fig. 1. Losange of problematization from [50], translated to english

- positioning, i.e., identifying that something is wrong;
- constructing, i.e., finding the right question; and
- resolving, i.e., coming up with a *solution*.

Fig. 1 reflects the cognitive and dialogic process through which someone problematizes a given problem, negotiating with conditions of the problem and data that can be relevant to tackle it (vertical dimension), focusing on the construction of the problem, but also questioning its positioning and potential solutions (horizontal dimension).

We are particularly interested in the notion of *framework*, which is the normative instance that gives to data, conditions and solutions their respective status. In scientific research for instance, this matches Thomas Kuhn’s notion of *paradigm* [52]. Social values play a role in framework definition, even in scientific research, as explained in Section III.

Disagreement between stakeholders can appear 1) regarding the choice of framework, or 2) inside a given framework, regarding what data and constraints are relevant, leading to various problem constructions and solutions. Such conflictuality is more central to some problems than others, with *cartesian problems* (called *tame problems* in the wicked problems literature) being at one end, and *wicked problems* at the other [53]. Critics made by Easterbrook in [2] and Zapico in [3] can be understood as a disagreement about using cartesian frameworks, *computational thinking* and *data-driven analysis*, to problematize wicked problems.

#### B. ICT for Sustainability, as described in [51]

As a starting point for our discussion on problematization in the ICT4S scientific community, we use the seminal article *ICT for Sustainability: An Emerging Research Field*, written by Hilty and Aebischer (2015) [51] as an introductory chapter to a book presenting the results of the first ICT4S conference of the series, which was held in 2013 and organized by the authors of [51]. We believe that this article presents an informed view of the positioning of the ICT4S community at the time, which remains relevant today.

The paper first provides a definition of sustainability, then a definition of the ICT for Sustainability (ICT4S) research field, mentioning also the various contributions that ICT4S research can make to sustainability and the various scientific paradigms that can be used. We now proceed to briefly rephrase this description in light of Fabre’s problematization theory, while

also commenting on how other choices could have been made based on other political views.

1) *What is sustainability?*: First, building upon the Brundtland definition of sustainable development [54], Hilty and Aebischer choose a definition of sustainability in terms of global resource management for fulfilling human needs, with an emphasis on distributive justice: “*the idea is to fulfill human needs and make sustainable use of global resources.*” (p.7) This is what we could call the general framework of ICT4S, which we denote  $Sust^{res}$  in the rest of this section. Building upon the precautionary principle, in particular regarding the assumption that human-made capital can substitute all natural resources, Hilty and Aebischer explicitly restrain the  $Sust^{res}$  framework to a more restrictive strong sustainability framework (denoted here  $Sust^{str}$ ), in contrast to a weak sustainability framework in which substitutability is considered possible<sup>8</sup>.

The fact that definitions of sustainability other than  $Sust^{res}$ , and therefore other problematization frameworks for ICT/S, could have been used, is partially acknowledged but not discussed in [51]. In particular, the authors state that there can be controversies surrounding what is sustainability, but add that  $Sust^{res}$  is the “*absolute concept of sustainability.*” (p.5) We argue that this framework is not universal, as it does not e.g., take into account more ecocentric approaches. For instance, an alternative framework is Latour’s *Green city*, a notion from political ecology building upon Kant’s moral philosophy, in which non-human entities such as biotopes and rivers are considered not simply as means (i.e., resources), but also as their own ends [55]. This view, which we call  $Sust^{city}$ , cannot fit into  $Sust^{res}$  as a subframework, and the conditions, data and solutions of the problematization process of a sustainability issue in  $Sust^{res}$  and  $Sust^{city}$  is radically different. In other words, if the  $Sust^{res}$  framework is chosen, then some solutions that would be valid in  $Sust^{city}$ , e.g., giving legal rights to non-human entities like rivers, are excluded, and conversely.

2) *What is the relationship between ICT and sustainability?*: The definition of sustainability provides the framework for what we see as the next step in the problematization process of ICT4S research, which is how the relation between ICT and sustainability is considered in this field of research. This relation is well summarized in [51] by the phrase “*sustainable development is seen a societal transformation, and technological impacts are interesting mainly for their transformational aspect.*” (p.21) This framework, which we call  $ICT/S^{tr}$ , builds upon the assumption that “*The transformational power of ICT can be used to make our patterns of production and consumption more sustainable.*” (p.21)

Note that the  $ICT/S^{tr}$  framework does not seem to accept solutions of the form “ICT should be removed”, as can happen

<sup>8</sup>Note that the use of the term *strong sustainability* can be in itself subject to debate, since it is here framed by  $Sust^{res}$ . People could claim this terminology for more ecocentric approaches [30].

while studying the negative transformational power of ICT<sup>9</sup>, for example in the oil and gas industry [56]. In other words, the view that ICT could be used in a relevant way to make the world more sustainable is not justified in [51], although it is not universally shared. For instance, a concurrent viewpoint could be that society should use less ICT in general, given the risks that ICT can represent in terms of resilience<sup>10</sup> [57]. The main difference between this view and  $ICT/S^{tr}$  is of a normative nature, regarding the trust one has in the consequences of using technology.

In addition, the *Lifecycle, Enabling, Structural* (LES) model, which aims at better understanding and analyzing the interactions between ICT and sustainability at various scales, can be seen as a sub-framework of  $ICT/S^{tr}$ , as it restrains even further the understanding one could have of the framework. As an alternative viewpoint, one could argue that adding layers of effects over the introduction of a technology through a consequential approach does not take into account how much that technology and its effects are shaped by the social context of its production (as abundantly studied by STS).

3) *How can ICT research contribute to sustainability?*: There are many ways to “*harness ICT for the benefit of sustainability*” (p.4) and some of them are listed in Table 3 of [51]: increasing the longevity of devices, reducing the environmental impacts of ICT hardware and software, enabling sustainable patterns of production, promoting sustainable behavior... These can be seen as leverage points, and are classified into Sustainability in ICT and Sustainability by ICT. Note that what the LES model determines is that, according to [51], for these leverage points to be considered effective, one should look at the effects of technology at a global scale.

4) *Which scientific contribution to choose?*: For research to practically contribute to a given leverage point, researchers must identify research questions and a relevant scientific paradigm [52] to answer them. There are multiple scientific paradigms at play in the ICT4S community, as stated in [51]: “*The methods used in ICT4S are as varied as the disciplines contributing to it.*” (p.21) These have been classified into 3 main categories : assessment methods, empirical methods from the social sciences and modeling/simulation.

While we acknowledge the role of social values in the choice made by researchers during this last step, we leave its analysis out of the scope of the paper. This is mainly motivated by the idea that the role of social values in the choice of a paradigm tends to be more implicit than for the other steps (cf. the political<sup>(5)</sup> norms presented in Section III-C), making an analysis significantly more difficult. We believe the main point of this paper does not require such an analysis.

<sup>9</sup>The expression “*Harnessing this technology for sustainable development*” (p.21) used in the paper to describe the aim of the first ICT4S conference does indicate that the focus was on increasing the positive transformational effects of ICT rather than addressing its negative ones. Negative impacts of ICT seem to be considered only as side effects of attempts at using ICT to achieve positive transformational effects.

<sup>10</sup>It is worth noting that such a study could have its place in a community like ICT4S, although resilience hardly appears to be mentioned at ICT4S.

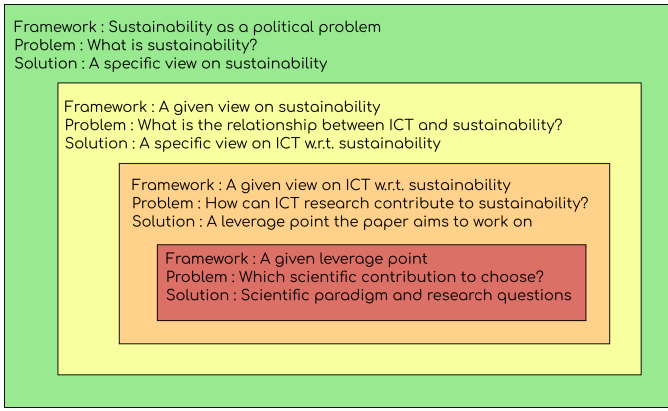


Fig. 2. Model of problematization process derived from [51]

### C. Proposal: a problematization process for ICT4S papers

Based on the discussion in the previous section, we now propose a model of what the problematization process may typically look like in papers published in the ICT4S research community. This problematization process consists of four nested problematization steps, where the problem addressed is, respectively:

- 1) *What is sustainability?* A solution to this problem is a specific view of sustainability.
- 2) *What is the relationship between ICT and sustainability?* A solution to this problem is a specific view of ICT/S.
- 3) *How can ICT research contribute to sustainability?* A solution to this problem is a specific leverage point for ICT research to contribute to sustainability.
- 4) *Which scientific contribution to choose?* A solution to this problem is a specific scientific paradigm and a list of research questions.

Fig. 2 is an illustration of this problematization process. The nested structure represents the fact that the framework for problem  $i + 1$  is the solution of problem  $i$ . We call *justification* for problematization step  $i$  the dialogic process taking place within framework  $i$  which leads to a solution that can then be used as framework  $i + 1$  for the next problematization step. In practical terms, these *justifications* combine to form *chains of justification*. These usually appear in the introduction of ICT4S papers as the motivation for research. They guide the reader from an initial motivation regarding sustainability all the way to research questions. The next section provides an analysis of these chains of justification in ICT4S papers.

## V. CORPUS ANALYSIS

Based on the model that we proposed in Section IV to characterize the way researchers in the ICT4S community build their research problems, and having established in Section III that such problems are partly of a political nature, we analyzed papers recently published at the ICT4S conference to address the following questions:

**Q1** Does our proposed problematization process fit recent ICT4S papers?

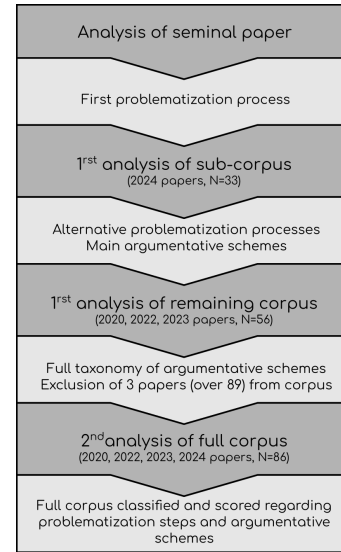


Fig. 3. Overall process of corpus analysis

**Q2** To what extent are choices made at each step of the problematization process explicit in these papers?

### A. Dataset

We analyzed research papers (excluding doctoral symposium, posters and workshops) published at ICT4S since 2020<sup>11</sup>, considering 5 years as a relevant threshold to consider research as recent. This represents a corpus of 89 papers, from which we removed 3 papers for technical reasons<sup>12</sup>, so that the corpus that we did analyze consists of 86 papers.

We were interested in the problematization process of the papers in the corpus, so we chose to restrict ourselves to the abstracts and introductions of papers<sup>13</sup>, assuming that this is where the problematization process would be presented. This choice is more extensively discussed in Section V-D.

### B. Methodology

We investigated the first three steps of the problematization process represented in Fig. 2, namely: 1) *View on sustainability*, 2) *View on ICT/S*, and 3) *Leverage point*. As already mentioned, we did not study the 4) *Scientific contribution*.

We analyzed the corpus using a mixed deductive and inductive approach, following methodological recommendations for qualitative content analysis [62]. The overall process of corpus analysis is summarized in Fig. 3. Discussions between the authors took place at each step of the analysis process.

The starting point of our analysis was deductive, building upon the following hypotheses:

<sup>11</sup>This represents 4 ICT4S conferences since there was no event in 2021.

<sup>12</sup>One paper [58] had an unconventional structure with no introduction that we could analyze. A second paper [59] did not refer to any obvious sustainability related concept in the introduction. Finally, a third paper [60] did not refer directly to (a conventional sector of) ICT in the introduction.

<sup>13</sup>We made one exception for [61], in which background information is presented as a subsection of the introduction. To be consistent with the other papers, we did not include this background subsection in our analysis.

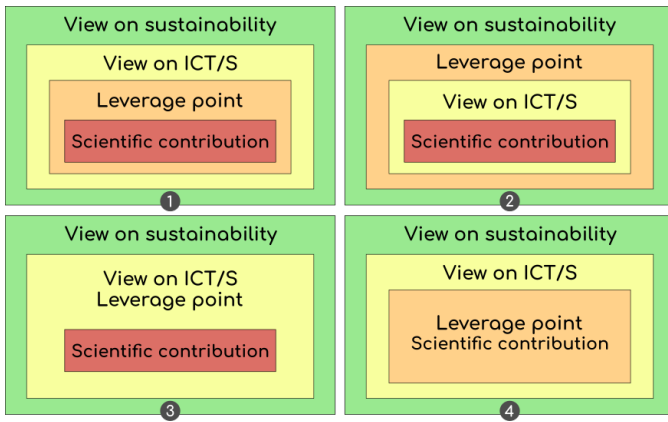


Fig. 4. Various problematization models resulting from content analysis. (1) Original one as in Fig. 2, (2) Contextualized ICT/S, (3) Discussion regarding ICT/S, (4) Global methodology.

- 1) The problematization process characterized in Section IV provides a useful model to analyze the introduction of papers in the corpus;
- 2) It is possible to evaluate the level of justification of each problematization step.

We started with an analysis restricted to the papers published at ICT4S 2024. We proceeded first by annotating each paper, looking for the *chain of justification* provided to motivate the research question answered in the paper, and highlighting sentences that matched one of our first three problematization steps. We found out that, in many cases, it was difficult to identify which part of the chain of justification corresponded to Step 2, and which part to Step 3.

We thus moved on to an inductive approach, where we looked for recurring structures in chains of justification, which we call *argumentative schemes*. We found that some of these schemes did not match our proposed problematization process (which answered **Q1**), and thus proposed three alternatives to complement our proposed model. Equipped with this taxonomy of argumentative schemes and our updated model (made of 4 variants) of the problematization process, we were then able to systematically split chains of justification into problematization steps. Finally, we could then evaluate, for each problematization step of each paper, a level of justification (thus answering **Q2**) with a 3-level evaluation score<sup>14</sup>:

- *Low score*: No justification is explicitly given, or only as an unsourced claim.
- *Medium score*: A justification is given, but not in contrast with other ways to problematize the same step.
- *High score*: A justification is given with respect to other ways to problematize the same step.

### C. Results

Let us now present in some detail our results, namely:

<sup>14</sup>There was initially a fourth level for situations where no mention at all of the step under analysis is made. As such cases were rare, we decided to include them into the *low score* level.

- 1) the argumentative schemes that we identified;
- 2) our updated problematization process model;
- 3) the scores that we found regarding the level of justification for each problematization step.

1) *Argumentative schemes*: Table I summarizes the taxonomy of argumentative schemes that we propose based on our corpus analysis. All schemes start with a first argument regarding what sustainability is and why it is important. This would be step 1) for all schemes, not represented in the table, and it matches the *View on sustainability* step of the problematization process. After that, all argumentative schemes except D.1 and D.2 proceed in 2 steps (cf. column 2 of Table I), which correspond to the *View on ICT/S* and *Leverage point* steps of the problematization process, as explained later. The fourth column of the table shows the number of papers corresponding to each scheme.

Categories of argumentative schemes (i.e., A, B, C and D) relate to similarities in the finality of papers. Category A accounts for papers trying to improve the ICT sector<sup>15</sup>. Category B contains papers which strive to mitigate sustainability issues outside of the ICT sector. Category C papers focus on a way to transfer knowledge. Category D is about a more global discussion regarding ICT/S.

To better illustrate these argumentative schemes, let us use examples taken from the two major argumentative schemes.

- For scheme A.1.2, we will use [63]. As a first step, the paper is characterized by a *View on sustainability* focusing on Greenhouse Gas (GHG) emissions. As a second step, its *View on ICT/S* is described by the fact that “*ICT represents between 1.8% and 3.9% of the global [GHG] emissions.*” (p.1) Finally, as a third step in their justification, they argue that “*mobile networks constitute a large part of the ICT sector;*” (p.1) their proposed *Leverage point* thus being a focus on the mobile network sector.

- Regarding scheme B.1, let us use [64]. As the first step, the authors also rely on a *View on sustainability* as a problem of energy consumption and associated GHG emissions. Their second step is an argument that “*buildings consume a significant amount of energy, accounting for approximately one-third of global energy consumption*” (p.1) thus pointing to a *Leverage point* for tackling sustainability issues that would be a focus on buildings. Finally, the adopted *View on ICT/S* is an argument that ICT-related devices can provide “*monitoring capabilities in buildings.*” (p.1)

2) *Problematization process*: As an answer to **Q1**, the problematization process proposed in Section IV was challenged by the identified argumentative schemes. Indeed, in some argumentative schemes, the *Leverage point* was justified first, independent from ICT, and the *View on ICT/S* was justified in the context of that leverage point. This is shown in column 3 of Table I. In other papers, the framework itself was the object of study. We therefore came up with alternative problematization processes (3 more in total), as illustrated in Fig. 4.

<sup>15</sup>Note that schemes A.1.1 and A.1.2 have in common that they focus on a specific subsector of ICT, in contrast to other A papers.

TABLE I  
STRUCTURE OF THE ARGUMENTATIVE SCHEMES FOUND IN THE CORPUS WITH THE CORRESPONDING NUMBER OF PAPERS CLASSIFIED

Scheme ID	Structure of the argumentative scheme	Problematization step	# of papers
A. ICT has a negative impact w.r.t sustainability that we try to mitigate			
A.1.1	2) A specific subsector of ICT has a negative impact w.r.t. sustainability 3) This subsector is key and/or growing in society so we want to reduce its impact	View on ICT/S ↳ Leverage point	14
A.1.2	2) ICT in general has a negative impact w.r.t. sustainability 3) A specific subsector of ICT represents a large share of the overall ICT impact so we want to reduce its impact	View on ICT/S ↳ Leverage point	20
A.2	2) ICT in general has a negative impact w.r.t. sustainability 3) We focus on the impact of specific stakeholders of the ICT sector	View on ICT/S ↳ Leverage point	5
A.3	2) A (non ICT specific) leverage point exists to contribute to sustainability 3) We apply this leverage point to the ICT sector	Leverage point ↳ View on ICT/S	4
B. A specific sector of society other than ICT has an impact w.r.t. sustainability and ICT has a role to play			
B.1	2) A specific sector of society must reduce its negative impact on sustainability 3) We study how ICT can help mitigate the impacts of that sector	Leverage point ↳ View on ICT/S	22
B.2	2) A specific sector of society must reduce its negative impact on sustainability 3) We study how ICT is used in that sector to amplify its impact	Leverage point ↳ View on ICT/S	1
B.3	2) Better evaluation of sustainability issues can contribute to sustainability 3) ICT can be used as a tool for better evaluation	Leverage point ↳ View on ICT/S	1
B.4	2) ICT can help various economic sectors improve their impact w.r.t. sustainability 3) We focus on specific stakeholders to enable this change	View on ICT/S ↳ Leverage point	1
C. ICT has an impact w.r.t. sustainability and specific social groups need to better understand it			
C.1	2) ICT has an impact w.r.t. sustainability 3) We help some decision makers understand better the impacts of ICT w.r.t. sustainability, so that they contribute to sustainability	View on ICT/S ↳ Leverage point	3
C.2	2) ICT has an impact w.r.t. sustainability 3) We help students understand better the impacts of ICT w.r.t. sustainability, so that they contribute to sustainability	View on ICT/S ↳ Leverage point	4
D. Contribution at the framework level			
D.1	2) Conceptualization of the ICT/S framework: survey or new proposal	Not analyzed	5
D.2	2) Evaluation of the impacts of ICT w.r.t. sustainability: new results or new evaluation methods	Not analyzed	6

TABLE II  
LEVEL OF JUSTIFICATION (LOW, MEDIUM, HIGH) FOR EACH PROBLEMATIZATION STEP

Scheme	Sustainability			ICT/S			Leverage point			Total
	Low	Medium	High	Low	Medium	High	Low	Medium	High	
A.	23	16	4	12	25	6	9	21	13	43
B.	14	10	1	2	15	8	9	5	11	25
C.	1	5	1	1	2	4	1	4	2	7
<b>Total</b>	<b>38 (51%)</b>	<b>31 (41%)</b>	<b>6 (8%)</b>	<b>15 (20%)</b>	<b>42 (56%)</b>	<b>18 (24%)</b>	<b>19 (25%)</b>	<b>30 (40%)</b>	<b>26 (35%)</b>	<b>75</b>

- Schemes that fit well into the original process (process 1 in Fig. 4) are: A.1.1, A.1.2, A.2, B.4, C.1 and C.2 (47 papers out of 86). Most of them correspond to what is usually called *Green IT*, in particular A.1.1 and A.1.2.

- Most of the other papers (28 out of the remaining 39), corresponding to argumentative schemes A.3, B.1, B.2 and B.3, fit problematization process 2 in Fig. 4. These schemes mostly correspond to what is usually called *Green by IT*, in particular those fitting the B.1 scheme.

- The remaining 11 papers are either: 1) discussions about

the role of ICT with respect to sustainability, i.e., about the *View on ICT/S* step, (corresponding to scheme D.1 and problematization process 3 in Fig. 4); or 2) global assessments of the ICT sector or generic evaluation methods, the *Leverage point* being at least partially merged with the *Scientific contribution* (scheme D.2 and problematization process 4).

3) *Level of justification for each scheme at each step:*  
As an answer to Q2, the level of justification of the *View on sustainability*, *View on ICT/S* and *Leverage point* problematization steps were evaluated on the 75 papers fitting

problematization processes 1 and 2. We did not consider the 11 papers corresponding to schemes D.1 and D.2, as they had only 2 problematization steps.

As explained in Section V-B, what we call level of justification here corresponds to a 3-level scoring, with *low* meaning that no justification is explicitly given, *medium* that a justification is given but not in contrast to other ways to problematize, and *high* that it is given with respect to other ways to problematize. Note that this does not reflect the effort that has been put into these justifications, given that we do not account for their quantity nor their quality. We only observe what is explicitly justified.

The results can be found in Table II<sup>16</sup>. We group the results by family of argumentative scheme (i.e., A, B and C).

- *View on sustainability*: About half of the evaluated papers have a *low score* and less than 10% have a *high score*. This could be due to the preconception that sustainability is a well-known concept that does not require explanation, unlike what we have argued in Section III. To give a *medium* or *high* score, we relied on the presence of various types of justifications, for instance mentioning specific consequences of sustainability issues, objectives or requirements set by public policies, or using bibliographic references to support the choices made.

- *View on ICT/S*: Most papers justify explicitly their view, but not in contrast to others views<sup>17</sup>. Besides, we observe different levels of justification depending on the argumentative scheme. For example, the level of justification is much higher for scheme C than for scheme A. This is not that surprising, given the finality of scheme C papers (explaining the relationship between ICT and sustainability to non-specialists).

- *Leverage point*: Typical arguments to justify a given leverage point are based on figures quantifying the share of some global sustainability indicator associated with the identified leverage point, or refer to growing concerns, that the identified leverage point tackles. The *Leverage point* step is probably the most difficult to compare between argumentative schemes, since it can be of very different nature. For instance, scheme B has many *high level* scores, which can be explained by the numerous papers fitting this scheme that deal with *Green by IT* approaches, where the leverage point is a sector of society that has sustainability issues. The justification usually focuses on why a specific sector of society deserves particular attention. Scheme A corresponds to fewer *high score* papers, possibly because reducing ICT's direct footprint is seen as a relevant end by itself. Why scheme B also has a significant number of *low level* scores for the same step is harder to analyze, maybe due to more heterogeneous reasons.

#### D. Trustworthiness and limitations

While some argumentative schemes are common and many papers were easy to classify, e.g., those corresponding to A.1.1,

<sup>16</sup>For readability, the opacity of table cells is proportional to the percentage of papers indicated in the cells (w.r.t. the total number of papers, i.e., 75).

<sup>17</sup>A high score would be given for example to a B.1 paper explaining why an ICT-based solution is a better way to address a given problem compared to non-ICT solutions.

A.1.2 and B.3, some other papers were harder to analyze. In some rare cases, several argumentative schemes seemed to match a paper, as a given step in the chain of justification in that paper could be mapped to different problematization steps. When that happened, we logged the reasons of our choice and made sure to follow the same rules for similar papers. Besides, for some papers the structure of the chain of justification was more complex, e.g., with more than four steps, and sometimes the logical structure of the justification was not linear. Still, these cases could be assigned to an argumentative scheme without misconstruing their justification. More information can be found in the supplementary material.

Note that some argumentative schemes are quite similar, e.g., C.1 and A.2. One may possibly argue that the distinction is not warranted. In that case, we made this choice to distinguish between knowledge production for specific stakeholders on the one hand, and knowledge transmission on the other hand. Whether we classify a given paper as belonging to one or the other scheme does not modify its score, as the problematization steps would be the same.

The scope of the analysis, which has been limited to the abstract and the introduction of papers, represents a limitation of our study, as taking into account the conclusion and discussion sections might have proved useful. A first reason of this choice is of a practical nature, as the complexity of the analysis increases rapidly with the amount of text studied. Second, we found interesting to focus on what authors deemed important to include in the introduction of their paper. The third reason is of a normative nature, as we would like justifications to be found in the introduction of papers to make it easier for external readers to understand quickly their positioning.

Lastly, let us emphasize the fact that our study intends to analyze what is explicitly justified in papers and what is not, and does not make any claims regarding the views that authors of papers may hold. In addition, while we do have our own views on how research questions should be framed, our intent in this paper was not to advocate for one specific representation of sustainability or of ICT/S; our intent was to advocate for a more open discussion of the social values underlying ICT4S research.

## VI. DISCUSSION

While our original motivation for this work was ICT/S education, we believe that our findings also provide some insights for the ICT4S community itself.

### A. Some possible actions for the ICT4S community

In their review of the debates within the Sustainable Human-Computer Interactions (SHCI) community, Bremer et al [16] posit that SHCI lost itself trying to agree on a common definition of sustainability. We argue that what the ICT4S community needs is not a common definition of sustainability and ICT/S, but a common culture and a concerted effort to confront our views (and those of other stakeholders outside the research community as well) about these notions.

1) *Improving the problematization effort*: Our results show that recent ICT4S papers rarely explicitly acknowledge the political dimension of the notions of sustainability and ICT/S that motivate their research questions. In this paper, we have argued that more effort should be invested by the community in the problematization process that is presented in the introduction of papers. This would have multiple benefits, for the authors (a better understanding of what their research contributes to in general, and not only with respect to the scientific questions at stake [17]) and for the research community.

One may worry that our call for researchers to take a stand on the political issues that underlie their research questions may blur the line between scientific research and politics. Based on some basic knowledge in epistemology, we argue the contrary. As Berlan explains in [40], Max Weber, in his seminal work on *value-free science*, does not present it as an endeavor to refrain from making value judgements, but as an effort to avoid conflating facts and values<sup>18</sup>. Rather than an ideal of scientific neutrality that is out of reach, Berlan then concludes by calling for researchers to develop more *insight*, by which he means both the ability to get a broad understanding of the consequences of their research and the reflexive ability to analyze their own biases and interests. We concur with that view. Berlan adds that gaining such insight is at odds with the extreme specialization that has come to characterize scientific research.

2) *Getting familiar with STS*: As already mentioned, Science and Technology Studies [28] provide a useful academic reference to better understand the complex relationship between science and politics, for example regarding the impact of the production of data and quantification [65]. In addition, STS focusing on specific ICT/S issues offer a contrasting view of how such problems can be approached compared to ICT4S, e.g., with a focus on the material reality of ICT and the conflicts surrounding its development.

Of course, getting even a basic understanding of the main concepts of STS is not an easy task for computer scientists, most of whom have had no (or limited) training on the subject during their studies. Acknowledging the need for interdisciplinary forums that are open and welcoming to researchers who want to get familiar with STS, several initiatives have been set up in France over the past few years, e.g., the Undone Computer Science [42] conference<sup>19</sup> and the CIS-PEN [45] working group. To follow this trend, the ICT4S community might aim at involving STS specialists in the conference.

3) *Providing a forum for discussing conflicting views*: Our model of the problematization process for ICT4S papers could provide a useful basis for characterizing recurrent critics (and their potential response), in particular regarding its *View on sustainability*, *View on ICT/S* and *Leverage point* steps. The

<sup>18</sup>“And behind this requirement, there is a double critical intention, against those who misrepresent reality because it upsets their ideals, but also against those who mask their ideological positions by pretending they let the facts speak for themselves.” [40, our translation] (p.138-139)

<sup>19</sup>The goal of the UCS conference is “to provide an opportunity to pause and reflect on the epistemological and ethical aspects of computer science.” [45]

argumentative schemes and their critics could for example be analyzed using tools from informal logics or related fields (e.g., argumentation theory, critical thinking, theory of reasoning, and so on) [66]. Furthermore, tools from the STS and its pedagogy, which are designed for the analysis of conflicts, could be of great help to better understand social dynamics of this situation of disagreement, e.g., the *Mapping controversies (Cartographie des controverses)* [29].

Last, but not least, providing a forum for discussing conflicting views at ICT4S requires an understanding that the format and the context in which such conflicting views are exchanged are as important as the quality of the arguments. The Ateliers SEnS<sup>20</sup> workshops [67] might provide a useful source of inspiration for the ICT4S community.

### B. Some possible actions for ICT/S education

As our initial motivation was teaching, we now discuss how our work fits into debates regarding teaching and education.

Topics such as ICT/S, for which didactical transposition [12] is difficult due to uncertainties at the level of knowledge production (scientific controversies) on one side, and socio-technical controversies in society at large on the other side, have been called *Socially Acute Questions* (SAQ) [68]. Specific methods have been proposed to address SAQ in classrooms, e.g., the SAQ didactics in the french-speaking literature [69] or the Socio-Scientific Inquiry-Based Learning (SSIBL) [70] in a wider context. These approaches match an emancipatory purpose for education as presented in [1] and combine a scientific and a political education.

This combination comes with three associated risks [71]. The first one is a technocratic posture where scientific knowledge is presented as the answer to political issues. The second risk is a relativist posture in which all political opinions are considered equivalent, and where the truth of facts is neglected. The third risk is a prescriptive posture where the teacher provide the students with concrete ways to act, while neglecting the reflection process that leads (or not) to these actions. To avoid such risks, and because the didactical transposition cannot be performed, SAQ didactics relies mainly on a pedagogy of inquiry in which students are asked to problematize the conflicting situation [53].

We argue that the technocratic, relativist and prescriptive risks appear not only in classrooms, and believe that more explicitness of the problematization process in research papers regarding ICT/S would benefit more broadly society in its interaction with scientific issues.

## VII. CONCLUSION

Understanding the complex relationship between science, social values and politics can be a powerful lever to teach socially acute questions, such as the relationship between

<sup>20</sup>Addressing the question “Does our research contribute to building a world that corresponds to our values?” the SEnS workshops state that “The objective is not to reach a consensus between the participants, but rather to provide everyone with the opportunity to reflect and take a stance on current environmental issues in a respectful and constructive setting.” [67]

ICT and sustainability, in an emancipatory manner [72]. This, however, calls for a better understanding of the human interests behind knowledge production. It is particularly true for research related to sustainability, that is from the beginning motivated by a question with a political dimension.

We argue that a way toward this understanding is through the analysis of how researchers problematize their research questions and justify (or not) their choices. Our results call for more explicit justifications of the political positioning of papers in the ICT4S community, arguing that it is a good practice not only to help educators, but more broadly to improve the relationship between science and society.

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