Hacker education and transformative agency: an empirical study in hacker communities and in the school case of Conexão Escola-Mundo

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Abstract

This paper investigates how particular aspects of hacker education are perceived as drivers of transformative agency in hacker communities and a brazilian school by applying a qualitative study of a broader mixed-method research. The analysis revealed a multidimensional understanding of hacker education, pointing to elements of a transformative activist stance based pedagogy in digitalized societies. Six dimensions emerged: inquietude, action-fun, collective, society-community, sharing and the humanistic-technological dimension. The findings indicate that in both contexts, the co-creative process, in addition to strengthening the sense of community, is what drives participants to act as transformative agents through the artifacts they can create.

Keywords: hacker education; transformative agency; digitalization; humanistic-technological

Introduction

The educational ecosystem of hacker communities (Davies, 2017; Menezes, 2022; Ortmann, 2022; Richterich, 2022; Schrock, 2014), has been gaining coverage over the last years. However, the possibilities of hacker education (HE) experiences in schools and universities have not had the same analysis. When studied, it is often reduced to learning-by-doing strategies (e.g. Tan, 2019), disregarding the ethical-political dimensions of HE, where aspects such as openness, technological activism and communitarianism are structuring elements (Davies, 2017; Menezes, 2022).

This paper focuses on the concept of HE as an educational approach to transformative agency in digitalized societies, bridging what hacker communities could potentially offer to schools as inspiration for critical/transformative pedagogies. Algorithmic societies and governance (Balkin, 2017; Zou, 2021), cyberbullying/cyberhate debates (Wachs et al., 2021), the widespread dissemination of fake-news (Petratos, 2021) and the expansion of surveillance capitalism (Lupton & Williamson, 2017; Zuboff, 2015) are just a few examples that require educational attention in formal educative environments like schools. In that regard, the development of digital competences (Aagaard & Lund, 2019; Brevik et al., 2019; Damşa et al., 2021; Frau-Meigs et al., 2017; Lund et al., 2019) goes beyond the instrumental to a more holistic way of understanding technology potential (Karanasios et al., 2021; Polizzi, 2020; Vakil & McKinney de Royston, 2022).

With all these ever-changing challenges and the need for a holistic understanding about social phenomena, which are entangled in the human activity (Engeström & Sannino, 2021; Hopwood,

2022; Karanasios et al., 2021), cultural-historical activity theory (CHAT) presents important theoretical frameworks to elucidate *transformative agency*. Transformative agency by double stimulation (TADS) (Engeström & Sannino, 2021; Sannino, 2015), transformative activist stance (TAS) (Stetsenko, 2016, 2020, 2021) and relational agency (Edwards, 2020; Edwards et al., 2017), although different frameworks, share a basis in the critical-dialectical processes of co-creation between people and the world.

In this work, we approached TA from a TAS perspective, which also guides our look at critical/transformative pedagogies. The ubiquity and pervasiveness of digital technologies in our societies (Kajamaa & Kumpulainen, 2019b; Vakil & McKinney de Royston, 2022) makes them even more necessary pedagogies of agentive actions (Engeström et al., 2022), enabling spaces/tools of agency that consider the analog-digital configuration of our societies, also taking into account the elements advocated in critical pedagogies (Freire, 1967, 2013; McLaren, 2003/2005) and complemented by pedagogy of daring (Stetsenko, 2016). In this sense, the purpose of this study is twofold: *1) empirically identify the ways in which specific features of HE are experienced by hacker communities and by participants of Conexão Escola-Mundo, a project that has been experimenting in Brazilian schools an activist methodology for citizenship centered on HE; 2) understand from these experiences how HE offers elements for a critical pedagogy from a TAS perspective.*

Theoretical framework

Although apparently distant concepts, *hacker culture*, *education* and *transformative agency*, looked in depth, are elements that can be intertwined, clarifying, contributing and interfering in the social dynamics of oppression in digitalized societies. Hacker communities are counter-cultural spaces for co-creation (technological or otherwise) (Davies, 2017; Levy, 1984/1994), whose educational ecosystem has aspects that identify with a perception of education as a practice of freedom (Freire, 1967; Menezes, 2022). These community spaces provide tools for activism and agency that enhance social transformations towards a desired future (Stetsenko, 2016).

Critical/Transformative pedagogies and digitalized societies

An important topic in educational research, *agency* has been theorized from different perspectives (e.g., (Emirbayer & Mische, 1998)). Approaches that understand agency merely as a quality of the individual or a result of an isolated interaction between the individual and their contexts are insufficient to understand this topic in the face of social complexity that we have today (Engeström et al., 2022; Sannino, 2022). For new agentive pedagogies to emerge, it is necessary to go beyond categorizations and measurements, seeking to elucidate the agentive processes, truly understanding that today's challenges require "multi-agency initiatives" (Sannino, 2022, p. 10). It is within cultural-historical activity theory (CHAT) and its concerning about human agency and transformation of the world that we find a significant part of the research on *transformative agency* (TA).

TA implies breaking away from the given frame of action and taking the initiative to transform it (Virkkunen, 2006). Hopwood (2022) brings closer three approaches to agency within CHAT: transformative agency by double stimulation (TADS) (Engeström & Sannino, 2021, 2021; Sannino, 2015), transformative activist stance (TAS) (Stetsenko, 2016, 2020, 2021) and relational agency (Edwards, 2020; Edwards et al., 2017). In common, these frameworks share a foundation in dialectical thinking, rejecting the idea of agency as a property of the individual, sharing the perception that through agentic actions both, the person and the world are transformed (Hopwood, 2022).

Sannino's work on TADS (Sannino, 2015, 2022; Sannino & Engeström, 2017) goes a step further on TA by using Vygotsky's double stimulation concept. The principle of double stimulation starts from the process in which people face a paralyzing conflict of motives, this conflict being the *first stimulus*. People resolve conflict by identifying and making artefacts filled with meaning and turned into a sign. They are the *second stimulus*. This mediating artefact allows the redefinition of the conflict situation and consequently to break out of it. Transformative agency "*usually emerges in a stepwise manner through multiple iterations of the double stimulation loop*" (Engeström et al., 2022, p. 3).

The challenges we have face as societies (poverty, climate change, inequalities, etc.) are paralyzing conflicts of motives enmeshed with the radical transformation of the objects of human activity, to which approaches through TADS can significantly make a difference (Engeström et al., 2022; Sannino, 2015). Engeströn and Sannino (2021) have demarcated the emergence of a fourth generation of activity theory, where the need for transformation makes it more urgent forms of activity through formative interventions in "multi-activity constellations" (p. 19). In this sense, however, emphasizing a clear ethical-political positionality by researchers and their commitments, Stetsenko (2021) invites us to act, in an even more emphatic and *activist* way, to overcome the realities of oppression. TAS suggests a shift from *participation* to *contribution*, with people acting in solidarity against hegemony and the *status quo* (Hopwood, 2022). Individual and social are understood as a unity (the concept of *collectividual*), where mind and shared communal practices are dialectically linked (Stetsenko, 2016). In TAS, people co-create the world in solidarity with others, building a desired future, and in this dialectic, the individual himself is developing, learning and humanizing (Stetsenko, 2016).

Stetsenko's construction of TAS dialogues profoundly with critical pedagogies, especially Freirian pedagogy of hope. The pedagogy of daring (Stetsenko, 2016), despite having its eyes on the desired future, finds in a critical understanding of the past and the present, the necessary elements for the composition of these desires. The critical pedagogy from a TAS perspective, suggests that practices must promote students and teachers transformative agencies, collectividually and engaging against the status quo. In a TAS-based pedagogy, students are agents of changes, premised by their active exploration and future-oriented goals (Vianna & Stetsenko, 2019). This pedagogy requires reading the world, as Freire (1992) says, currently involving paying special attention to the power dynamics of a world in constant digitalization. Pedagogies that seek to problematize social dynamics, apart from interfering in social inequalities, must face the oppressions that digitalization is causing (McLaren et al., 2018). Digital technologies are transformative forces in the world and need to be understood beyond their capacity to be mediating artefacts. They can cause societal damage or significant social improvements. Recent phenomena such as fake news, the manipulation and distortions of the world's far-right, the manipulation of big data, contribute to the complexity of a world where it becomes difficult to understand whether actors are being more agentic or increasingly being led docilely (Karanasios et al., 2021, p. 244). The pandemic showed the potential of digital technologies due to the constraints imposed on our mobility. However, such opportunities do not reach everyone (Madianou, 2020), or are not equally accessible (Beaunoyer et al., 2020). With the outbreak of the pandemic, trying to guarantee the continuity of classes, schools and teachers signed up to educational videoconferencing platforms, and other cloud-based services, most of them offered by the GAFAM companies (Google, Apple, Facebook, Amazon and Microsoft). In doing so, GAFAM strengthened their oligopoly (Robinson, 2020). In addition, the process of *teaching datafication* (Williamson et al., 2020) promoted by opaque big tech's technologies exposes school communities to capitalist surveillance (Zuboff, 2015).

The critical (and contradictory) challenges in today's world requires pedagogies that allows people to face these conflicts (Engeström et al., 2022), thinking pragmatically and philosophically about them (Vakil & McKinney de Royston, 2022), preparing them to deal critically with big tech and their algorithms of surveillance and opinion-driving (Dias Fonseca, 2019) and making technologies serve our common interests (Lund et al., 2019). In this paper, we argue that hacker communities are spaces that foster these elements, through the approach we call hacker education (HE). These communities are educational spaces that provide access to tools of agency, allowing people to change their limit situations and oppressive circumstances co-creating the world with the community.

Educational Ecosystem of Hacker Communities

The term *hacker* is often wrongly associated with cyber criminals. In fact, criminals are crackers (Raymond, 2001). The concept of hacker originates in the late 1950s and early 1960s at the Tech Model Railroad Club (TMRC) and refers to those who are passionate about challenges and creative activities (Levy, 1984/1994, p. 13). Technically speaking, both hackers and crackers have similar digital capabilities, the difference lying in the fact that hackers follow an ethic of construction (not destruction) and are enthusiasts from any field who like to overcome intellectual challenges and limitations (Raymond, 2004). Additionally, there is a hacker ethic (Himanen, 2001/2001), depending on how hackers relate with: 1) work, 2) money and 3) the network. Each dimension is based on certain values, which lead to a lifestyle focused on creativity, understood as the ability to (re)create the world, the community and the networks (Fig. 1).

The subversive, creative and communal way in which hacker communities have been acting in the world (Davies, 2017; Levy, 1984/1994; Raymond, 2001), already place them as agents of transformation, however, when we observe the artifacts that they have been building, as a response to the dilemmas posed, this association becomes even clearer: the *GNU/LINUX Operational System* (Stallman, Torvalds among other hackers); hypertext and the *World Wide Web* (Ted Nelson; Berners-Lee); *Wikipedia* (Jimmy Wales); the *Open Educational Resources* (OER) movement and many community-operated physical places called *hackerspaces* or *hacklabs* (Davies, 2017; Maxigas, 2012). Currently 992 active and 360 planned hackerspaces are listed on the hackerspaces.org[1] site. They are physical community spaces for critical agents of change (Vakil & McKinney de Royston, 2022).
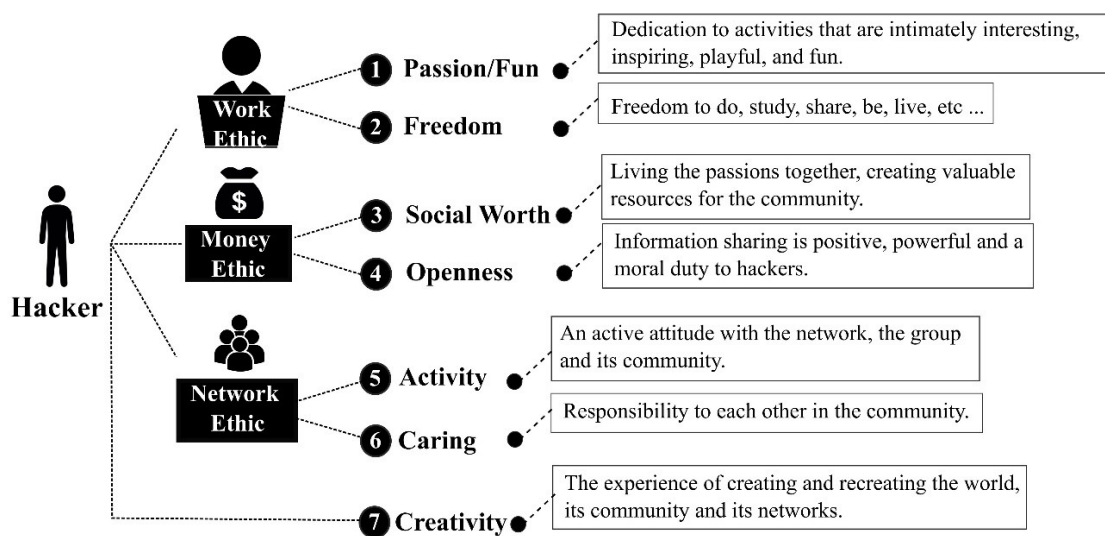

Figure 1. The seven values of the hacker ethic according to Himanen (2001/2001).

[1] Available in <https://wiki.hackerspaces.org/List_of_Hacker_Spaces>.

The educational ecosystem of hacker communities has attracted the attention of some researchers in recent years. Systematizing the elements of the pedagogy present in hackerspaces was the objective of Menezes (2022) by presenting a pyramid with multifaceted pedagogy commitment, with four specific and interrelated faces: technical, affective, ideological, and political. *Collective learning from common and pleasant projects*, *open sharing of knowledge* and *horizontality in decision making processes* are among the characteristics highlighted by some other studies, resulting from the empirical observation of hackerspaces (Davies, 2017; Schrock, 2014). In culture and arts education, Escaño (2018a, 2018b) synthesizes some characteristics of HE such as *active commitment*, *shared knowledge*, *incentive to critical thinking*, *creative action,* and *educational passion*. However, hacker communities do not get away from the gender bias, as being predominantly white and men (Davies, 2017). Consequently, feminist hackerspaces have been gaining more space bringing technofeminist hacker pedagogy into the spotlight (Ortmann, 2022; Richterich, 2022).

Based on several studies (Davies, 2017; Escaño, 2018b, 2018a; Himanen, 2001/2001; Levy, 1984/1994; Menezes, 2022; Pretto, 2015, 2017; Raymond, 2001), Aguado and Alvarez (2019) organized 15 features of HE, which also give us clues to the transformative-agentive nature of this educational approach (Table 1). These characteristics are drivers of self-reflection for policy makers, teachers, students, principals and other public actors, pointing to aspects of human activity, community experience and relationship with society, overcoming a technological deterministic perception that can be attributed to hackers. Even so, it is important to emphasize that the digital technological dimension is a structuring part of HE, addressing the relationship between power, ethics and digital technologies (Levy, 1984/1994; Menezes, 2022; Pretto, 2017).

Table 1. Summary of the characteristics of hacker education according to the theoretical framework.

Characteristic	Authors
1. Have fun and do things with passion	(Escaño, 2018a; Himanen, 2001/2001)
2. Freedom as something fundamental	(Pretto, 2015)
3. Respect and encouragement of diversity	(Pretto, 2015)
4. Care for each other	(Escaño, 2018a; Himanen, 2001/2001)
5. Full access educational resources	(Escaño, 2018b; Pretto, 2015)
6. Openness	(Escaño, 2018a; Pretto, 2015)
7. Active stance	(Escaño, 2018)
8. It's okay to make mistakes	(Pretto, 2015)
9. Stimulate creativity	(Escaño, 2018a, 2018b; Himanen, 2001)
10. Encourage curiosity	(Pretto, 2017)
11. Be an activist education	(Escaño, 2018a; Menezes, 2022)
12. Encouragement to copy, reuse and remix	(Escaño, 2018a; Pretto, 2015)
13. Critical attitude	(Escaño, 2018a, 2018b; Pretto, 2015)
14. Extrapolate the community space	(Escaño, 2018a)
15. Be a political education	(Menezes, 2022)

Methods

Research design

Considering the complex scenario that involves understanding the characteristics of educational ecosystems, we opted for mixed methods research with differentiated instruments, according to each context (Cohen et al., 2017; Creswell & Clark, 2017). Although quantitative methods have

been important in the research, in this paper we focus on presentation of qualitative data and analysis. The main contributions emerged from them.

Over two years of data collection, the instruments (questionnaires and interviews) were evolving based on pre-analyses carried out dynamically. The study was conducted in two macro-contexts: a) hacker communities and b) Conexão Escola-Mundo project (Lapa et al., 2019), which aims to promote in Brazilian schools, *an activist methodology for citizenship centered on HE.*

Contexts and participants

The Hacker Communities online questionnaire, sent to communities' mailing lists was answered by *115 hackers*. The criteria for choosing the communities were: 1) self-identification with the hacker culture and 2) the active search for composing a geographically diverse sample and in diversity of movements. The sample contains people from all continents and 8 different movements. Most identify themselves as men (75,7%), the continents with the greatest representation are Europe (36,5%), South America (33%) and North/Central America (19,1%). The movements with the greatest participation are hackerspaces (57,4%), free software communities (56,5%), hacklabs (23,5%) and maker movement (20,9%). In the second stage of data collection, *15 hackers* were selected for interviews, based on willingness and the criterion of relevance of their answers to the objective of the research.

In this paper, the data from Colégio de Aplicação (CA) are presented as exemplars of schools participating in the Conexão Escola-Mundo project. The CA was created in 1961 and is located in the state of Santa Catarina, in southern Brazil. It is part of the Education Sciences Center of the Universidade Federal de Santa Catarina (UFSC), as an experimental school that provides the development of pedagogical experiences and supervised internships for pedagogy and other graduates studentes. CA offers elementary and secondary education. Until the 1980s, it only attended children of UFSC teachers and technical-administrative staff, but since then, it has attended the whole community, with 20% of its places reserved for black, indigenous and quilombola students. The teachers work at the school on an exclusive basis, which, together with the existing structures for pedagogical support, reception and economic support for students in situations of socio-economic vulnerability, make CA a structurally privileged school in relation to other Brazilian public schools.

The inclusion criteria that made us choose CA were: 1) a school which formed part of the fund project from the beginning; 2) Having a partnership established between school and university, and 3) a school whose project has greater integration in the daily routine of the school, through activities developed together with the students, connected with the classes and the curriculum.

At CA (N=214), over two cycles, 18 researchers (8,41%), 14 teachers (6,54%) and 182 students (85,04%) participated in this research, 65 from 5th Year, 63 from 7th Year and 36 from high school. Since the project's actions are different for each group, designed from specific demands, the sample were organized in 5 micro-contexts: a) 5th year students - A and B (actions related to the understanding of caregivers about children's digital habits); b) 5th year students - C, (podcast creation); c) 7th year students (actions to combating oppression and building empathy in social networks and physical spaces; d) High school students (developing models of an ideal society); e) the network formed by the project's actors around the management, organization and actions planning.

Instruments and Data Collection

Three different online mixed questionnaires, originally created for their contexts, were the instruments used in the first approximation to the research participants. Validation was carried out by a team of 12 specialists, in a dynamic process during iterative cycles.

In the Hacker Communities questionnaire, in addition to sociodemographic (gender, age, country and collectives in which they participate) and closed questions (dichotomous and Likert scale representing indicators created from the literature), an open-ended item asked: '*What characteristics of the hacker culture can be taken to schools and universities?*'. A response time of 10 to 25 minutes was foreseen. The questionnaire was distributed in Portuguese, English and Spanish, by mailing lists, available for 3 months.

The CA school 1ˢᵗ Cycle questionnaire, had 3 main open-ended questions: *1) What is hacker culture in your opinion? 2) Suppose a friend wants to join the project. Knowing that you have already participated, he asks for your opinion. What would you say? 3) What did you experience in the project and do you think it should be part of the daily life of schools?* After approximately 1 year of 1ˢᵗ Cycle, and a process of pre-analysis and identification of emerging dimensions, the school 2ⁿᵈ Cycle questionnaire was applied. We expanded the open-ended questions to understand a) the most remarkable moment of their experience in the project; and b) motivate them to cite moments of the project that could be related to the sentences representing HE features. These questionnaires, available for 1 month, was distributed in Portuguese and the link was sent to teachers and researchers. Students responded during lectures, with an expected response time of 10 to 25 minutes.

The interview participants were chosen after the data analysis of questionnaires, based on the criteria: 1) willingness to participate and 2) the relevance of their responses to the research objectives. The interview scripts varied according to the unique experience of each participant. Interviews with the hackers lasted from 30 to 60 minutes, conducted online, with approximately 9 questions that delved into their experiences and communities in detail. With teachers and researchers, the interviews took place in person, from 30 to 60 minutes, about 10 questions. With the students, the interviews took place in person, in groups of 4 people, each lasting approximately 15 minutes. As a playful way to motivate them to share, cards were made representing the features of HE. Students drew these cards and had to share a moment they experienced in the project that was related to that item (if any).

Qualitative data analysis process

A *preordered analysis* was carried out*,* through analytical categories identified in the theoretical framework (23 predefined codes) and *responsive analysis,* through attention to the emergence of new categories and codes (14 emerging codes). After the emergence of 6 dimensions of HE in the analysis process (Inquietude, Action-Fun, Collective, Sharing, Society-Community and Humanistic-Technological), we decided to reorganize the encoding of CA school data with codes representing these dimensions (Table 2). All collected data were converted to text format and imported into the RQDA[2] software.

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[2]Know more: https://rqda.r-forge.r-project.org

Table 2. Categories used in coding process and their corresponding frequencies.

Hacker Communities Context		Hacker Communities Context	
Categories / Codes	Frequency	Categories / Codes	Frequency
First encoding cycle codes		New codes generated in the process	
Not provisioned	125	Do It Together	53
Active Attitude	88	Share	52
Critical Attitude	70	Humanism-technological	44
Extrapolate the community	56	Deconstruction	11
Curiosity	34	Experimentation	10
Diversity	31		
Openness	30	CA School context (1st. Cycle and 2nd. Cycle)	
Access	26	Categories / Codes	Frequency
Collaboration	23	Collective	65
Use of FLOSS technologies	23	Humanistic-Technological	46
Freedom	22	Society-Community	39
Activism	20	Action-Fun	38
Creativity	19	Inquietude	17
Passion-Fun	17	Limitations and difficulties faced	15
Failosophy	15	Sharing	14
Political participation	14		
Remix	12		

Note. This table shows only the codes with frequency greater than 10.

This analytical work allowed us to gain a significant understanding about the ways in which some features of HE are experienced by hacker communities and by participants of Conexão Escola-Mundo project (meeting our first research objective). Approaching the theoretical framework on TA in CHAT, we realized the potential for significant alignment between HE and, in particular, the ethical-ontoepistemological construction of TAS. From this, we revisited our data, now looking at it in the light of this framework. This new analysis cycle allowed to put into perspective the theoretically constructed elements of TAS-based critical pedagogy and the empirical experience of HE in hacker communities and school, taking into account the socio-political and historically situated reality that we face: a digitalized world.

Ethical Issues

This research has been approved by the Committee on Ethics in Animal and Human Experimentation of the Universitat Autònoma de Barcelona with the reference CEEAH 4804.

Findings

We opted to organize our research findings on the basis of the six dimensions of HE that emerged during the data analysis process: *Inquietude*, *Action-Fun*, *Collective*, *Society-Community*, *Sharing* and *Humanistic-Technological*. These dimensions, which are closely interwoven with each other, organize the elements of HE first understood in the light of the theory (i.e. Table 1), allowing us to understand the ways in which HE features are experienced in the research contexts (first objective) as well as allowing us to see more clearly how HE offers elements for a critical pedagogy from a TAS perspective (second objective).

Inquietude

Our analysis revealed that the primary fuel of Hacker Education is an interesting combination of *curiosity* and a *critical attitude*. The hackers often cited a desire to understand how things work in

depth as a principle of their creative and learning processes in the communities. One example from Hackerspace Valencia sharing what motivated him:

> … "why is this so? Is there no other way?", in principle it comes from a curiosity but as the years go by, that curiosity, you read, information that you see, you become more critical. For example, I have used Linux for years at home […] i have control over the technology… (Hacker from Hackerspace Valencia)

When we perceive curiosity in the experience of hacker education, we realize not only something that hackers or students bring individually, but we also notice that the community experience, the journey through the creative process, makes curiosities sharper, and as we see in the example, they are more critical and well-developed curiosities. These critical curiosities range from understanding how the electronic circuits of a washing machine work (shared by a hacker from Garoa Hacker Club – São Paulo) to an in-depth and critical co-understanding of the technical-social-humanistic mechanisms involved in setting up security cameras in the Paris metro (in the context of a community that understands itself to be an activist for people's privacy, i.e. DataPaulette etextile hackespace - Paris).

In the context of CA school, we also found these elements but with an important emphasis on teacher mediation. The group of students from the 5th year in order to create their podcasts, conducted collective interviews with people from the university, assisted by journalism students. This was the teacher's way of piquing the students' curiosity and adding critical elements as a community. As shared by teacher:

> ... they worked with this element of journalism, understanding what is a collective interview, [...] so there was a lot more journalism footprint than this thing from last year that had much more production. There was much more interviewing and thinking about journalism and the curiosity as a possibility to answer questions that one have... (5th Year Teacher)

These interviews took place during a strike at the university where CA school is based (UFSC). The activities were carried out in groups. One of the groups chose to create podcasts about the importance of the university:

> ...then I was like, "why don't we show its [UFSC] importance, why it is so good, why it is important and also what the CA provides for us to be able to go to UFSC later, so that we have a better future". And then we interviewed NIC. The other people of our group also interviewed and so we created a group about the importance of UFSC... (5th Year Student)

The interviews proved to be a way to expand and feed the curiosities that the students brought, so that they could improve their own activist agendas.

We also observed that inquietude expands and is healed in *activist stances, hands-on activities*, *experimentation*, i.e., in a non-passive, co-creative posture. An example of how this happens in hacker communities can be found in the words of a Finnish hacker:

> … I was very interested in designing board games especially like heavy simulations of conflicts and economy and I didn't know anything about that, so I wanted to learn and I started with the Scientist games, this was like an example of learning by doing, and then I asked the community "does anyone else have this kind of interest in games?" turned out that actually quite many, so I started to host a session each week ... (Hacker from Hacklab Mikkeli)

This dynamic represented in the hacker's speech, where from his individual curiosity, a work/study/creation group is formed in the hackerspace, is a constant in hacker communities.

Action-Fun

Another aspect we found and must be emphasized is that hackers' actions are closely linked to a feeling of passion for something, which Himanen (2001/2001) also calls *Fun*. In other words, it's not doing it out of obligation or imposition, but doing it from the heart. We realized with the hackers a unity between being-knowing-doing, an essential element for a TAS-based pedagogy. The same Finnish hacker cited before, when asked about aspects of HE that must be part of schools, replied: *Doing things we have passion for and teaching it to others who enjoy the topic.* It is important to emphasize that we saw great diversity in the hackers' creative practice. For example, in the R'lyeah hacklab (Buenos Aires), their constructions follow a much more activist agenda on gender issues and humanistic-social perspective of information architecture, always seeking to co-create technological artefacts (*softwares, hardwares, media content, etc*), awareness campaigns, etc. Another example comes from the nomadic hacker lab Nodosomos+ in Colombia, where for decades they have been an itinerant community that generates spaces for free education, co-creation and promotion of local culture.

> … NodosSomos+ is a laboratory with legs and a heart, and it was just that, with legs, that is, with the capacity to walk on its own territory and a heart because we did it with the heart of a lover, if there is something that interests us it is this pedagogy of falling in love … (Hacker from NodoSomos+ - Colombia)

Turning our gaze to CA school, we noticed that in the different subcontexts of the Conexão Escola-Mundo project, a constant aim was to mobilize the students around co-creation, trying to give as much scope as possible to their passions and interests. For example, in the 5th. Year classes, the production of podcasts took place in an integrated way with the Portuguese curriculum, during Portuguese classes. The students sometimes thought they were not having lessons (but they were learning). See:

> We loved those classes, at least I loved them because before the project, Portuguese classes was "Ah, how boring, today is Portuguese", and after "Wowww, today is Portuguese !!!" That's it… (5th Year Student)

> We brought the cell phone, the headphone and the equipment. Then we recorded, first we used to create the script, we chose the theme that we were going to use, [...] so we chose the musics, then we went to classes, we recorded and we learned how edit on the computer. (5th Year Student)

With high school students, this process of co-creation was aimed at building the ideal society. The students, organized into groups, studied various models of society in their different dimensions (economy, health systems, human rights, guidelines for technology and information management, etc.) throughout the year. They then had to create theoretically based models of the ideal society and take part in debate cycles to defend their creations.

Collective

Realizing the collective/community dimension of HE, we come across projects/actions that start from individual inquietude (such as the examples mentioned above) and feed and are fed collectively. This recursive "collectividual" movement is a strong element identified in the co-creative paths in the communities studied. This quote from an Australian hacker portrays this spirit well:

> The hacker culture foster's an open community of collaboration to allow a group of people with likeminded interests to come to together and achieve awesome things. (Bluehackers – Australia)

The hacker communities represented in our study are generally managed by assemblies, where we see an effort to make them a non-hierarchical, collectively managed space, but also a place

unbureaucratized, that values doing over passivity (hackers call this element, DoOcracy). Some of the comments illustrate this organization:

> We do at least once an assembly of members where we take decisions among all, we vote, propose, discuss … (Hacker from Hackerspace Valencia)

> The communities that I did participate in, were with no visible hierarchy and which allowed and enabled anyone to contribute in whichever manner. (Hacker from Free Software Foundation – India)

> It's very interesting because it [a kind of hackespace management manual] covers the decision-making process that we are trying to evolve too and also tries to avoid bikeshedding by a stop signal in the meeting. If somebody says STOP and two people agree, the meeting stops and goes to the next week. There are also some guidelines on how we could make things if there is no consensus […] "Having no solution is worse than a bad solution" ... (Hacker from Ghent Hackerspace)

The experience of the collective dimension of HE at CA School is also perceived, in particular, through an effort to maintain a horizontal community, whether in the university-school relationship or in the teacher-student relationship, as shared by a teacher-researcher:

> I think we are doing a type of approach, of mediation at school, which slightly reverses the expectations we have about the educational process [...] it is not even top-down from UFSC to the teachers of CA, nor from the CA teachers to the students. Even when we were developing the tasks, we had high school students participating in the process in the same table with Phd professors. I think that this exercise, this experience of an education project that is not in the top-down logic, it potentiates dialogical processes (Teacher-Researcher)

A community made up of university researchers, teacher-researchers and students at different levels was formed around the Conexão Escola-Mundo project. This heterogeneity of roles, knowledge and experiences was an element that, according to the participants, contributed greatly to the project. Asked about the most memorable moment in the project, a 5th grade CA teacher's replied: *The moments of joint discussion between students, teachers, academics, researchers and coordinators. The feeling of working with partners for something common*.

Society-Community

Just as we noticed unity between the individual and the community (collectividual), interacting in a dynamic and recursive way, we realize that this movement in relation to the community and society is also true (society-community). The hacker communities we met are not closed in on themselves, but are in a dialectical relationship with society, critically questioning it and seeking to build on it, especially at the interface with technologies and human rights. We verified this through the diversity of social projects involving the communities: the Eter project developed by R'lyeh hacklab in Buenos Aires, creating pollution sensors with local schools; the Radar Parlamentar developed by different groups in Brazil, especially PoliGNU, closely monitoring public authorities; the Chaos Macht Schule, a project of the Chaos Computer Club strengthening students, parents and teachers in the areas of media literacy and understanding of technology and No2somos+, a collective enabling free education in Colombia. It is in this sense that we realized hacker communities as activist communities, seeking to co-construct desired futures, e.g:

> … it is all the time doing activism and from the free software communities as well. [...] the comuna digital has a workshop that they do about digital self-defense, which is how to raise awareness about social networks, privacy and control … (Hacker from Red Conocimiento Libre – Ecuador)

> … one of the interesting actions we did was this streaming, which is like placing the peasant community to dialogue from a stream, it was like a "batalla de Copas" (Hacker from NodoSomos+ – Colombia)

Turning our gaze to CA school, we realize this activist identification right from the community's conception (understanding community here as this collective formed around the project), aiming creating transformative methodologies for citizen education that establish a new paradigm at school, centered on education for authorship, collaboration and production: a school with a hacker way of being. This inseparability between society and community was reflected in the way the 5th. Year students problematized local demands (strikes, hate speech in the Brazilian political debate, polarizations, etc.) and sought to interfere by creating podcasts, just as, in the case of the high school students, they also took a reflection-action route by constructing models of the ideal society.

> ... a lot of things that we talked about the model of society that was thought of in a group, also individual, I talked a lot with my parents [...] it's not just inside [the school] but it's conversations that go outside, like talking about education, what could improve, health system, like, all this, so it's something that really goes beyond the limits of the school, it's not just inside the project (High school student)

Throughout the educators' speeches, we noticed an individual and collective desire to overcome the school walls, or at least, make it a little more porous, however, given the bureaucratic constraints that a naturally hierarchical, in dispute, curriculum-oriented space, the feeling of some was of insufficiency in this dimension.

Sharing

An element that we perceive to be essential to the community spirit of HE and that is permeated in the speech of the hackers is the open *sharing*. The dimension of sharing is perceived in the way in which free software communities share source codes, always concerned with ensuring open licensing, in the open sharing of scientific creations of the Open Science movement, in the assumption of openness from Open Educational Resources movement and in all other branches of the hacker movement. Openly sharing the creations is a practice intertwined with the way hackers experience the solidarity that Stetsenko places as an essential element of communitarianism in a pedagogy of daring, with a cyclical contribution-benefit movement being generated in a culture of open sharing. An iconic example of this cyclical movement is told by an Argentine hacker:

> This burning of garbage is around slums, very precarious neighborhoods where there are schools. The idea of the project was to create infrastructure in the hacklab [...] the schools would build those monitors with Arduino and a special shield made for this, so, they could take them to their homes or in their public places and collect information about the level of contamination in the area […] Córdoba is a province of Buenos Aires where there are issues with Glyphosate, the pesticide that Roundup uses to grow soybeans, which is quite disseminated in Argentina and that University took that project and modified it to collect samples of Glyphosate in water (Hacker from R'lyeh hacklab)

Note that a community project between hackers and students from a local school in Buenos Aires, developed using free technologies an artifact that was later remixed by students from the University of Cordoba, to meet their local needs. This was only possible because all practices, instruments, hardware and software were shared openly.

At CA school, participants said they shared knowledge, learning, ideas and research data. In addition, the dynamic process of co-creating the project, the activities that were developed with the students, involved constantly encouraging a spirit of sharing. The 5th Year students, for example, shared their podcasts on the Internet:

> ... I saw the students, their joy when they listened to each other, […] there was a boy who bit himself with anxiety because he [realize that] exists, he is signing up, you know? And I think that since it's publicized on the web, they were very interested in understanding who was going to see it, what page, how their photo looked like. I think they had this dimension that they were creating something for the outside … (Teacher-Researcher)

Note that the feeling of authorship, of being able to create and share, has been highlighted by students and clearly noticed by teachers-researchers. This feeling proved to be powerful in the agentive development of students and in the development of self-esteem, which is very necessary to perceive themselves as creators of culture.

Humanistic-Technological

One of the arguments we have defended throughout our research is that HE presents elements for a critical/transformative pedagogy in our *digitalized societies*. The results obtained from the hacker communities show elements that reinforce this; after all, we saw in these communities an understanding of the inseparability between the human and the technological. One of the ways hackers experience this dimension is through technological activism that constantly denounces and acts against the oppressive way in which big tech and governments incorporate technologies that are opaque, vigilant and disrespectful of human rights. An example comes from the Blackboxe Hackerspace in Paris, which seeks to raise awareness against the use of surveillance cameras in the Paris Metro.

> The first thing I heard of at Blackboxe was related to cameras in Parisian metro: supposed to make use of a not publicly disclaimed facial recognition technology; rose fears of potential of use for mass surveillance; creative reaction of those hackers == design and use of anti-facial recognition make up. (Hacker from DataPaulette etextile hackespace – Paris)

The development, remixing and defense of free technologies is another element that stands out in the hackers' speech, such as this excerpt from the interview with an Indian hacker and education activist:

> In the southern Indian state of Kerala, about 15 years back, the teachers union went on strike across to state to pressurize the government to only include free software in school textbooks to teach computers and programming to children … (Hacker from Free Software Foundation – India)

The presented examples of technological creations by hacker communities, which contribute to society, are illustrative of this dimension, giving technology a humanistic purpose, fleeing from a-political approaches, which even though not being perceived in this way by its actors, reveals a powerful transformative activist stance.

In the CA school context, most of the productions were made using free software. Audios were edited with Audacity, research group meetings with BigBlueButton, data analyses using Taguette and R and other free technologies. In addition to the coherence sought in relation to technological adoption, this use has always been accompanied by reflections on why to use these technologies: code transparency, inclusion, community contribution, etc.

Another element that reveals how the humanistic-technological dimension was experienced at CA School are the problematization activities about oppressions that occur on social networks. These discussions sought to bring demands from the real experiences that the students face. This account from the 5th. grade teacher tells us a little about this:

> ... the things they brought up in the comments were very worrying: inappropriate comments about girls, hatred on social media, the relevant questions for them had a lot to do with this thing of being in this universe without knowing what to do in it, how to deal with hatred on the Internet? (Teacher-Researcher)

Despite the constant problematization about oppression and the impact of mainstream technologies on issues of surveillance, the promotion of hate speech, manipulation of people, etc., teachers and researchers perceived difficulties in transforming critical reflections into behavioral changes:

.. they [Teachers] can have a super critical perspective about technology, about proprietary tools, about Facebook. They can problematize advertisement and all that, however, for this to be perceived in the classroom i think we had to have expanded our training as hacker teachers. (Teacher-Researcher)

It is important to emphasize that changing behavior and habits takes time. Perhaps in a few years it will be possible to verify more reliability whether these experiences have resonated in different technological appropriations.

Discussion

In this article we postulate hacker education as a critical/transformative pedagogy in the context of digitalized societies. This postulation translates into the dual objective of this work: 1) identify the ways in which specific features of HE are experienced by hacker communities and by participants of Conexão Escola-Mundo and 2) understand from these experiences how HE offers elements for a critical pedagogy from a TAS perspective.

In the previous section, the six emerging dimensions of HE helped us to organize the experienced features of HE both in their original contexts (hacker communities) and in a school, understanding the motivations, norms, mediating artefacts, dynamics and objectives of these educational ecosystems. In particular, we now want to shed light on the agentive-transformative pedagogical aspects of these experiences, from a TAS-based perspective (Stetsenko, 2016, 2019, 2020; Vianna & Stetsenko, 2019).

A first point of convergence between TAS-Based critical pedagogy and HE lies in the very definition of education and its role: to provide tools of activism and agency envisioning transformative social changes and the free development of individuals and society (Stetsenko, 2016, p. 367). This perception, in unison with Freire's vision of education as a practice of freedom (Freire, 1967), unites us in the understanding that education is not adaptation to the world, accommodation, but rather men and women critically and creatively engaging with reality, which is permeated by digital dynamics that affect everyone's lives on a large scale. In the empirical findings, as in other works (Aguado & Alvarez, 2019; Davies, 2017; Menezes, 2022; Pretto, 2017), we can notice that hacker communities are spaces that enable the tools of activism and agency, with a view to co-creating the world and, recursively, the individual themselves. (Stetsenko, 2016).

TAS-based critical pedagogies must contribute to learners not only seeking their desired futures, but also formulating and developing their goals and meaningful pursuits (Stetsenko, 2016, p. 355). In this sense, a major challenge, especially for educators, is the non-imposition of their own activist agendas, but rather, mediate the construction and discovery of students' agendas (Vianna & Stetsenko, 2019). It is from this perspective that the dimension of *inquietude* in HE points to the combination of curiosity and a critical attitude as a way of mediating this. The inquietude represents the desire of hackers to understand the world and how things work (Davies, 2017; Levy, 1984/1994). This is also noticed in CA school. The 5th year teacher does not ignore the curiosities of her students when choosing the themes for their podcasts. More than that, she motivates the expansion of those curiosities through investigative journalism, so the students go out to interview strikers, teachers and other people who could help them to understand their curiosities. These curiosities, at a certain point, cease to be a simple curiosity and became a more critical curiosity. This is the movement that Freire (2013, p. 32) calls moving from a naive curiosity to a more rigorous curiosity, an epistemological curiosity. Educators have a fundamental role to play in stimulating epistemological curiosity, which, as in hacker communities, is not solved by superficial explanations, but rather in practice, in activism, in the exercise/strengthening of agency, where we become "capable of challenging and changing our own limit situations and often oppressive circumstances" (Stetsenko, 2016, p. 368).

In TAS, the key goals of education are related with the co-creation of "tools of agency for each learner's unique voice and stance" and the co-creation of "visions for the future from which the past and the present can be known and transformed" (Stetsenko, 2016, p. 354). We realize that the perception of people as creators/constructors/authors is at the heart of the understanding of pedagogy in TAS, but always understood in a community dimension, in which everyone has a unique place and always guided by a sought-after future. It is interesting to see how this understanding is closely linked to Freire's concept of "*esperançar*" (Freire, 1992), by which we are invited to hope, but not passively: by creating it now. Similarly, but from a different perspective, Himanen (2001/2001), when detailing the hacker ethic, defines *creativity* as the reason for hackers' existence, understanding it as the supreme ability of hackers to create and recreate the world. This theoretical convergence is reflected in the empirical findings, when we noticed in the *Action-Fun* dimension the creative, agentive, authorial way in which hackers, and also the students and teachers-researchers in CA school, co-create artifacts and knowledge (e.g. software, pollution sensors, awareness campaigns, open educational resources, podcasts, pedagogical practices, etc.). In the *Collective* dimension, we realize that co-creation, starts from the people's inquietudes, respecting this unique place of each person, however, recursively, these inquietudes are fed and supported (as well as the creative process) by the community itself (which is also fed by the people who are there). In other words, it is a pedagogy made by "Learners-through-community and community-through-learners" (Stetsenko, 2016, p. 353). Also in the CA school, these elements are strongly mentioned by the participants. From the preparation of the project's actions to its execution and evaluation seminars, all actors (university researchers, school researchers/teachers, students of different levels) participated horizontally, which, among other advantages, enabled multiple points of view (heterogeneity of the collective).

Another structuring element in the pedagogical perspective of TAS is the *society-community* dialectic, carried out by subjects who identify themselves as activists, that is, as people with the ability to take a stand, knowing what is happening in their communities and the wider world, and challenging the status quo, acting to build a better world (Vianna & Stetsenko, 2019). The movements of Hacker Feminism and Media Activism (Ortmann, 2022; Richterich, 2022) are examples of communities that are in line with this perspective. In the findings we noticed several examples expressing how these communities tend to go beyond their walls, connecting to their surroundings and acting to intervene positively in society, e.g., creating pollution sensors with schools, strengthening students, parents and teachers in the areas of media literacy and understanding of technology, enabling free education. Addressing social dynamics in schools, an element which for Mclaren (2003/2005) is essential for the practice of a critical education, in the CA school context, especially in the high school, was present through all the debates and studies for the construction of the models of ideal society. The 5th Year students visited radio stations, conducted interviews outside of school and in their podcasts covered topics such as the strike at the university and fake news in the political process. Making from a critical perspective (critical maker), is an invitation to social debate, allowing people to question their roles as active change agents in their communities (Nation & Durán, 2019, p. 261).

An essential condition for human development based on communality is solidarity, which, in union with a notion of freedom, enables access to conditions and tools of agency, as well as, through free choice, allowing people to have a unique agentive position from which to contribute to collective and collaborative endeavors (Stetsenko, 2016). The *sharing* dimension of HE presents the elements that show how hackers experience this solidarity-freedom bridge: hackers share openly their deeds (Himanen, 2001/2001; Levy, 1984/1994). The case shared by the Argentinian hacker in the findings clearly demonstrates the solidarity of a community that shares its technological

creations, allowing others to benefit from having access to them, just as they initially benefited from the free hardware and software they initially used (i.e. mutuality in (Stetsenko, 2016, p. 361)). It is a recursive process that contrasts with the capitalist exploitation of intellectual creations, even in a moment of so much human fragility, such as the Covid-19 pandemic, when some big vaccine-producing corporations and their governments have defended patent conditions that centralize the manufacturing chain in a few countries, even imposing limits to technological transfer and to the distribution of vaccines to other countries (Callaway, 2020; McMahon, 2021; Price et al., 2020). Fomenting a commons culture in our societies is fundamental for solving local and global problems, and in this endeavor, educational processes are essential for fostering transformative agency, because it allows social practices based on the relationship between individuals and collectives, around their constructs, as, also, for open educational resources for teacher development (Wolfenden & Adinolfi, 2019, p. 2). At CA school, the 5th Year students shared their podcasts on the Internet and, the feeling of authorship, of being able to create and share, has been highlighted. It´s something that Marsh at al. (2019) also noticed in early childhood making education (maker agency).

Permeating all these discussions is the *humanistic-technological* dimension. Since the first generations of hacker communities, the defense of code transparency, solidarity sharing, respect for privacy, among others, have been aspects that have permeated their cultures (Levy, 1984/1994). We can notice in the findings that this humanistic-technological perception (understanding the two as inseparable) manifests itself, among other ways, through technological activism, whether in denouncing (the abuses of big tech and governments), announcing (social/human technologies) or creating a desired technological future. This desired technological future, that has been agentively created in hacker communities today, is one where people are not atomized or simplified (as has happened with the advance of AI), technologies are not opaque but transparent, it is a future where there is technodiversity (avoiding algorithmic prejudice and technological colonialism) and the immigrants are not victims of surveillance (i.e. Vakil & McKinney de Royston, 2022). As we realized in the CA School case, the challenges are enormous, especially in contexts that are more prone to capture by big tech. Despite the constant problematization about the importance of open technologies to human rights in algorithmic societies, we noticed difficulties in transforming these critical reflections into behavioral changes, both in the incorporation of technologies in pedagogical strategies and in daily technological choices. Further studies are needed to help us envision this experience in schools, not only approaching the use of digital technologies from the perspective of civic youth agency, but also, in terms of awareness of the social structures that influence technologies (Dias Fonseca, 2019, p. 367). Critical literacy and the functional appropriation of digital technologies must go hand in hand, and the Citizenship curriculum should adopt a more critical approach to Internet and democracy (Polizzi, 2020). The humanistic-technological dimension alerts us to the importance of overcoming the false humanism-technology dichotomy (Freire, 1967, p. 97; Lund et al., 2019), essential in societies where our technological choices are decisive for social directions (Winner, 2020).

Conclusion

The findings obtained throughout our study allowed us to build a multidimensional perception of HE which aspects and experiences offers elements for transformative/critical pedagogies in digitalized societies. Both in the context of hacker communities and in the school, the transformative-agentive pedagogical action starts from individual inquietudes and interests that mature critically in the community context, giving rise to a co-creative and dialectical process with the community and its surroundings, demonstrating a way of agentively co-creating the analogue-

digital sought-after future. Open sharing and the perception of technologies as common goods, enable the creation of new open technologies and social proposals that the community proposes to do, which in hacker education is a way of living fraternity and mutuality, essential element in a TAS-based critical pedagogy. At the same time, the community (Hackers and schools) act as transforming agents through the constructions they make, the artifacts they create, thus exercising their activism through technologies. These artifacts strengthen the sense of community of those who are part active of the transformative process. In the dialectic individual-community-society, all of them are transformed.

Throughout this research, we sought to do everything possible to overcome or minimize the possible limitations that arose. Still, some limitations were the result of methodological options that we had taken, and we have had to assume them: 1) We chose to construct our vision of hacker education based on the heterogeneity of this movement. In such an approach, some participants may not feel included in the resulting constructions in that they might detect differences with respect to their own personal experience and to their specific collective; 2) The CA school, with very specific conditions, it is part of the Universidade Federal de Santa Catarina and the teachers work in exclusive dedication. Such specificities make this context an ideal case for research like the Conexão Escola-Mundo project, which is nevertheless significantly different from most public schools in Brazil. Considering this latter limitation, we would highlight, as a future line of action and research, the experience of hacker education in other educational contexts, with special attention to those where the lack of resources are more acute. The transformative activist stance of the hackers, while giving us hope by pointing a path, warns us all of the risks posed by the dynamics of oppression present in the hyper-capitalist culture of Silicon Valley, which is often based on surveillance, the attention economy, the precariousness of work and the simplification of human beings. The consequences have been more unequal societies and the sickening of people. It is urgent that we act in an activist way to hack these dynamics, co-constructing a different future.

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No conflict of interest is reported by the authors.