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MORE AWARE THROUGH REPAIR: EDUCATING ABOUT CRITICAL RAW MATERIALS

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Abstract: The issue of Critical Raw Materials (CRMs) and potential interruptions to their availability due to shortages, trade restrictions or other factors in their supply are topics that are relatively unknown to the general public. For this reason, education has been promoted as a key enabler of a circular economy. One key intervention point is the movement of electronic repair events. Repair events already exist throughout Europe and around the world; however, continuing innovation is needed to further enhance their ability to educate the public about complex issues such as CRMs. Raw Engagement for Electronics Repair (REFER) is a KIC Raw Materials project that seeks to educate wider society about CRMs through engagement in repair events. In this paper we explore the gap in awareness about CRMs and outline the process and initial outcomes of the REFER project in developing and evaluating potential awareness-raising approaches.

1. INTRODUCTION

Raw materials are crucial to the European economy and essential to maintaining and improving the quality of life of its citizens. For the general public, the modern-day quality of life that people have come to enjoy and the enabling technologies and devices needed to support this are all reliant on access to a growing number of raw materials. With the growing number of people owning, using or relying on such technology and the ever-increasing number of electronic devices and appliances available in the marketplace today, an over-reliance on certain metals and minerals is a growing concern.

In 2011, the EU released its first list of 14 Critical Raw Materials (CRMs), which has grown in its third iteration in 2017 to include 27 materials. CRMs for the EU are materials assessed to have a high risk to supply while being important to the EU economy [1]. CRMs are considered to be of paramount importance to a modern, technological society and potential supply interruptions due to shortages, lack of raw material, trade restrictions or other factors would be very disruptive to both the economy and the society that depends on them.

Consider, for example, the case of the ubiquitous smartphone in modern society. A typical smartphone can use up to 75 different kinds of minerals and metals in its construction [2], including CRMs that provide it with its functionality, connectivity, light weight, and compact form factor. We are also highly dependent on many CRMS to deliver green technologies such as solar panels, wind turbines, electric vehicles and energy efficient lighting systems in our cities and countries [3]–[5]. While these are only two examples, they highlight the prevalent nature of technology in the modern world and how our society depends on the availability of materials for such devices, appliances and technology in order to operate in its present state.

In spite of their importance to the EU economy and society, the concept of CRMs, their supply situation and associated issues are topics that are unfamiliar to many business leaders and product designers [6], [7], as well as the general public. Those

more aware have become concerned over the sources of supply, inefficient use of many of these materials, and poor collection and recycling rates. Securing reliable access to these raw materials is becoming a growing concern within the EU at an official level [1].

Significant action at many levels is required in order to tackle this problem of material criticality, with the education/informing of the general public being one of the key steps needed to address this issue. Most people remain largely unaware of the materials issues associated with their personal electronic devices and appliances. There is an overall lack of awareness about CRMs, their impending shortage and associated issues, which is currently hindering the development of long-term solutions and developments in this field and towards the larger transition to a circular economy.

This is evident in the behaviour and actions of the general public regarding these devices and appliances. For example, many people see no problem with putting such devices into "long term storage" in drawers, shelves, spare rooms and sheds. However, such behaviour impedes the collection, recycling and recovery of materials while these products are "hibernating" [8]. Research also shows product lifetimes decreasing [9] when the aim should be to keep the devices in use as long as possible. These are only limited examples, but serve to highlight the need to redress the lack of understanding amongst the general public, if any headway is to be made in combating the problem and transitioning to a more circular economy. The first logical step in this scenario is to educate the general public audience on the existence of CRMs, the problem of their supply and how they can help contribute to addressing the issues.

However, like many scientific issues and concerns, the existence of CRMs and associated concerns such as environmental issues can appear as abstract problems to the public, who perceive such problems as having little relevance to their everyday life. In particular, the public do not seem to associate the nature of their consumption/use of electronic appliances and devices with these issues. The OECD cited outreach and public engagement as a vital factor in the implementation of change to address global challenges such as energy production, e-waste, climate change, raw materials and the associated economics [10]. Traditionally, engineers and scientists frequently lack the appropriate vehicles with which to engage the general public on these issues. In order to participate as citizens of the 21st century, the general public (and students in particular) need to be critical consumers of scientific information [11]. Often peoples only previous experience with science & technology issues was through school, and traditional school science frequently fails to tackle current and relevant issues [12].

2. REFER PROJECT

The main objective of the REFER (Raw Engagement for Electronics Repair) project is the creation and establishment of an international network of educational-driven, repair-based events which focus on raw materials. These events will function as the vehicle for general public engagement with these complex scientific and societal issues. The scope of the events will see them being hosted for the general public across Europe, allowing people to bring their electronic devices such as computers, phones or small household appliances to be repaired. Attendees will sit down with expert repair volunteers and staff to understand how the technology works, identify the problem and repair their device. Supported by a range of educational resources developed for the project, this allows discussions on the nature of the technology, the range and amounts of CRMs and other scarce resources used and what can be done to address the lack of these resources.

Electronic devices are an excellent conduit through which to approach the general public about raw materials. WEEE (Waste Electrical and Electronic Equipment) is the fastest growing waste stream in Europe, growing at 3-5% per year [13]. Electrical and electronic equipment are the products with the highest concentration of CRMs in the marketplace, embedded in a complex multi-material matrix. While recycling technologies for some key materials are in place (e.g. ferro-metals, aluminium, copper, gold, silver, tin, platinum group metals, cobalt, etc.) thus far there is no equivalent system for all of the high-tech materials contained in EEE. Currently, no industrial-scale recovery of high-tech elements such as antimony, arsenic, beryllium, silicon, gallium, germanium and rare earth elements is attempted for most WEEE, with close to zero recovery rates for tantalum, lithium and magnesium [14]. A number of EU projects[1] and papers [15] have highlighted the fact that no technological solution or market drivers to this problem are expected for at least 15 years.

The REFER project therefore works to increase public awareness about CRMs using this novel model of active participation through the medium of these repair events and workshops. Inspired by the broader community repair movement, it promotes engagement among the general public with technology; the materials from which it is made with their associated challenges throughout the

[1] See e.g. CYCLED (www.cyc-led.eu) and RECLAIM (www.re-claim.eu), among others.

lifecycle, from extraction through to use, repair, collection, pre-processing and recycling.

Some of the key points to be raised during such discussions will be the increased use of CRMs and resources in modern-day consumer products. These include the low recycling rates of CRMs at present and the reasons behind this situation. To improve recovery of CRMs support of new approaches and technologies currently being developed, and those still missing, is needed. The low collection rates for WEEE in general at national and international levels need to be addressed. In general, why these issues are so important, what can be done about it and finally the use of extended product lifetime, repair and reuse as a means to conserve some of these CRMs need to be discussed and promoted.

Education, discussion and engagement around this topic with the general public is facilitated through the unique opportunity presented by the repair event in this regard. By offering people the option of fixing their own appliances and devices during the course of this series of repair workshops, the project aims to engage people in discussion and discourse over the issues of CRM and their importance to all modern electronics. Repairing products is also a strategy for addressing CRMs by slowing material loops as part of a transition to a circular economy [16], so people not only learn about the issues, but are actively engaging in strategies to address them. Furthermore, the project hopes to use these repair cafes as a platform to show how our growing reliance on technology is placing an inordinately high demand on these scarce resources and tackle some of the questions associated with addressing the issue.

The repair café setting creates an engaged dynamic, making participants far more likely to get involved in the next stage of the process. Thus, these repair workshops are intended to be the triggers for larger conversations pertaining to science and technology; engineering and the environment; product life cycles; what materials are needed for the manufacture of these appliances; how much energy this manufacturing process uses and what happens with these devices once they become waste.

Through the time that participants spend in the repair workshops and events, these and other related topics can be examined and discussed with the individual participants in a relaxed and comfortable setting. Participants will engage in the repair process to gain a better understanding of, and appreciation for, the roles of raw materials and CRM recovery in electronics. This, in turn, changes their perspective towards CRM and the circular economy as well as the repair/recycle/re-use of electronic appliances within society.

The project envisages that these repair workshops/cafes and associated information sessions/discourse opportunities will be hosted in 6 different E.U. countries over the 18 months of the project lifetime. This should allow direct access to approximately 6,000 members of the general public over the proposed timeframe with a multiplier effect of 10-20 times based on the social networks (physical and virtual) of the participants. In addition, an accompanying website will be hosted by the project with additional information, educational material, links, videos and supporting content for interested parties. Over the 18 months the website will be active, 500,000 hits/social media interactions are expected across all of the member states.

2.1 Approach to Restart repair events and developing REFER educational material

The educational material to support the REFER project repair events was developed in a project workshop hosted by the Restart Project[2] in London, England. The first part of the workshop involved REFER project partners attending a Restart Party to observe and better understand repair events. The next day the REFER partners and Restart discussed the event and Restarts approach to repair events, to support REFER participants in planning their own repair events and setting the stage for enhancing these through education about critical materials.

Key roles in a REFER repair event (i.e. repair event and learning event) which were identified included:

- Fixers: technically competent/confident, good at narrating repair. (possible recruitment: at shops, students, tech societies, retirees, women in STEM)
- Organisers: pick venues, do reconnaissance and publicity. (REFER and Restart in conjunction with local groups, e.g. Transition Towns, municipality, university)
- Hosts: people who help set up and facilitate on the day, with empathy and social skills (possible recruitment: Retirees, university staff or students)
- Educators: Storytellers, recognise teachable moments, basic knowledge and informed about CRMs. (possible recruitment: students, teachers)
- Data collector/analyser: technical knowledge, knows about LCAs, data handling. (possible recruitment: University staff or PhD students)

[2] See www.restartproject.org more information about the Restart Project.

After discussing how to make repair events more successful, the REFER partners then brainstormed possible learning activities that could take place during the repair event. These ideas were then categorised by the focus area for the repair event, e.g. the introduction or walk-in to the event (e.g. waiting room entertainments, posters, explainer videos), during the repair itself (e.g. augmenting repair, tablemats, cards, etc.), hands-on experiments for participants (Hardware teardown, Engineering 4 kids), and games.

On the second day of the workshop, the REFER partners prioritized the work areas and goals defined for the repair events. The strengths and weaknesses of different options were discussed. The group decided that working on intro-welcome packages was important, but inherently passive (leaflets, posters, etc.). It was agreed that participants would want to focus on interactive and experiential processes at such events. The game concept was de-prioritised mainly because the hands-on and augmented repair work areas were also experiential learning processes, applied to specific activities. It was decided to work on these areas first, rather than dedicate time to creating a game design from scratch (instead a list of existing games related to sustainability were compiled).

The next step was defining the main teaching concepts that the activities needed to express. There were two types of teaching concepts discussed:

1) Hands-on experiments comprised activities separate from the act of repair itself (i.e. which are not linked to the repair event participant having their devices repaired). These activities are meant to help demystify the act of repair by familiarising participants with tools and components of electronic repair.

2) Augmented repair comprised learning and interactive activities with potential to enrich the actual repair moment: all the things that a participant could do while a volunteer is repairing their device. The strong benefit is a captive audience: a person is literally sitting down, curious and excited about the act of repair happening in front of their eyes.

Restart and REFER project participants were interested in exploring how to integrate game design concepts into these activities — how to create experiential learning activities that could keep Restart Party participants engaged both during repair as well as before and after. So the second phase of the day focussed on designing activity prototypes based on game design theory and the insights from the morning sessions. Participants split into breakout groups: each group picked up a work area and referred to the teaching concepts when designing their prototypes. The workshop ran two design rounds: the first brainstorming round, and the second more in-depth design round.

Besides the type of learning concepts, the CRM content underpinning them also required development.

3.1. QUANTIFYING AND EDUCATING ABOUT CRITICAL MATERIALS

CRMS are an increasingly important topic in scientific research, but still relatively unknown to the broader audience of the general public. To count the amount of a material used in a device is not sufficient as there are many different impacts (e.g. toxicity, climate change, material depletion). Defining CRMs is already difficult because ‘criticality’ depends not only on physical existence but also on different, fast changing aspects such as the political stability of a country/region, technical feasibility of exploitation, etc. While no indicator can comprise all relevant aspects of CRMs, nevertheless they are still helpful to convey information in an understandable way. Simplification is unavoidable in non-technical communication. Within this project a rough prioritization of relevant CRMs provides enough input for the attendees of repair events.

3.1. Generation of ‘top 3 CRM’

Before any kind of shift in the mind-set of the general public can happen, one must first realise what CRMs are and where these exist presently in daily life. People in general are unaware of how wonderfully complex our devices are and more specifically which materials are used to enable their existence and functionality. The era of smartphones is such a strong example in this regard, since life is becoming unimaginable without them. Such high computing capacity contained in such a small form factor would not have been feasible without the use of complex mixtures and forms of these materials to make it better, faster, thinner and stronger. By linking materials with the occurrence in common devices, a first step in awareness is achievable.

Several important aspects are considered in developing educational material. One initial aspect is that the framework of a repair event should not be altered to a classroom-like learning experience. The transfer of knowledge should be concise and to the point so that the focus remains on becoming more aware of the materials through the shared repair experience. Most promising are memorable facts or stories related to personal experience for the learner. Such “a-ha moments” will be remembered over a long time. Secondly, the knowledge needs to be universally comprehensible so that a widespread applicability is ensured, even beyond the framework of this project. A final aspect is that the events should be straightforward in setup, usage and relocation to event venues. With these aspects in mind, the following idea was born.

Considering that smartphones are not the only devices used in daily life that contains CRM's, the list of CRM's [17] is matched to the product category list from The Restart Party, based on a preliminary literature study investigating the occurrence of these materials in commonly known devices [18]. From that list, a "top 3" CRM short list is distilled per product category to easily and concisely indicate (during the repair process) which materials occur in the participant's device, without overloading the overall repair activity and event. Colour coded stickers will be used to indicate on the fix list which device contains three CRMs and a legend will be set up for their display during the event. An additional benefit of such a list is that other participants' curiosity is sparked, which in turn triggers another conversation and hence another learning experience.

3.2. Visualising critical materials

In addition to quantifying CRMs and connecting them to the repair legend during the event, a visual "workplace" mat is also being developed, which will illustrate key aspects of CRMs and where they come from - discovering, mining and processing, with depiction of social and environmental impacts. The mat is designed to literally underpin the repairs taking place and remind both repairers and participants about the further significance of the repair activity in the context of environmental and social benefits in slowing material loops for these raw materials.

4. OUTLOOK

Looking forward, the next goal for the REFER project will be the recruitment of the key personnel for the hosting of the repair parties. Based on the Restart repair event discussions held during the project workshop, a number of key roles for event personnel have already been identified and highlighted, such as fixers, hosts and educators. These people will be instrumental in implementing the actual workshops and repair events at the various venues internationally, so it is critical that a sufficiently large and capable number are recruited. Recruitment from local repair groups, University students, hobbyists and other interested parties will help to fill the ranks for event personnel, with round table discussions and recruitment meetings helping to agree and decide implementation issues for the events going forward.

Once key personnel have been recruited into the required roles for the repair events, scheduling of the actual events can start to take place across the various international venues and cities. As previously mentioned, the project envisages that approximately 70 repair workshops/events will be held in 6 different E.U. countries over 18 months. It is expected that this will allow direct interaction with approximately 6,000 members of the general public across the different countries and over the proposed timeframe, with a multiplier effect of 10-20 times based on the (physical and virtual) social networks of the participants.

To augment the reach and scope of the projects educational and outreach component, an accompanying website (hosted by the project) will be advertised, which contains additional information and the educational material developed for the project, as well as videos, links and supporting content for interested parties.

At each repair event, participants will arrive with their electronic appliances to be repaired, where they will be met by hosts and introduced to the repair/restarter event process. When ready, they will sit down with experienced repair personnel and will participate in the repair process, helping to effect the repairs on their appliances first-hand. Attendees will gain an understanding of how the technology works through the identification of problems with their device. Supported by the platform and material developed to share a range of educational resources internationally through the project, this will allow discussions on topics such as the nature of the technology, the range and amounts of CRMs and other scarce resources used and actions to address the lack of these resources.

Promotional activities preceding each workshop at a national level will include advertisement of the events through social media (Facebook, Twitter, website, etc.) and local channels such as posters, flyers, etc. The online project website will provide a central repository for information about upcoming events, progress updates and related information about CRMs for interested parties after the events. Furthermore, it will provide information/guidance for those who wish to join the team or contribute to future endeavours. Visual media will be available to download as will repair briefs and links to the wider repair community blogs and videos. Partners and facilitators will be invited to blog about project development.

5. CONCLUSION

There is a need for raising public awareness and understanding of CRMs needed for modern society as well as actions, such as repair of electronic products, which can slow critical material loops in a circular economy. This paper has provided insight into how the REFER project endeavours to address these issues through both development of educational resources and the dynamic atmosphere of public electronic repair events. The model of development and collaboration can be useful for other repair activities and actors seeking to raise awareness about CRM issues and strategies for addressing them.

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