Students' Views on Adapting Computing to Climate Change

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ABSTRACT

Climate change is an increasingly hot topic, impacting a wide range of fields. In this study, we are interested in querying computing students views on the issue: what are challenges and opportunities as the field adapts itself to climate change? We conducted a series of interviews that revealed that students agree that it is an urgent issue, but they feel that it would not have major impacts in their field. The adaptations that were suggested are of a generally more superficial nature, lacking a structural understanding of the challenges of the climate change, and students do not generally feel that they themselves could initiate action.

1 INTRODUCTION

As its harsh realities spread over everyday life, climate change has become a dominant theme in societal discourse. While discussions about the extent of the damage already done, our shared future prospects, and possible mitigation strategies are still a highly politically charged topic, even traditionally denialist blocs have started acknowledging that *something* must be done [8].

In computing, the discussion about how the field is related to and could act on climate change is not new but has become more prominent in recent years. Considering scholarly work, for instance, in the ACM Digital Library there were 295 climate change-related papers published between 1991 and 2009, with another 2,095 then published from 2010 to 2020 [4]. As a complex, multi-variate issue, different researchers have adopted varied approaches about what role computing should play. Easterbrook [3], for example, argues that the software community has to "step up to the plate," as other fields have done, and calls for a discipline-wide effort on work on software to "support the science of understanding climate change[,] to support the global collective decision making[, and] to reduce the carbon footprint of modern technology."

This fits what Silberman and Tomlinson [7] call *adaptation-oriented pre-apocalyptic computing*, which assumes a future apocalypse[1] is likely, but attempts to "develop tools for users to negotiate it successfully," making it "less apocalyptic [with] materials and social relations available at design time (pre-apocalypse) but likely to be unavailable at use time." An alternative approach, *adaptation-oriented post-apocalyptic computing* works within material constraints as if the apocalypse had already happened, thus anticipating and easing a transition towards future conditions — which, interestingly, makes this approach share methods with the already-present realities of "disaster informatics, community informatics, ICT4D, HCI4D, humanitarian logistics, sociotechnical action research and 'post normal science'" — for many underdeveloped regions around the world, the "ingredients of apocalyptic computings and other related practices [constituting] deindustrial techne" are are already a given.

In that vein, Nardi et al. [6] challenge computing's assumed premise that "exponential growth of computing capacity and an ever-expanding infrastructure for computing will continue into the future," positing that, as world-limits make themselves felt, an alternative, and even optimistic, approach would be to strive for a "transformative change to a system more like steady-state economy," i.e. one not predicated on continuous economic (and resource consumption) growth. Wong [9] goes further: in denouncing how designers "often confuse needs with desire," they claim that designers "will need to recognize the pervasiveness and insidiousness of denial in materialistic populations," and that perhaps a reality shock (brought upon a collapse of much of what makes present-day computing possible) will allow sustainable interaction design to "shift its focus from persuading to sustaining the human race."

All of this begets the question: how is the new generation of computing professionals readying themselves to act within this scenario that, while bleak, will inevitably shape their future careers? While climate change affects the field as a whole, new and old professionals alike, we chose to focus on computing students since their mental models about computing's role in the Anthropocene are supposedly still being shaped by their on-going education. This, we posit, might give a good indication of where the field is heading. This study attempts to answer the following research questions:

(1) If students feel that climate change will impact how their field of expertise works?
(2) If they do, what do computing students think their field of expertise will look like during the effects of climate change?

2 METHODS

We aim to understand perceptions of computer science students about climate change and how their field affects and is affected by it. To gauge these opinions, we conducted semi-structured interviews with students varying from undergraduate and graduate levels. In this section we describe how we collected the data, extracted themes and deduced results from the data.

2.1 Materials and Procedure

The semi-structured interview included 13 questions that are tailored to provide insights for our research questions. Q1-Q5 collected demographic information on participants (name, gender, age and area of expertise). Q6 was a general warm-up question about the participant's professional plan for the future. Q7-Q9 were used to answer "How climate change was perceived in daily life?". Q10-Q11 aimed to find out "How climate change would influence their area of expertise?" Q12-Q13 discovered "What opportunities were presented in terms of alleviating the effects of climate change?"

[1]The term, which the authors acknowledge as perhaps too *inflammatory* for scholarly use, "denotes an event in the intersection of the spaces of events denoted by the terms *collapse* and *disaster*."

There were a total of 5 interviews conducted. They were semi-structured and conducted online using a video messaging platform called Zoom, all lasting around 20 minutes each. The interviews were recorded with permission and transcribed afterwards.

2.2 Analysis

After conducting and transcribing the interviews, we analyzed them using a bottom-up, inductive process, as per Braun and Clarke [1].

2.2.1 Generating and collating initial codes. Interviews were bundled into one document. Each author was given a copy of this final transcript and annotated them individually without communication or interference from other authors, extracting initial codes from the interviews. After being generated, they were collated and collapsed by the similarity of their content, then displayed as sticky notes using a collaborative whiteboard platform.

2.2.2 Defining themes. After pasting all codes in the same place, we created an overall coding diagram to identify similarities that allowed thematic grouping. We ended up identifying four major categories, to which we attached the codes' post-its. All four categories provide insights to our research questions for the "perception of climate change" and the "impact on area of expertise." Finally, in writing the report, we established the final two themes, *Unsystematic risks* and *Limits to action*, with which we wrote our final analysis.

3 RESULTS

Participants' names coded for anonymity, and their responses edited for clarity and brevity.

3.1 Are individuals affected by climate change?

"It's affecting everybody, it affects humans, animals, at the end of the day, the tech field are still people who get adversely affected by climate, right? So honestly, I don't know if there is a demarcation between tech people and non-tech people when it comes to climate change, it just affects everybody regardless." (PR1)

From the interviews, we observed that all the participants believe that climate change is urgent and needs to be planned for. PR1 mentions that although the effects of climate change will be seen on the tech field, it is not isolated to the tech field and should be considered as a global problem.

"I was listening to this climate-related podcast, I think it is called 'How to change the world,' and one of the episodes was about Miami, and how the sea level continues to rise and they just keep building and elevating their buildings, and no one really talks about how this is an issue, you know, we can't keep putting our buildings on stilts." (PR2)

"Particularly sensitive to climate change I would think of the energy field. Fossil fuels are a big part and climate change. I would also add real estate, because if the ice caps melt and the sea levels rise as you're seeing in some places already, those beach side properties will be underwater." (PR4)

"Actually, I think in city it is also urgent or sensitive, because as more and more people are moving from rural areas to cities, this will increase CO_2 emissions, which is one of the major causes for the global warming." (PR5)

"I think the poorer will be more affected by it, but the richer can reduce the impacts of climate change for themselves." (PR1)

All participants agree that there are certain areas that are more sensitive and will be affected adversely by climate change. PR2 and PR4 talk about the melting icecaps and rising water levels in the oceans and how this is problem for cities built on the coast. Hitz and Smith [5] illustrate the rising sea levels will cause loss of land, larger damages from storms, saltwater intrusion and increased cost in coastal defenses. PR5 feels that due to the migration of citizens from rural to urban areas there will be an increase in emission of CO_2, contributing to global warming — which, it is worth noting, is not in line with recent research on the topic [2]. PR1 feels that rather than only looking at the effects from a global standpoint, we must also look at them for groups from lower economic backgrounds, who will be less prepared for the effects of climate change.

While most participants talked about how the drastic change in climate would affect the population of earth, they did not mention how these changes would personally affect them. PR2 did mention that although they were concerned about the effects of climate change, they felt that it would not personally change their plans.

"I don't personally fear for myself or about whether where I live down there is going to catch on fire." (PR2)

3.2 Are individuals affecting climate change?

Our interview participants all acknowledged that climate change is indeed an urgent issue and can be addressed through both monitoring individually daily usage of technology and raising awareness of power consumption of certain computing fields. However, there are challenges to adopt a more environmentally friendly lifestyle.

3.2.1 Individual Behavior Changes. Several participants express the intention to incorporate personal behavior changes to combat climate change. It's worth noting that electric cars are often mentioned as something they would considering purchasing:

"I may change my private car to energy-saving and environment-friendly in the future. Electric cars are a good choice." (PR3)

"I've read suggestions of using your current appliances till the end of their lifespan, and to then recycle them, avoiding byproducts that would harm the environment. For instance, I plan on buying an electric car or hybrid in the future, but I'll drive my current car until it is no longer operable." (PR4)

"I'm becoming more conscious about the power that tech uses. For example, I used to leave my PlayStation on rest mode, but now I power it off. I know it's not much, but if a million people started doing it, that's a big deal." (PR1)

One participant mentioned that structural change should be more emphasized in term of impact on climate change:

"I do not think that the everyday use of technology will change much, but those big companies that consume a lot of plastics will have to change." (PR5)

3.2.2 Challenges of changing lifestyles. While most participants stated that they would love to adapt an environmentally friendly and energy-saving lifestyle, they also realized that such change

can be unpleasant and hard to execute. Affordability is the major concerns for some of our participants:

"I would say that I couldn't afford an electric car right now, but that would be an ideal plan." (PR2)

"It again comes down to the trade-off, because the greener the tech you want right now, the more expensive it gets. Very weird situation but unfortunately that's what it is. If it's within budget, or even if it's reasonably above budget, then I would go for a greener option, but yeah at the end of the day it comes down to economics." (PR1)

The tension between a comfortable lifestyle versus an inconvenient and expensive but environmentally friendly one is present in many participants' answers:

"We're so used to having everything accessible within days or hours. I can order something from across the country and it'll be here in two days, and I can do that through an app, through the click of my fingers. As someone who's in the field of user experience, I think that we want to make things easy and accessible for users, but I feel like we also don't want to neglect being environmentally conscious, and we don't want to make things too easy that people become lazy and neglectful." (PR2)

3.3 Is computing affected by climate change?

Many participants believe their own computing field of expertise can both worsen and help alleviate climate change's effects:

"As we know, the effects of climate change can be recorded in databases. If we want to get more useful information, we cannot ignore the powerful tools of the AI."(PR5)

"There is a lot of room for optimization. Power efficiency in data centers, for instance. There are also a lot of industries where ML and AI could help." (PR1)

"I think that games would let people be more conscious about how they affect the climate." (PR4)

One participant reported their ambiguous and confused attitude when considering the field of user experience:

"We want to make things easy and accessible for users, but I feel like we also don't want to neglect being environmentally conscious, and we don't want to make things too easy that we are lazy and neglectful. I definitely will order things from Amazon, and I'm like, 'that's probably not the best thing to do. Why don't I just go outside of my apartment, walk down the street and buy things locally?' " (PR2)

"When I was an undergrad in architecture, the topic of climate change was very much in my everyday language, but since taking the HCI path, it kind of lost it a bit..." (PR2)

Some participants also reported the negative effects that computing has on climate change. Most of these concerns were related to large-scale energy consumption:

"Cloud services need to consume a tremendous amount of energy and, to maintain operating speeds, additional power is needed to dissipate heat." (PR3)

"Some large-scale machine learning use a lot of electricity, and their long-term goals are not aligned with climate trends." (PR5)

Some participants mentioned that even though computing brings light to the climate change issue, it is just a piece of the puzzle in terms of solving climate change. For example, one participant considered that, in most cases, technology could be just a complementary tool. Another participant reported that what current computing can do is to make small and minor improvements.

One participant mentioned that social media had a big impact, but they were unsure about its effects on climate change:

"In the computer field, our advantages are very strong social communication and influence. But depending on past experience, good media tend to spread virally. However, we won't know how people will behave after transmission." (PR3)

3.4 Is climate change affecting computing?

Most participants considered their fields to be less at risk, at least in the near future.

"In terms of the computing field, a lot of data centers are trying to green. Even for cloud services, there are a few that claim they are green-powered." (PR1)

Many participants believe the current situation has raised people's awareness about climate change, and that climate change-related topics research will become more prominent:

"As climate change continues to be a pressing issue, and so does our use of technology, there are many opportunities for people in HCI to integrate that with climate change somehow." (PR2)

"In terms of meteorological studies, there would be more modeling for weather changes or stuff like that." (PR1)

"There would be more games geared towards the climate change issue, with preventing it as their main topic." (PR4)

"I think that they (games) would let people be more conscious about how they affect the climate." (PR4)

4 DISCUSSION

4.1 Unsystematic risks

All participants were unanimous in stating that they felt climate change as a real and urgent issue. In their understanding of the scope of the risks posed by it, however, its effects were generally perceived as if of an unsystematic nature, in line with what Silberman and Tomlinson call *emergencies*, i.e., "events that have impacts on social units, which mobilize responses to these impacts," but which do not usually *exceed* society's capabilities for response.

This is seen both in how they imagine themselves potentially affected by climate change and how they feel the computing field will (if at all) change in response to it. PR2, for instance, knows that Albuquerque, New Mexico (where they plan to move to), is suffering from out-of-control wildfires and an on-going major drought. Yet, these are seem as inconveniences but not necessarily deal-breakers.

While there were hints of how parts of computing are interconnected — e.g. PR4 saying that "if you were working with hardware [and you could not get the resources because] they would be shutting down the plant" —, the more general perception is that there are certain *localized* risks that could cause disruptions, but not a *collapse*. The societal status quo is seen as inherently stable.

In this sense, participants seem to call for a loose *adaptation-oriented pre-apocalyptic computing* within a very limited scope.

They propose specific changes, both for the field and their personal lives, but these are discontinuous and, more especially, non-structural: on a personal level, many mentioned wanting to change an ICE car for an electric one, but there was little discussion of car-dependency embedded in city design; in computing, there was mention of the use of green components in computer manufacturing, but consumerism itself was only briefly mentioned.

PR2 hinted at this contradiction between how limits to what non-structural changes are capable of achieving when they pointed that convenience, as it is embedded in everyday apps and services, is contradictory with environmentalism, an apparently unsolvable conundrum since "companies should not make bad apps."

4.2 Limits to action

A second theme we perceived in participants' answers was that they seemed to see themselves as if helpless to initiate any major changes, be it societal or in their own fields of expertise. Not only did they generally avoid discussing the need for structural changes, what changes they did suggest or see as forthcoming are all implicitly initiated by unknowable forces, over which the interviewees seem to have no say.

This, again, seems to be tied to a notion of climate change-related risks as if geographically and chronologically far off, and to the belief that whatever society emerges from it will be a superficially improved but structurally similar version of ours.

Even if one assumes, like Easterbrook, an *adaptation-oriented pre-apocalyptic computing* scenario, mitigation is necessarily a costly endeavor and one which needs careful coordination and intense effort. In this case, this passivity is worrying, as it seems to indicate that reflections about climate change are still superficial.

It also worrying when one considers that, if *collapses* do occur, current students might be ill-equipped to adapt to new circumstances. If, as states Wong, "our future lacks some of the technology opulence we have grown to expect, there are still plenty of opportunities for sustainable interaction design to have an impact," it would seem important to explore some of these opportunities at our present *pre-apocalyptic* context.

4.3 Limitations of this study

For one, time restrictions limited our number of interviewees to only 5. While we were able to obtain a varied set of responses, sub-fields of computing were underrepresented, when at all, i.e., we only had one participant from HCI, one from game development, etc. Considering how [3] proposes sub-field related responses, a broader and more representative sample could deepen the discussion of more specific educational interventions, for instance.

The small sample also meant that we did not achieve data saturation, so while there were common themes between participants' responses, there was also a lot of variety among them. Given our decision to design a short interview guide, more participants could increase confidence in our thematic analysis.

5 CONCLUSIONS AND FUTURE WORK

As a way to potentially help the debate about how the computing field can evolve to better deal with climate change, and also as a query into how its next generation of practitioners imagine the field will change in the coming years, our research interviewed computing students from different educational levels.

We asked them about their perceptions about the interactions between the field and climate change. In response to our first research question (*if they feel that climate change will impact how their field of expertise works?*), the general answer seems to be that yes, the field will change, even if the extent to which this is perceived as true seems to be quite limited, and it is not clear to our participants who should initiate these changes.

This feeds into our second research question (*what do computing students think their field of expertise will look like during the effects of climate change?*), for which our answers pointed to a field that is only superficially different than it currently is at its present state.

These answers are worrying for two reasons. First, they indicate that, even if climate change is named as an urgent matter, computing seems to have a passive attitude towards it, both in terms of protecting itself against probable disastrous future scenarios and in terms of helping society to avert them.

Second, the answers also show that these students themselves might be receiving an education that aims an each day more unlikely future professional landscape, while at the same time ignoring steps they could be taking now to prepare themselves for this *post-apocalyptic computing*, to use Silberman and Tomlinson's term.

Given these bleak findings, it is urgent that climate change adaptation is given a greater role in computing courses. This could be through a greater emphasis in topics like those mentioned by Silberman and Tomlinson, Easterbrook, among others.

5.1 Future work

One gap left by our research is: do computing students actually think what is currently being done as enough to deal with climate change? Are they optimistic, or, if pessimistic, what should change? Also, it would be worth querying the reasons behind the current passivity we have found.

To maybe gain a more in-depth understanding of how computing students could react to more structural changes to their field, further research could present some of the alternative scenarios discussed here and probe how students think they would fare in each of them, and if their opinions of the current status quo would change.

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