Melbourne Knowledge Week 2021 Evaluation

Event: Melbourne Knowledge Week
Date: 26 April – 2 May 2021

Event description

Melbourne Knowledge Week (MKW) is an annual festival that brings Melburnians together to explore and discuss, to share ideas, to challenge assumptions, and to spark new ways of thinking. Across seven days, the broad program of events included workshops, performances and interactive exhibits of which FLEET participated in the latter. FLEET's interactive display used the mobius strip, jumping rings, Van der Graff machine and a build-a-circuit kit for kids (and adults) to experiment with and build different circuits. To accompany the physical build-a circuit kit, there was an online interactive that kids could replicate what they did with the physical kits. We had up to three FLEET volunteers (four on weekends) managing the exhibit at any time to engage with the public.

FLEET objectives for the event

I developed the event to attempt to achieve the following outcomes:
- An appreciation/awareness of the purpose and value of FLEET research and physics generally.
- Increased public awareness of problem of the increasing demand for and energy consumption of computation, and the implications of this.
- A public thinking critically about the meaning and value of FLEET research.
- Primary and secondary students with a greater interest in and awareness and appreciation of physics
- FLEET researchers with improved communication skills and greater understanding of audience values and perceptions of physics/FLEET research

Audience and number of engagements

The following is an estimate of the number of people that visited the FLEET exhibit.
Weekday (Mon-Frid): 30-40 people per day
Weekend (Sat-Sun): 80-120 people per day

Significant was the quality of each engagement. The shortest conversation with any member of the public was about 5 minutes. The longest was about 20 minutes with most being about 10 minutes. Any discussion covered the motivation for FLEET's research, the varied research problems that underpin the research, the research itself and the social implications of FLEET's research.

Most of the audience were adults. Only two groups of secondary students came through during the week. On the weekend there were a lot of families in the mix of adults. Most children were less than 10 years old.

Key findings

- The public had mid- to low awareness about the increasing level of demand for computation and its implications for energy use. In contrast, the public had a relatively high concern about this problem, once made aware of it.
- "The realization" that the increasing computational demand and energy consumption could be an issue was a core theme that facilitated further dialogue in which the public thought critically about FLEET research and its implications.
- Sustainability was a second core theme underpinned by the sub-themes, Change and Concern. People thought critically about what were acceptable alternatives or pathways to achieve a sustainable digital future.
- FLEET had a positive effect on the public's appreciation and awareness of physics.
- There was good engagement from children that used the build-a-circuit kit and observational evidence suggests they learned something about circuits.
- FLEET volunteer outcomes: Along with enjoying the engagement and talking to the public about their research, volunteers found a connection with the public that provided a justification for their research. They also confronted unexpected public values that provided a novel perspective on how the public perceives FLEET research.

Evaluation

To evaluate Melbourne Knowledge Week pre- and post-evaluation tools were developed. Pre-evaluation was a short two-question survey on butcher's paper and placed on a wall visible to the public. It asked the following two questions with the public to select answers from a 5-point Likert scale:

1. Describe your awareness of the increasing demand for computation and the energy costs to meet that demand (low to high awareness)
2. Describe your concern for the above demand and costs (low to high concern)

Post-evaluation asked the public to contribute to a mind map, again on a large sheet of butcher's paper on display for the public. See Figure 1. An online survey was also conducted that asked the following four questions:

1. Participant's age
2. Write one new / interesting thing that I learned from this experience with FLEET today?
3. On a scale of 1 - 5, How has your appreciation and awareness of physics changed after your time with FLEET?
4. Only if you want to. Provide other comments about your engagement with FLEET

Notes were also made on some of the more interesting conversations or points that were being raised continually by members of the public. Data from these notes is integrated into the analysis of the mind map and online survey data.

Figure 1. Mind map used for Melbourne Knowledge Week that asked people to think about what was an acceptable digital future and the pathway to achieve it.
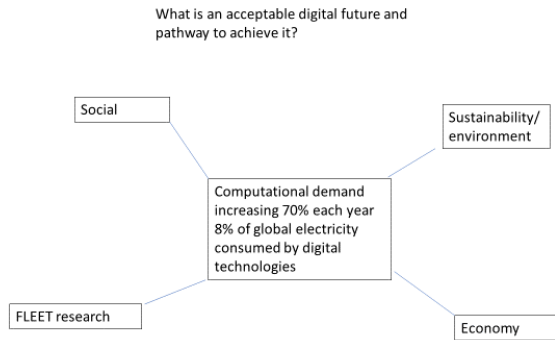
This report examines the pre-evaluation data, then the post-evaluation. I then draw conclusions about what this data means relative to the FLEET's objectives/outcomes for the event.
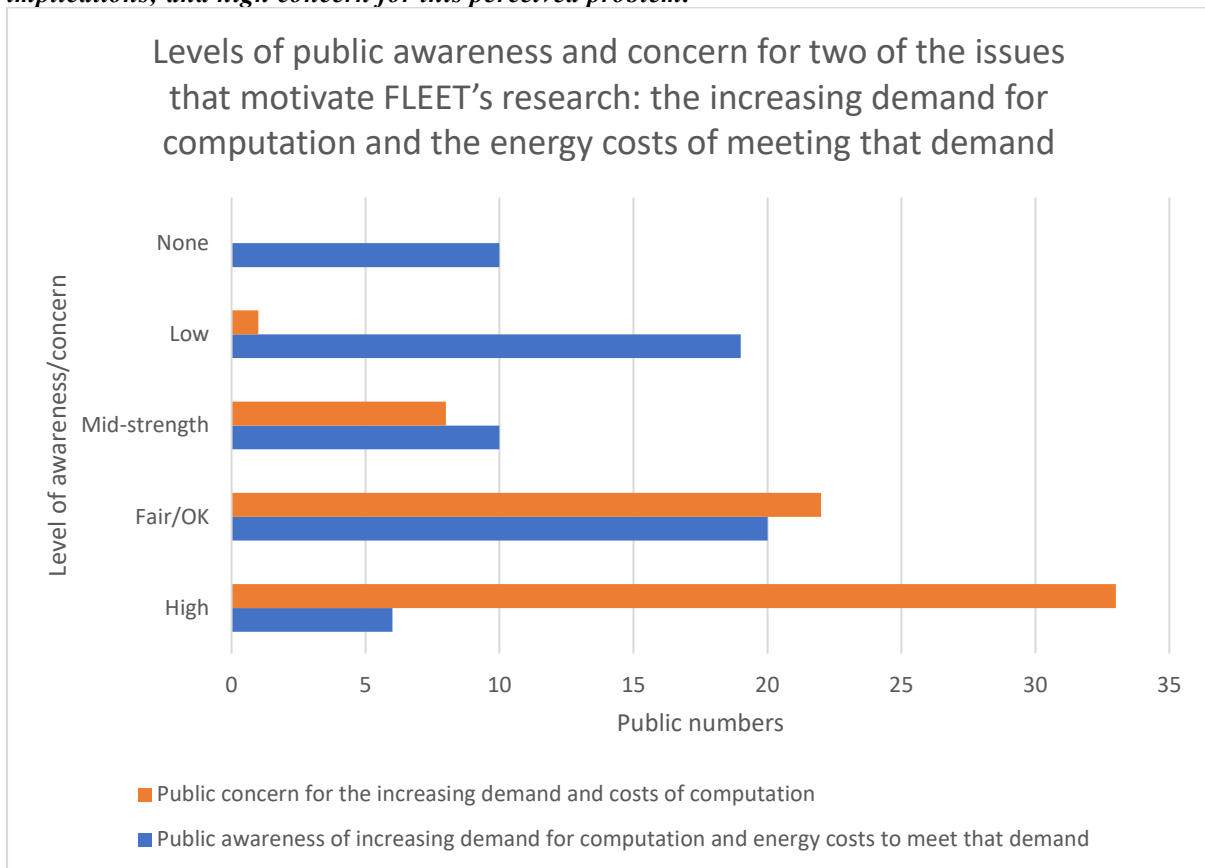
Pre-evaluation

Table 1 and Figure 2 suggest that the public had mid- to low awareness of the problem motivating FLEET research. That is, the increasing demand for computation and the consequent energy demand of this computation. In contrast, the public had a relatively high concern about this problem.

Table 1 Levels of public awareness and concern of two of the issues that motivate FLEET's research: the increasing demand for computation and the energy costs* of meeting that demand.

	High	Fair/OK	Mid-strength	Low	None
Public awareness of increasing demand for computation and energy costs to meet that demand	6	20	10	19	10
Public concern for the above demand and costs	33	22	8	1	0

*It was made clear to the public that costs in this context concerned social, environmental and economical costs.

Levels of public awareness and concern for two of the issues that motivate FLEET's research: the increasing demand for computation and the energy costs of meeting that demand

Post-evaluation: Online survey

Number of responses to the survey, N=41
The four survey questions are analysed individually below.

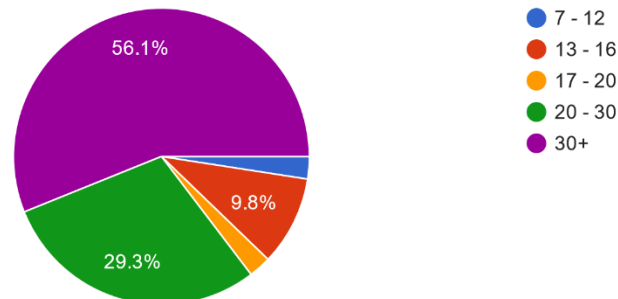### *Online survey question 1. Your age*

Most people participating in the survey were 30+, though five respondents were less than 16 years old. See Table 2 and Figure 3.

Table 2 Age range for survey participants

Age	Number of survey participants
30+	23
20-30	12
17-20	1
13-16	4
7-12	1

Figure 3. Pie chart show distribution of survey respondents age

Your age
41 responses

Legend:
- 7 - 12
- 13 - 16
- 17 - 20
- 20 - 30
- 30+

Pie segments: 56.1%, 9.8%, 29.3%

Online survey question 2: Write one new / interesting thing that I learned from this experience with FLEET today?

The following four themes emerged from the data from question 2:

- Computational, energy demand
- Valuing FLEET research
- Triggering critical thought
- Learning physics.

Each of the four themes is discussed in more detail below, but the computational, energy demand was the dominant theme and this sudden awareness of the issue from talking to FLEET people is what facilitated the dialogue about the value of FLEET's research and what the implications of this research might be for social and environmental sustainability, themes that were reflected in the Mind Map data.

Computational, energy demand: Participants became aware for the first time of the increasing demand for computation and the associated energy requirements. This was the dominant theme to emerge and appeared in nearly half the survey responses, which are reflected in the participant quotes below.

Participant quotes:

"We won't be able to support our energy demands for our devices in 10 years at the current rate the demand is growing."

[recalling] "how quickly the demand for electricity from computers will exceed our capacity to produce it."

[unaware of] "the amount of computing power being used"

"A lot of coal is burnt for electricity" [Child less than 12 years old]

"We are pretty much at the limit of data storage with silicon - it is time to spin"

This new awareness facilitated the thinking that underpinned the themes, Valuing FLEET research and Triggering critical thought.

Valuing FLEET research: This theme reflects participants' perceptions that FLEET's research had value, see quotes below. This perception extended to the potential of FLEET to

help solve the issue of increasing computational demand and energy consumption, and that such research had social benefits. Again, this reflects data from the Mind Map.

Participant quotes

"I am glad to hear about the research being done…"

[Recalling] "the need for low energy electronics"

[Recalling] "importance of quantum physics for more sustainable future"

"amazing potential new material can save power"

Triggering critical thought*:* This theme reflects how FLEET's engagement made the participants think critically, from a global perspective, about a problem they were either unaware of or had not considered before. People thought critically largely about the social and environmental implications. For example, the potential unsustainable consumption of energy to power digital technologies.

Participant quotes

"In 10 years we won't have enough power to meet the demand for computational energy - food for thought how we consume and use computers etc."

"Energy loss and thinking about research and innovation on new materials to help with reducing [energy loss]."

There was some evidence of critical reflection where people considered how their own behaviour or computational needs contributed to the problem of demand and energy use, which was something they had not previously considered.

Participant quotes

"I never thought of the computation-electricity demand problem and how closely related the issue is with my technology needs. It is definitely an eye opener."

This was supported by a visual artist working in Virtual Reality who thought they did some "cool stuff", but until now had not considered the consequences of his own work's high computational demand, a demand he acknowledged that was only increasing. He now realized his footprint was "massive" and this concerned him.

A second individual worked in a data centre where her role was to "get more and more people to use the cloud". Until now she had only vaguely thought about the implications of this and the impact her role had on social and environmental sustainability*

*See Reflections section below where it is noted that there is missing context to many of the conversations that may have influenced participants' responses.

Learning physics: Learning was another theme that appeared in about 38% of responses. What was learned/recalled varied with the participant. For instance, participants recalled learning about topological insulators, electrical resistance, electricity and 2D materials.

Participant quotes

"I learnt why our computers and phone heat up."

"[You] demonstrated what lightning (electricity) is for my children aged 7 and 5. It helped my earlier explanation of the difference between coal and green energy is. Very enjoyable and well explained demo."

"Didn't know graphene was one atom thick"

Online survey question 3. On a scale of 1-5, How has your appreciation and awareness of physics changes after your time with FLEET?

Figure 4. shows that FLEET had a significant effect on at least 90% of survey participants who ranked their change in appreciation and awareness of physics at 4 or 5 on the Likert scale with 5 being "Wow, a lot [of change]". This suggests that FLEET had a positive effect on the public's appreciation and awareness of physics.

Figure 4. Graph depicting change in awareness and appreciation of physics following engagement with FLEET
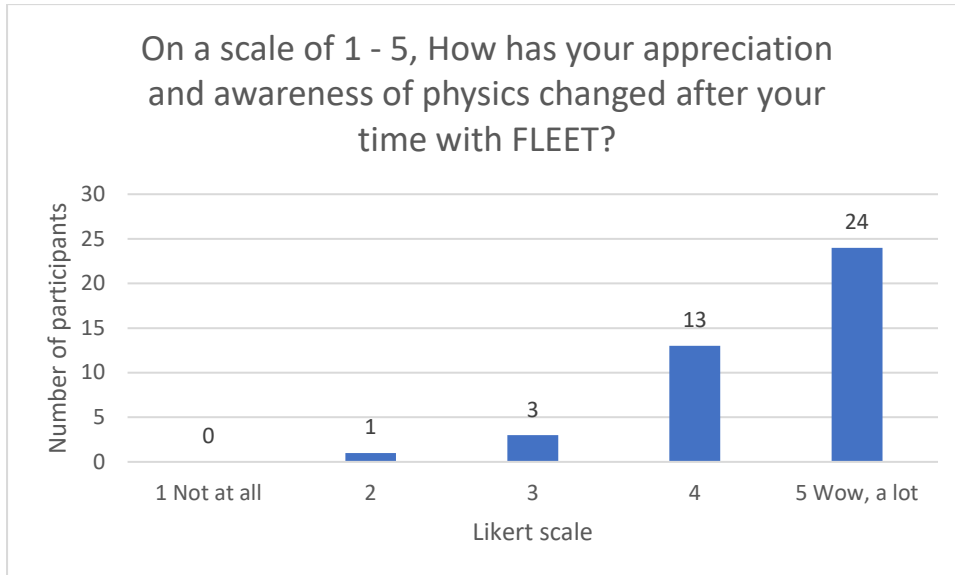
Online survey question 4. Provide other comments about your engagement with FLEET

Most responses to this question were about how enjoyable, engaging and informative their experience with FLEET was. The key words from all the responses to this voluntary question (N= 22) were placed into a word cloud with the more prevalent words being the largest. See Figure 5.

Figure 5. Word cloud generated from key keys words extracted from the online survey question 4.
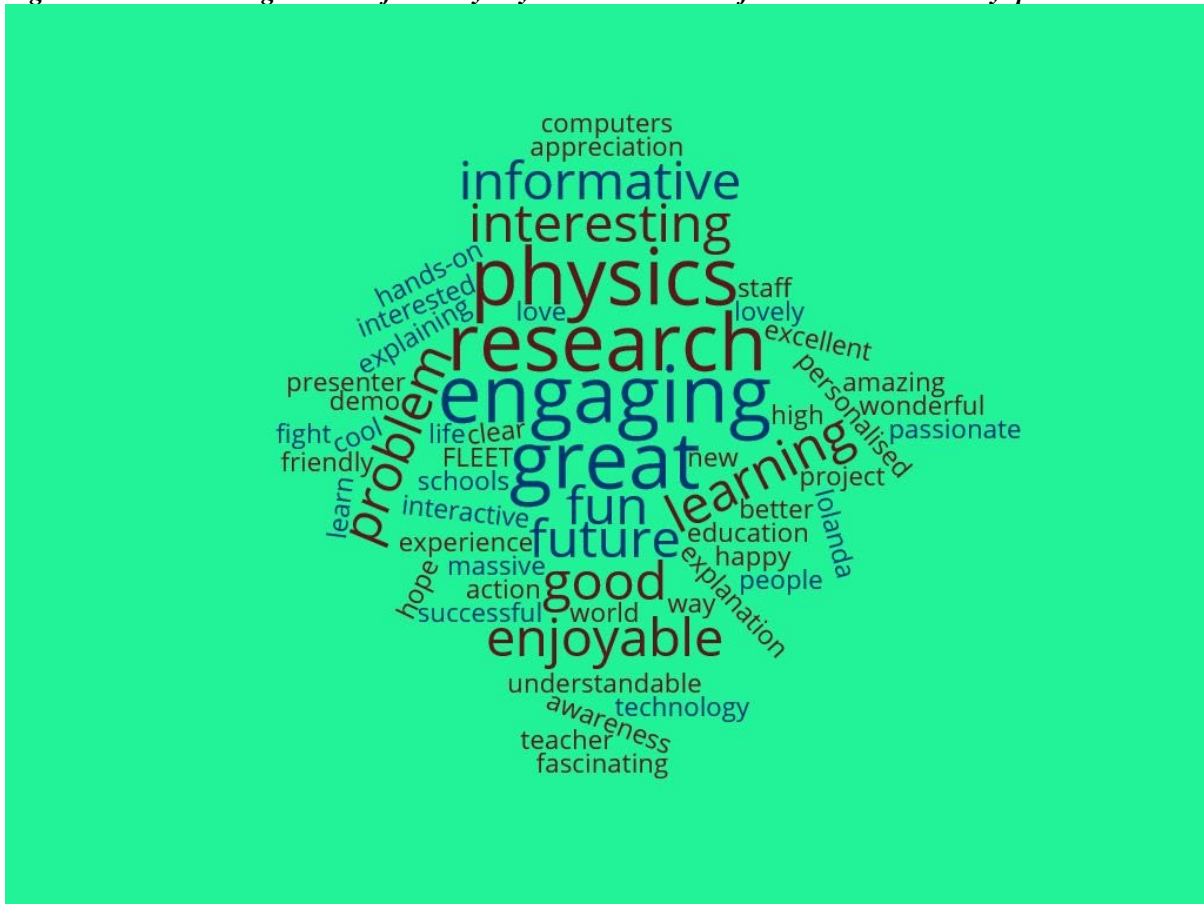

Mind Map

People were asked to think about what was an acceptable digital future and pathway to achieve it in the context of the increasing demand for computation and the implications of that, for instance, the energy consumption of that computation. What were the potential benefits and acceptable costs? What pathways/outcomes were potentially unacceptable? What does this mean for FLEET research? They were then asked if they would like to contribute those thoughts to our mind map.

The core theme to emerge from the public's contribution to the Mind Map was sustainability that was underpinned by the sub-themes, Change and Concern, which are examined below. People had varied concerns about the digital path society was on and the implications of this pathway. They contributed critical thought about the what they considered were acceptable alternatives or pathways to achieve a sustainable digital future.

We did not delve into individual interpretations of the concept of sustainability, but the following provides some indication of how they apply the concept to their perceived digital future. Figure 6 models the relationship between the themes and concepts that emerged from the analysis of the mind map.

Figure 6 Model of themes and concepts that emerged from the Melbourne Knowledge Week Mind Map
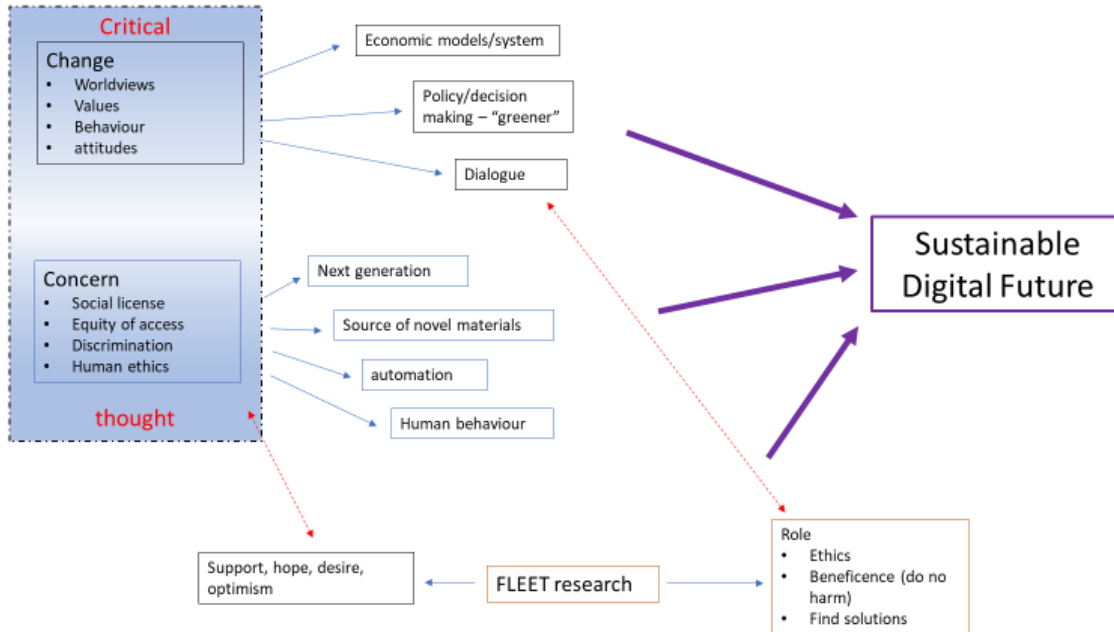
Sub-themes – Change and Concern

Change

People thought a broad change in the public's worldview, values, attitudes and behaviour was required to achieve their desired sustainable digital future. These changes, which are also suggestive of the participants own existing values and worldviews, covered the following broad topics that are examined below: Economic model/systems; Policy/decision making; and dialogue.

Economic model/systems: There were varied calls for a change to the existing economic model of growth. Participants had worldviews that perceived degrowth or zero growth were more appropriate paths to a sustainable digital future and questioned the social and economic sustainability of the model of growth.

Participant quotes

> "Degrowth and development of systems with longevity"

> "New economic models"

> "Just use what you need to survive – nothing else"

Policy/decision making: There was some call for political decisions to be "greener" or implement policies that respected the environment.

Participant quotes:

> "What are the 'green' alternatives [to FLEET's materials used in research?]"

> "More 'green' political decisions"

Dialogue: There was a call for greater awareness and effective community dialogue on this issue alongside a need to change the dialogue/narrative about our growing reliance on digital data. A small number of participants thought that the public appear to be fixated on all the potential benefits and scary things that can result from digitalization and greater computing power without understanding or being aware of the issues that underpinned the narrative FLEET presented and used this as one rationale for greater community discussion. As noted,

there was a relatively low awareness of the increasing demand for computation and the associated costs.

Participant quotes

"Advancement of knowledge. Awareness of connectivity use"

"Community discussion re: ICT, ethics and development roadmap"

"Teach young people about strategies for developing renewable energy"

Concern

People expressed concerns expressed in the quotes below that reflected the following broad concepts: a social license to conduct the research, equity of access for technologies, and discrimination and human ethics. These broad concepts represent the manifestation of more specific concerns about the implications for the next generation; the source of FLEET's novel material; the implications of increased automation; and human behaviour – a perceived innate nature of humans to resist change and the challenge to change our behaviour. This latter concern is also relevant to the sub-theme, Change.

Participant quotes

"Social license, social inequity"

"Concerns about slavery in supply chain/mining of materials"

"Coded bias - AI and racial discrimination. Lack of representation"

"Greater sustainability, less mining, more even society"

"Innovation forward and negative impact backwards"

"The future of the next generation"

"Laziness" [toward behaving sustainably]

One person who expressed a high concern about the increasing computational demand contrasted the individual who thought human laziness would make it difficult to effect change in human behaviour that could help reach that sustainable digital future. Her concern was more about the environment than social because she said damage to the environment is permanent so that should be the focus, but perceived there was potential to change human behaviour, so was less concerned about social/ethical implications.

FLEET research

There was general support for FLEET research, though it came with caveats and questions. Two concepts emerged: FLEET's role; and Support/hope.

Support/hope reflected participants' overall support for FLEET's objectives and role. There was hope it would facilitate more sustainable digital futures. There was some element of techno-optimism – a perception that as an individual I do not need to make any change because research and technology will solve the problems for us.

Participant quotes:

"Discovery. Bringing new technology for material used with saving energy"

"Investment and support in research"

"Increased use of technology can reduce fossil energy use"

"Increase efficiency"

One member of the public with an engineering background, while positive about FLEET research, saw greater potential in how we can use renewables in energy production. He could

not see humans changing their behaviour when it came to their digital requirements. A second individual saw this increasing computational demand as an opportunity rather than a problem. While concerned about the energy consumption of computation, he was optimistic about the ability of research to find solutions and that the 'problem' was a driver of innovation and solutions.

FLEET's Role: While there was optimism and interest in FLEET research and support was positive, it was for many participants provisional on the social and environmental implications of the research. FLEET's research should be transparent and open to scrutiny, provide benefit and do no harm, be socially equitable, and maintain or improve lifestyles without compromising the environment. This applied to FLEET's research and the technologies it might be applied to.

Participant quotes:
> "Greater sustainability, less mining, more even society"
>
> "Environment-friendly society without compromised lifestyle"
>
> "Open access and duplication of effort"
>
> "Innovation forward and negative impact backwards"

Build-a-circuit

This activity was evaluated via limited observation only. It was, as expected, only used by children, though some parent/guardians did oversee in some instances. Children used both the physical and online interactive version. At least two children used it for longer than 10 minutes.

In one instance, I asked two children about 7 years old what they learned from playing with the kit and they responded, we learned that circuits have to be closed for current to flow.

There was good engagement from those that did use the kit and it was used enough to justify its place in the exhibit. When there were children in the exhibit, most played with the kit.

FLEET volunteer outcomes

FLEET used 14 volunteers over the week-long event. I sent two questions via email to the ECR and PhD volunteers and got three responses.

Despite only three responses two core themes emerged (Connecting with the public Confronting unexpected public value) that I consider worth exploring in greater depth to determine if they hold up over time and in different outreach contexts.

Connecting with the public
Volunteers got value and enjoyment by being able to connect with the public about their research. They found some justification for their research because of this connection through dialogue

> "Seeing other people's interest in our work helps remind me of why I'm doing this research and keeps my passion in science alive."

Confronting unexpected public value

Volunteers were confronted by a public who placed a meaning and value on FLEET research was unexpected or had not previously been considered. To some extent this forced reflection about what that might mean for how volunteers communicate in outreach, but it possibly gave them a different perspective on their own research – see quote below. A lot of that surprise was relative to the focus the public put on the social implication of the research rather than the research itself. The caveat here is that the public's thinking was likely primed by attendance by many at Melbourne Knowledge Week talks and workshops focused on sustainability and the future. FLEET's own narrative around computational demand and energy use may have also primed this sort of thinking.

> "I was somewhat surprised by the concern people had for computer energy consumption. It's generally not broadly advertised, but it seems this issue resonates with many people."

> "I think the thing that stuck with me the most is that I've never actually thought about the source of the materials we use, and the environmental and societal impact of mining those materials. It's easy to focus only on the research questions and not realise what other people (stakeholders) are concerned about…"

In addition to the above themes, volunteers enjoyed the opportunity to engage with the public and practice communication skills.

> "Working at Melbourne Knowledge Week has made me realize I still need to practice a lot, though there were a lot of questions from the public that were more technical than I expected."

> "What I learnt is that sometimes it's fine to just straight up leave out information if it helps get the message across. You don't have to explain the entirety of something for someone to get to grips with why it's useful/important in the wider scope."

General

At least 6 members of the public enquired about FLEET doing outreach at their school, or in one case their local library. I did discover that the outreach flyer does not have an email address on them. This is something to rectify.

Caveats/Limitations

Based on most of the conversations I had with the adult public that visited the FLEET exhibit, the Melbourne Knowledge Week audience appeared well-educated and with a deep interest in science. Given some of the talks that people had gone to they will also have a particular set of ethics and worldview that will likely differ from other demographics. A different event in a different context would likely generate different themes.

Conclusions

The reality of computational demand and energy use is more complex than implied in the majority of FLEET's dialogue with the public, despite some in-depth conversations. But FLEET succeeded in raising awareness of the social and technical problem that is the motivation for FLEET's research, and got people thinking critically about the value of FLEET research and the implications of that research. The event raised awareness of FLEET research and generated greater awareness and appreciation of physics. There were insufficient secondary students visiting the exhibit to know if we generated a greater interest in physics, but some of the feedback suggests we did have an impact on some of the kids. This is suggested in the following comment:

"[You] demonstrated what lightning (electricity) is for my children aged 7 and 5. It helped my earlier explanation of the difference between coal and green energy is. Very enjoyable and well explained demo."

The fact that three of the more dominant words in the word cloud for the online survey were, informative, learning and interesting suggest some effect on interest and appreciation for physics.

Reflections

Because the reality of computational demand and energy use is complex a lot of context was missing from our dialogue with the public. For example, driving computing to the cloud where data is managed in the more ultra-efficient data centres can help reduce energy consumption. And there are many more variables that were likely not raised in the dialogue that could affect when and if the energy crunch occurs. A more contextualized dialogue on this issue might have led to different perceptions from the public FLEET engaged with at this event. For example, one "fact" used to support FLEET's narrative was that in about 10-15 years the world may struggle to generate sufficient energy to support the expected computational demand. I now consider this "fact" to be a bit rubbery because of the variables that can affect this potential outcome. While the issue of growing computational demand is real and there is a potential social cost to this (energy consumption, etc), I would argue it is more appropriate to simply pose the question, how do we meet the energy demands of our increasing computational needs? How do we generate the energy? What are the appropriate/acceptable solutions? What will this tech/energy bottleneck mean for our digital future? This will avoid getting people to draw conclusions based on less-than-rigorous data or scenarios, and instead get them to think critically about what is an acceptable digital future.

Finally, the term ICT confused people. Digital technologies had more meaning to people and should be used in future public events.