

Computer Recycling: Networks and Possibilities for Expansion in Tucson, Arizona

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Abstract: Sociological and anthropological studies have shown that while most individuals express concern with the state of the natural environment, this concern translates into pro-environment behavior only in certain social contexts (Derksen and Gartrell 1993). With this in mind, our paper considers computer recycling in Tucson, Arizona by examining people's attitudes and knowledge level of computer recycling opportunities and investigating the current local institutions and networks that exist to recycle computers. In a broader sense, this helps to place electronic refuse such as old computers in the context of wider U.S. material culture and to consider the cultural implications of these objects. As a response to various citizens' initiatives to begin and expand computer-recycling programs in Tucson, Arizona, the authors conducted a study of computer recycling in this city, which was then presented to interested parties in December of 2001. This paper is adapted from our final report. Our results suggest that the demand for used computers within Tucson currently exceeds the supply, due largely to a lack of awareness of and incentives to participate in local computer recycling programs. However, we see possibilities for solidifying computer-recycling programs if communication barriers are surpassed.

"I have a bunch of computer stuff laying around. Some of it works, some of it doesn't. If someone would be willing to take it I'd give it away. If there was a comfortable recycle location I'd recycle it. But it just might end up in the dumpster if no one wants it".

Anonymous

Response to survey, November 2001

INTRODUCTION

The disposal of hazardous materials is a growing concern within urban planning schemes. Computers in particular not only contribute considerably to the total mass of any landfill, but also contain many hazardous materials such as lead, cadmium, lithium, mercury, and beryllium. A personal desktop computer, for example, contains between 2 and 5 pounds of lead (Duran 2000). This is of particular concern considering that in 2002, in the U.S. alone, an estimated 63.3 million desktop computers will be taken out of commission, according to a study by the National Safety Council (Heim 2001). This number does not include the millions of notebook computers, personal digital assistants, and cellular phones that will also be retired from use (Heim 2001). In addition, computers also contain plastics and precious metals like gold, silver, copper, and palladium that can be recycled, and the boards and circuitry can be resold to manufacturers at high prices.

The disassembly and remanufacture of computers is a possible solution to environmental problems associated with the disposal of computers, and can provide a means for recovering some materials. In addition, the redistribution of old computers may help provide computer access to those in need. However, instituting such recycling behavior is not a straightforward task. Despite the prevalence of pro-environment attitudes, adoption rates for behaviors, such as sorting and separating household waste for recycling, have generally been low (De Young 1986). In an informal poll of 6000 readers conducted on PCWorld.com, only 3% of respondents reported that they recycled their PC through formal channels (Heim 2001). Interestingly, according to the EPA, 75% of obsolete electronics end up in storage (Heim 2001), rather than being reused in any way.

It is clear then that, in order to establish any recycling program, it is first necessary to understand people's attitudes and knowledge regarding this topic, as well as the existing

networks that might or might not lead to a successful computer-recycling program in a given community. As with most cities in the United States, Tucson, Arizona currently has no formally established computer-recycling programs. However, there are various citizens' initiatives to begin them, and these initiatives require additional basic information about the available resources for and interest in computer recycling within the city. This paper intends to shed more light on these issues.

This paper was also inspired by and is in some respects an extension of the University of Arizona's Garbage Project. Researchers working on this long-running project, which began in 1973 and continued for nearly three decades, sought to investigate American's refuse and its cultural implications by collecting garbage from neighborhoods and landfills and analyzing it in terms of socioeconomic and other cultural data. As Garbage Project researchers Rathje and Murphy wrote (1992:54), "what people have owned—and thrown away—can speak more eloquently, informatively, and truthfully about the lives they lead than they themselves ever may." In that vein, we hope that the research discussed in this paper offers some insight into American's fascination with technology through presenting some observations on how Americans currently deal with technology when its original owner no longer considers it of use.

This paper is adapted from the final report of a project conducted by graduate students of the University of Arizona attending the anthropology class "Applying Anthropology to Environmental Decision-Making" in the fall of 2001. Our project originated as a response to the interests of community partners, which included the City of Tucson Solid Waste Management, represented a former Garbage Project researcher. Our results were presented to our community partner organizations and other interested parties in December of 2001. The specific objectives of our project were to (1) better understand the current ways in which personal computers are disposed of in

Tucson, (2) estimate the willingness of individuals and institutions to participate in a computer recycling program, both as donors and recipients, (3) obtain an understanding of existing networks for computer recycling, and (4) assess the level of understanding of citizens regarding the existence of hazardous materials in computers. More broadly, anthropology's stake in this work includes issues of meaning ascribed to objects, specifically to those considered to be high technology, and how and why pro-environment behaviors arise in certain situations and not in others.

As the reader will see from our review of relevant literature and our results and discussion, many questions remain to be answered in order to further the establishment of successful computer recycling programs in Tucson and to better understand the meaning ascribed to these material possessions. For the former, one important topic that could prove fruitful for further investigation is the largely untapped potential of businesses as donors of second-hand, but still fairly new, computers. Future research could also include a more widely administered survey to explore the public's attitude and knowledge with regards to computer recycling and reallocation, as our own survey reached only a select portion of one university population.

We will begin with a brief discussion on the term recycling and how it is used in this paper, drawing insight from Schiffer's (1996) discussion of the formation of the archaeological record. We will then examine the history of computer recycling as documented in the popular press, before turning to a brief discussion of recycling behavior as addressed in social science literature. We will then offer an examination of our study methods and data collected, along with some discussion of that data. Finally, we will offer some concluding thoughts about what wider cultural implications may be inferred from our data.

WHAT IS (COMPUTER) RECYCLING?

One point of confusion in examining our research results arose in trying to understand both how to define recycling and how to categorize different kinds of recycling, specifically with regard to computers. Though on the surface this may seem like a straightforward task, in practice we found that the term "recycling" when applied to computers often meant a variety of different, even mutually exclusive sets of actions, such as giving an old computer to a friend for free, selling a used computer to an electronics store, donating it to a charity, or giving it to an organization that would disassemble the machine and sell it for scrap. This confusion likely reflects the lack of established ideas and programs for what to do with old technology.

With this in mind, we have decided to use the term 'computer recycling' to indicate the entire spectrum of reuse of computers. However, it is worthwhile to briefly clarify the different kinds of recycling that occur, as they may have different practical implications for establishing programs and may even be symbolic of different meanings ascribed to technology. In *Formation Processes of the Archaeological Record*, Schiffer (1996) offers a helpful discussion of the different ways that people reuse material objects. He breaks down reuse into four main categories: lateral cycling, submitting to re-manufacture, secondary use, and conservatory practices.¹ Lateral cycling means the object changes ownership from one user to another; for example, a father gives his old computer to his daughter, or a business donates or sells a used computer to charity. We will see that lateral cycling of computers is a common occurrence, and that it can happen through both informal and formal means, and both with and without the

¹ Schiffer actually calls this second type of reuse, or re-manufacture, "recycling," however, given the existing terminology already in popular use in relation to computer reuse, for the purposes of this paper we have retained the more general sense of the term "recycling."

exchange of money. Re-manufacture of an object means submitting it to another manufacturing process of some kind. In our research, we found that re-manufacture of computers appears to take place to varying extents; it can range from refurbishing computers (usually upgrading hardware while maintaining the integrity of the machine) to complete disassembly of computers in order to sell metal parts for their scrap value. In contrast, secondary use means taking a used object and employing it in a different function; for example, taking an old computer and using it as a decorative object or a footrest.² Secondary reuse did not come up in our formal research, however we have encountered anecdotal evidence of this kind of reuse. Finally, conservatory practices constitute preserving objects for posterity, often in the form of public or private collections; as with secondary use, this concept did not surface explicitly in our interviews or surveys.³

A BRIEF HISTORY OF COMPUTER RECYCLING

In the popular press, the first wave of articles on computer recycling seems to have appeared in the mid-1990s. Many of these “articles” were little more than one-quarter page boxes in magazines such as *Inc.*, *InfoWorld*, *Consumer Reports*, and *The Village Voice*, telling their readers that it was in fact possible to donate unwanted computers to good causes, and listing a few phone numbers for relevant organizations. Longer articles detailed the good works of such organizations, and emphasized

² One example of secondary computer reuse was provided by a colleague, who reports using a computer once purchased for \$25,000 as a door-stop, because he can't bear the thought of giving it away, knowing that it is now worthless in the marketplace.

³ Given the recent and still limited advent of home computers into U.S. life, it is not surprising that none of our informants mentioned conserving their computers for posterity. However, a brief Internet search will quickly reveal that there is some interest in preserving obsolete computers for conservatory purposes. For example, a variety of websites and museums on the subject exist; most appear to be based in the U.S.

that computer re-allocation was creating a new niche in the recycling business world. For example, *MacWorld* devoted two pages of its January 1995 issue to recycling Macs. The emphasis was on reallocation and the article congratulated the East West Development Education Foundation, Non-Profit Computing, and Gifts in Kind America for their efforts to provide computers to needy groups.

In the late 1990s, computer recycling dropped out of the popular press. However, there was a resurgence of interest following the collapse of the tech boom in the U.S. Again, many of the articles are short pieces meant simply to inform the public that computer recycling/ reuse is a possibility. Some of the organizations have changed, however. The most frequently mentioned organization is the Christina Foundation, which matches organizations needing PCs with donors. Readers are also being directed to the PEP (Parents, Educators, and Publishers) National Directory of Computer Recycling Programs for lists of programs in their area. At the same time, American City and County devoted a substantial article in its March 2001 issue to computer recycling/reuse programs in cities and towns of varying sizes, a clear indication that local government involvement is a growing trend (Wade 2001).

SOCIAL SCIENCE RESEARCH AND RECYCLING BEHAVIOR

Most recycling programs for all kinds of objects have one thing in common: reliance on individual participation. For this reason, it is very important to understand the factors that lead people to give away used objects for recycling. The social sciences, particularly environmental psychology, have looked at general recycling behavior for disposable goods for a number of years, although not at computer recycling in particular.⁴ Thus far, this research has shown that demographic factors tend not to be

⁴ It is worth bearing in mind that recycling of disposable consumer goods, unlike computers, generally involves only re-manufacture of those goods.

good predictors of general recycling behavior and/or attitudes (Schults, Oskamp, and Mainieri 1995; Werner and Makela 1998). Individual attitudes, however, do seem to play a significant role. Werner and Makela (1998) found that a pre-existing “pro-recycling” attitude was the best predictor of recycling behavior when a program was established. They observed, as did Schults, Oskamp, and Mainieri (1995), that non-recyclers tended to cite personal inconvenience as a reason for failing to recycle. However, Werner and Makela (1998) noticed that those with pre-existing pro-recycling attitudes tended to cite the positive elements of the same recycling experiences. For example, pro-recyclers noted enjoying the social and family aspects of making a trip to the recycling drop-off location, while non-recyclers referred to the hassle of such an excursion.

At the same time, social scientists have noted that social norms, as opposed to individual attitudes, play an important role in determining recycling behavior. For example, Hormuth (1999) presented a comparison of apartment complexes and showed that social integration (good “neighbourly relations”) was positively correlated with recycling; individuals in apartment complexes where residents had relatively less interaction with each other were less likely to recycle.

Finally, knowledge about recycling opportunities is an important factor in determining recycling behavior, as would be expected (Vining 1992; Schults, Oskamp, and Mainieri 1995). While this may seem an obvious point, it seems to be an issue in the computer-recycling field and therefore bears stating.

RESEARCH METHODS

We conducted fieldwork between October 20 and November 25, 2001 in the city of Tucson, Arizona. For our research, we relied on a mixed method qualitative and quantitative approach that included general exploratory work in various key sectors and with key informants using surveys, semi-structured and informal interviewing, and pertinent literature review. In

addition, we attended the Southwest Public Recycling Association Conference held in Tucson on November 9. This conference provided us with new contacts for our research and a means to interview key individuals involved in the computer recycling industry in Tucson and Phoenix.

We conducted extended semi-structured interviews and short phone interviews with key informants from non-profit, governmental, academic, and private institutions involved in the recycling industry. A total of 36 interviews were conducted, including 6 people from non-profit recycling organizations, 10 from for-profit recycling enterprises, 14 from the public sector, and 6 from the University of Arizona. Key informants were selected following a snowball sampling approach (Bernard 2002). We began this process by asking our community partners to refer us to some key individuals within the recycling community and by attending an informational meeting for computer recycling held at the University of Arizona on November 9, 2001 organized by the Southwest Public Recycling Association (SPRA). At the point when we felt we were "saturated" with the same information, that is, we were being referred to the same individuals repeatedly or were not obtaining any considerable new information; we targeted other people outside of our pool of informants. This approach gave us a means to reduce the possibilities of being cycled within a pool of key individuals who might not necessarily be representative of Tucson's overall computer recycling network. We learned, however, that this recycling network is relatively small. We feel that after a month of fieldwork we obtained a good estimate of its structure.

Our survey data was restricted to the University of Arizona community. The survey was distributed widely throughout the University by depositing it in the mailboxes of students, faculty and staff in a selected department, and handed out opportunistically in classes and to acquaintances. In addition, we posted the survey electronically on the listservs of amenable

departments to increase the representation of respondents from various departments. Whether through the on-line or paper forms, students, faculty, and staff from 20 departments of 15 colleges had access to the survey. Survey data from both paper and online formats were then compiled and analyzed with SPSS, JMP, and Microsoft Excel software.

Forty-four percent of respondents were undergraduate students, 27.7% graduate students, 9.6% faculty, 15.7% staff, and 3.6% were undeclared or other. Regarding the gender of our respondents, 47.4% were males and 52.6% females. Finally, 95.5% of respondents reported that they owned a computer. However, we cannot infer the rate of computer ownership throughout the university from this, because it is possible that potential respondents without computers chose not to answer our surveys.

RESULTS AND DISCUSSION

The interviews and surveys we conducted included a variety of questions focused on how computer recycling, in the broad sense, is practiced in Tucson and how it may be possible to expand it. Our survey dealt specifically with the following topics:

- a) computer use history
- b) potential individual motivations for recycling computers
- c) public awareness of existing computer recycling programs, and
- d) attitudes and behaviors of computer owners on the subject of computer recycling.

Our interviews included questions dealing with the above topics, and were also targeted to the following areas:

- a) the concerns of those facilitating computer recycling in Tucson
- b) issues enabling or complicating computer recycling in Tucson, and

c) concerns of potential donors and recipients.

A description of our findings follows, separated according to our initial project objectives.

DISPOSAL OF COMPUTERS BY CITIZENS

Results from our surveys at the University of Arizona suggest that individuals will tend primarily to give their unwanted computer to a family member or friend, constituting one form of lateral cycling, or to a lesser extent, trying to sell the computer, in another form of lateral cycling. Storing it or saving it for use also appears to be another way in which people say they dispose of their computers. The latter case is notable in that it does not technically constitute disposal at all; however, we provided this option as a possible answer in our survey because we had heard so much anecdotal evidence about people keeping used computers stored in garages and closets. Throwing the computers away or recycling them through charitable or environmental organizations, on the other hand, were rarely mentioned (see Table 1). Whether the unwanted computer was a laptop or desktop also affected how the respondents claimed they would deal with it.

Type of Computer	Laptop	Desktop
Give to family/ friend	35.3	52.1
Give to organization/ charity	0	7.7
Give away	7.8	5.1
Save for use	23.5	20
Sell	25.5	11.1
All other responses	7.9	4
Total	100	100

Table 1. How survey respondents said they would dispose of their current computer (percent of respondents that mentioned each of the options below).

We also compared disposal of computers according to the computer system (e.g. 486 system, Pentium I, II, etc.). In this case, a larger percentage of people owning older 486 system computers than those owning newer Pentium computers mentioned that they would give their computer to friends or family. No one who owned a 486 computer mentioned they would sell it. This leads us to believe, as expected, that there is a higher possibility for individuals to consider selling their computer if it has a more recent system and thus a higher current market price.

That few people said they would donate their computer to a charitable organization or otherwise give it away outside of personal networks is possibly a reflection of the lack of understanding of citizens regarding the various options to dispose of computers in Tucson. Although there are several avenues open to individuals and businesses to dispose of used computers, 88.4% of survey respondents mentioned that they had never heard of any computer drop-off sites in Tucson. Not surprisingly, the drop-off rate of computers by individuals in Tucson's landfill drop-off sites is very small (approximately 3-4/day).

It appears that most of the computers that end up in landfill drop-off sites come from businesses and organizations rather than from individuals. Moreover, donations of computers to institutions that will refurbish and redistribute old computers also seem to come mainly from businesses. Examples of this type of institution include the non-profit organization Desert Waste Not Warehouse (hereafter DWNW) in Tucson and the for-profit chain store Computer Renaissance, which has franchises throughout the U.S. and Canada. DWNW, possibly the biggest recycling institution in Tucson, receives as many as 500 computers a day, primarily from businesses.

Regarding the incentives that lead or could lead citizens to recycle their computers outside of their personal networks, the majority of respondents (44.5%) mentioned that knowing their

computer would be given to charity was a factor. Other incentives mentioned were economic compensation, the presence of convenient drop-off sites, having a computer pick-up service, and environmental safety reasons (see Table 2 below).⁵

Response	% who mentioned incentive
Give to charity	44.5
Economic incentives	13.4
Convenient drop off	33.1
Convenient pick up	20.7
Environmental Safety	24.6

Table 2. Incentives to donate/recycle computer outside of personal networks according to respondents (respondents were allowed multiple responses, so totals > 100%).

Given that a convenient drop-off site was consistently mentioned as an important incentive to recycle personal computers, computer donation events at convenient sites could be a good strategy to enhance the collecting of computers. An example of this is the recent Computer Recycle Day in Phoenix run by STRUT (Students Recycling Use Technology), a non-profit program for technology education and computer recycling created in Oregon in 1995 by the Intel Company. With the sponsorship of Westech, a for-profit recycling business in

⁵ Interestingly, for incentives to recycle computers as reported by female and male respondents, a larger percentage of females than males mentioned charity as an incentive to recycle. However, no significant differences were found between the percentage of females and males who mentioned the other recycling incentives.

Phoenix, STRUT advertised and collected computers at drop-off points in the Phoenix metropolitan area. The surprise of this event was that a large percentage of the equipment dropped off (40%) was still useable in the schools, having Pentium or higher systems. Westech collected the rest of the computers for recycling purposes. During this computer recycle day, STRUT conducted brief surveys with computer donors, asking them if in the future they would be willing to pay to properly recycle their computer. Most people (63%) said yes, the majority willing to pay between \$5-10 (Source: SPRA conference, Tucson Arizona, November 9).

INSTITUTIONAL COMPUTER RECYCLING NETWORKS IN TUCSON

The network of institutional computer recycling in Tucson appears to be fairly small, but communication within the entire network and with the general public is limited. Most of the organizations dedicated to some form of computer recycling reported that a lack of publicity was a problem for them. In addition, our research efforts uncovered instances of mistaken and outdated information provided to the public by the Waste Department and the Recycling Directory regarding which organizations will accept computers for refurbishment or recycling.

Considering the ways in which computers are disposed of and the magnitude of such disposal, we have identified three different types of donors: businesses, local government offices/academic institutions, and individual households. The initial fate of used computers originating from these different donors varies considerably. Computers may (a) end up directly in local landfills, (b) be donated directly to charities, friends, family members or needy individuals, (c) be sold to interested buyers (such as in the cases of Computer Renaissance and individual person-to-person sales), (d) be donated to non-profit, for-profit, or local government intermediaries, or (e) be given to

for-profit recyclers, which usually disassemble old computers and sell metal parts for scrap.

COMPUTERS IN LOCAL LANDFILLS

Citizens and businesses, due to lack of knowledge of existing computer drop-off sites or for other reasons, will sometimes dispose of their computers by simply dumping them in the City's landfills together with other trash. This is of particular concern considering the risk posed by monitors, which if broken can release lead and contaminate the groundwater. Monitor screens are composed of two pieces of heavy glass fused together with a lining of lead that between them. As is the case in most other cities in the U.S., there are currently no regulations regarding the disposal of computers or other electronic equipment in Tucson. Therefore, it is not illegal for individuals to dispose of computers in the same manner as all other refuse, i.e., by depositing them in landfills. However, when consulted, the City of Tucson Solid Waste Department encourages citizens to bring their computers to recycling drop-off sites rather than simply throw them away. Currently, it is difficult if not impossible to estimate the number of computers going into landfills in Tucson.

CHARITIES, FRIENDS, FAMILY MEMBERS AND NEEDY INDIVIDUALS

As mentioned above in our survey results, our data suggest that most used computers from households appear to be handed down through lateral cycling mechanisms directly to individuals or, more rarely, to charities. When this occurs, the recipients may depend on someone who can help refurbish or fix these computer hand-me-downs. For the most part, businesses do not appear to donate their computers directly to this category of recipients but rather rely on intermediary organizations.

INTERESTED BUYERS

Buyers of used computers consist mostly of individual citizens who are interested in acquiring a computer at a more affordable price than what they would pay for a new one. For-profit intermediaries such as Computer Renaissance, among others, also sell refurbished computers to these recipients.

NON-PROFIT, FOR-PROFIT, AND LOCAL GOVERNMENT INTERMEDIARIES

Computer recycling intermediaries include organizations that exist partially or even primarily for the purpose of redistributing used computers. These used computers are either given or sold to individuals or to other organizations (in some cases after being refurbished). Computers received at the local government drop-off stations located at certain area landfills usually end up in the hands of the non-profit intermediaries. For instance, DWNW picks up computers left at Los Reales and Tangerine landfill drop-off sites every week. DWNW and other non-profit intermediaries also accept direct donations of computers from both businesses and individuals. Some businesses have contracted with DWNW to pick up used computers on a regular (e.g., weekly or monthly) basis. In addition, DWNW receives un-sellable computers from used computer dealers, such as the local Computer Renaissance, and from the University of Arizona. Between their various sources, DWNW alone receives as many as 500 computers a day. DWNW refurbishes computers within the constraints of available space, labor, supply of computers, and the demand of its member organizations. They send all other computers, components and parts, approximately 6,000 lbs/week, to Gold Circuit, a for-profit recycling enterprise in Phoenix.

Certain non-profit intermediaries rely predominantly on volunteer technicians, while others have received grants to provide employment and job training in computer refurbishment. Furthermore, certain organizations such as

Unicor, a branch of the Federal Bureau of Prisons, are considering expanding similar programs to prisons in Arizona.

Non-profit intermediaries attempt to redistribute refurbished computers to needy individuals and institutions. DWNW, which seems to be the most well known organization within the Tucson recycling community, also sells items to non-profits to cover its costs. Computers are sold for between \$75 and \$90 with all accompanying hardware (monitor, keyboard, etc). Buyers must be members of DWNW and pay a membership fee of \$25. At present DWNW has 120 members, all of which are non-profit organizations. Those computers not offered for sale to non-profits are donated to needy individuals and families. At Technology for Everyone, another non-profit intermediary, computers are refurbished and donated to disabled adults, low-income residents, students, as well as anyone else in need. Tools for Schools, another non-profit intermediary local to Tucson, receives computers donated from citizens and computer companies all over the country. They refurbish these computers, and distribute them to schools, students, and other needy recipients in Tucson. The Salvation Army Computer Shop, a not-for-profit organization, also boasts a high processing rate, with several computers refurbished per day. They sell refurbished computers at a low price to the general public as well as selling computer parts at auction. The revenues from computers sold at the Salvation Army go toward a live-in drug and alcohol rehabilitation program, where the patients are also trained to do much of the computer refurbishment.

Although most of these non-profit organizations have volunteers working for them to refurbish computers, oftentimes they do not have sufficient technicians or space for the number of computers that they receive. More job training programs may provide a solution to this problem of human resources.

Another salient problem for non-profit refurbishing intermediaries concerns the rights to software licenses. In the

United States, computers resold or given to non-profits or needy individuals often retain the original software, although this is illegal. However, many of these recipients cannot afford the license fees for Microsoft software, which can cost as much as \$200, and they are unfamiliar with other options (e.g., Linux). Recent litigation in Australia by Microsoft, against the non-profit organization PC-Kids, shows that software and software licenses are potentially dangerous issues for non-profit organizations. As if to illustrate this point, one of our survey respondents mentioned the following:

I have no problem giving the hardware. However, one cannot give it away loaded with licensed software and hardware by itself will not be of much use to anyone.

FOR-PROFIT RECYCLING COMPANIES

Computers that are considered to be beyond refurbishment, generally because of their age, are usually submitted to remanufacture. They are generally sold by weight to recycling companies in Tucson and Phoenix, where they are disassembled for scrap. Some companies in Tucson, such as AMCEP, Allied Precious Metals, Recyco Inc, and Tucson Iron and Metal will take PC CPUs (hard drives) from citizens and businesses to extract metals. They do not, however, accept the monitors. Metals are later sold as scrap to different regional companies in Tucson, Phoenix, and El Paso or are sold overseas in Taiwan. One company receives entire computers from donations, destroys them, separates plastic from electronic materials, breaks the glass of the monitors, and exports everything overseas mainly to Hong Kong, from where the materials are distributed to other places such as Vietnam. In general, these for-profit recycling companies have varying rates of computer receipt, ranging from 0 to 250 computers received per month.

Most of the non-refurbishable computers from Tucson, however, appear to end up in various computer-recycling

businesses in Phoenix. These businesses will usually take the computers apart, sell or reuse the individual pieces, and sell the plastics and metals such as gold, aluminum, and palladium. Circuit boards are the most valuable component in a computer because they contain gold, and older computer equipment actually has more scrap value because it contains more precious metals. Some items such as outdated computers or dot matrix printers, for which there is little demand in the U.S., are sold whole to third world countries. Keyboards can also be sold to other countries, although it is unclear what they are sold for or what happens to these keyboards once they are sent abroad.

Plastics are difficult to recycle, especially as different types of plastics traditionally cannot be co-mingled. In fact, working with plastics is often a profit-losing endeavor for these computer-recycling businesses. These plastics are sold to other companies to be recycled.

Monitors represent the biggest problem in the computer recycling business because they contain large amounts of lead and new ones can be purchased cheaply, rendering reuse of old ones less likely. Recycled leaded glass, however, can be used to assist in smelting processes for glass baking dishes. At this time it is unclear how the shift to flat screens will affect monitor recycling.

By law, businesses are more restricted than individuals from disposing of monitors/TV sets. While dumping monitors is legal for individuals in most municipalities, businesses are restricted in their disposal of electronics by Environmental Protection Agency regulations (Heims 2001). However, it is not clear to what extent, with what level of consistency, or how these regulations are enforced. There do appear to be several, non-mutually exclusive options that organizations have for dealing with used monitors. They are as follows: (1) lateral cycling, which is the ideal, (2) remanufacture through repair, which is often not cost effective in the U.S., (3) send the monitors to countries where labor is cheaper and repairing monitors is

more cost effective, (4) recycle the monitor glass, and (5) land-fill the monitors.

Regarding monitors that are sent overseas, apparently there is a market for these in Pakistan and other countries, but local businesses work with brokers and do not deal with foreign agents directly. For this reason, the fate of these monitors once overseas is largely unknown. Up until recently, many of the old monitors in Arizona were being shipped to a free trade zone in China, where they could be repaired cheaply. However, China recently stopped accepting monitors because repaired monitors were being resold in China, rather than being repaired and re-exported as they should have been according to the rules of free trade zones. Gold Circuit, a for-profit computer recycler in Phoenix, is planning to open a monitor recycling plant in Casa Grande, AZ, which may offer an alternative to shipping monitors overseas.

POTENTIAL DONORS AND RECIPIENTS OF USED COMPUTERS IN TUCSON

Our interviews with eleven Tucson community centers suggest that the demand for used computers in these centers and in the immediate community that they serve currently exceeds the supply. However, community/recreation centers could never logistically be major recipients of computers because they simply do not have the space or infrastructure. They all appear interested but could not accommodate more than approximately 20 computers. All of the centers we contacted actually acquired their computers used and then had them refurbished. One of the centers, for instance, has computers with a 5" floppy drive (considered quite outdated by today's standards).

There appear to be three ways in which the centers' coordinators acquire used computers: (1) from parents who do not want their computers anymore, (2) from non-profit intermediaries, and (3) from local government offices, such as the Sheriff's Department. It seems that computers are "handed-

down" within government departments for some time before finally ending up in the hands of community centers.

The centers that are in greater need of computers are those located on the outskirts of the city because there are fewer facilities in those areas. One of the coordinators of a center specifically mentioned that the number of people who need to use the computers at the local library is very high. Often, this coordinator needs to direct people of all ages to the library so they can have access to a computer and the Internet.

More importantly, all but one of the centers expressed substantial interest in acting as facilitators to connect people in need of computers within their immediate community with those who could supply them. In fact, some centers have been doing that informally already. Our conclusion at this point is that one of the most important roles that community centers could play, if a recycling program were to be instituted, is to act as major focal points to network those citizens in need of computers with the organizations or people who could offer them.

Within the University, there appears to be a disagreement between our key informants regarding the potential for University students to act both as donors and recipients of computers. Many university employees that were interviewed in the course of this research indicated that university students, including minorities, are not likely potential recipients for used computers. Students will usually want fast, powerful computers, in other words, new computers. This may reflect the particular case of natural sciences, where students normally require computers with high capabilities. We were told that there may be potential among the new minority students arriving to the U of A, but probably only in the short-term, until they are able to purchase a new computer.

According to U of A Residence Life, a quick survey of the boxes seen entering the dorms on move-in days suggests that many students already arrive with new computers. During the

academic year 2000-1, Residence Life Recycling had arranged for the Salvation Army to collect cast-off items from the dormitories in the spring after students went home; this was very successful overall but only one computer was turned in to the Salvation Army. Based on these observations, we can infer that most freshmen keep their computers for at least a few years. However, some university employees interviewed felt that University students could be both potential donors and recipients. For this reason, there is a great deal of interest from Residence Life Recycling and UARC (U of A Recycling Council) to support and facilitate a computer-recycling program at the University. However, because of liability issues, a computer-recycling program could never be instituted within the University premises.

Our surveys at the U of A show some interesting findings. When asked if one would accept a used but refurbished computer for free, 79.0% of respondents mentioned they would, 17.6 % mentioned that they would not and 3.3% said they were not sure. The primary reason (65.4%) given by these respondents as to why they would accept a refurbished computer for free was that it made no sense not to given the fact that it was “free” and it could meet their needs. Environmental reasons were seldom mentioned (0.9 %). Similarly, when asked if they would purchase a refurbished computer, 60.5 % of respondents said they would, 36.2 % would not, and 3.3 % were not sure. Again, a cheaper price was mentioned as the primary reason why they would purchase a refurbished computer (50.3 %) and environmental factors were seldom mentioned (1.0%).

Regarding those people who reported not accepting a refurbished computer for free, the majority (69.8%) said that they simply did not need another computer. However, of those who reported not being interested in purchasing a refurbished computer, (38.8%) mentioned they would not because of reliability issues.

Regarding their interest in knowing about existing computer drop-off sites in Tucson, the majority of respondents (65.7%) expressed an interest in knowing about such sites, while 33.8% were not interested. Further, a significantly larger percentage of graduate students compared with undergraduate students expressed an interest in learning about computer recycling programs (Table 3). People with other statuses (e.g., faculty, staff) were not included in the analysis because of the low number of respondents.

Status	Interested (%)	Not Interested (%)	Total (%)
Undergraduate	63.04	36.96	100
Graduate	77.08	22.92	100
Faculty	66.67	33.33	100
Staff	55.56	44.44	100
Total	66.17	33.83	100

Table 3. Whether respondents were interested in learning about recycling programs

Based on our examination of current and potential donors and recipients for used computers, we conclude that businesses are the largest source for the donation of computers. The donations of computers by businesses could be particularly appealing because these donations can be tax deductible. However, for individual citizens other incentives, such as convenient drop-off sites, seem to be more important.

KNOWLEDGE OF HAZARDOUS MATERIALS

Although we did not directly ask in our survey if people knew of any hazardous materials contained in computers, as this might have biased the response to the other questions addressed in the survey, we can infer that, in general, there is a lack of

awareness among citizens and possibly among corporations regarding the presence of hazardous materials in computers.

The fact that such a low percentage of people mentioned environmental concerns as a motivation to recycle is indicative of this matter. Similarly, although there are no present formal restrictions on the disposal of computers in Tucson, we expected that if people knew that computers contained large amounts of hazardous materials, more respondents would have thought that there were restrictions for their proper disposal. In some surveys we did receive comments regarding the awareness of the existence of hazardous materials in computers. However, most of these comments came from the Computer Science Department, where students and faculty most likely have a better understanding of computer contents.

CONCLUSIONS AND RECOMMENDATIONS

As a result of careful analysis of all of the data, including the interviews, observations, and surveys, we have arrived at a set of conclusions regarding computer recycling in Tucson, as it is practiced now and how it may be expanded upon in the future. We also offer some brief discussion on the wider cultural implications of how computers are and are not recycled, and suggest some avenues for future research.

We conclude that the computer-recycling network in Tucson is fairly small and is not well known in the wider community, especially by individual citizens, and that there is a lack of institutional communication among those entities involved in the computer recycling/refurbishing industry in Tucson. Community awareness of computer recycling options is low, partly because information available to the public about computer recycling possibilities in Tucson is often inaccessible and misleading.

Further, what happens to computers that are given to U.S. organizations for disassembly is not very well understood, especially when these items are shipped overseas. It is thus

difficult if not impossible to estimate the number of computers going into landfills in Tucson. Monitors in particular appear to be problem in recycling computers. They are bulky, and contain large amounts of lead, which is toxic, and the prospect of widespread landfilling of monitors is worrisome. Also, new monitors can be purchased cheaply, which reduces the incentive to refurbish them. Hence, most are sent overseas, where labor is cheaper. In this vein, the problem of hazardous waste is likely just being transferred to other countries. As most of the for-profit businesses in Tucson that resell computer parts, particularly metals, do not receive monitors, they do not really help to solve the problem of hazardous materials.

Another concern is software licensing rights and fees, which represent a delicate issue within the computer refurbishing industry. This issue must be resolved if effective computer recycling programs are to be established, and it points to how establishing these programs goes far beyond the need to identify potential donors and recipients, although this also needs to be considered. In general, there seem to be recipients for refurbished computers, especially when the computers can be offered cheaply or for free. The organizations with which we communicated were not concerned about finding recipients, but these organizations often lack the space and infrastructure that would be necessary to implement more widespread redistribution of computers.

With respect to possible sources for refurbishable computers, it appears that businesses are more important donors than households in terms of quantity and quality of computers. Businesses seem to replace their computers more often and have a larger volume of machines than individual households, thus seem to be better sources of "good" computers.

We also noted that our data reflects a disconnect between market realities and people's perceptions of value, in that owners of old computers are often highly reluctant to dispose of

them in any way, and would prefer to store them for some unspecified future purpose. However, our data also shows that the people we interviewed and surveyed place a value on having these objects donated for charitable purposes, however they define that; if more information were available to them about such opportunities, computer recycling behavior might increase. Given that the knowledge level about the toxicity of older computers also appears to be low, it is difficult to speculate as to how environmental values shape computer-recycling patterns. We suspect, however, that if knowledge of the potential environmental impacts of older computers was better known, people such as those who participated in our study would place a higher value on recycling their old electronics.

In terms of future research possibilities, we recommend further investigation into the ways in which businesses dispose of unwanted computers, and how relationships could be forged between businesses and non-profit intermediaries or charities. A more comprehensive look at computer recycling in other countries is also highly recommended, as this is not an area that has been very well explored. Further, older used computers, as our research indicated, have a life cycle that is sometimes shrouded in mystery and can extend beyond national borders; a study following these commodity chains might further illuminate the extent to which other countries are bearing the brunt of U.S. electronic refuse. As Appadurai (1984) argues, material objects, like people, have lives that are shaped by social interactions and cultural meanings. Computers and other technology are no different from other commodities in this respect, and are notable in that they depreciate in value so rapidly, and are distributed so unevenly both within and outside of the United States. Further research into the topic of computer recycling could help to shape recycling programs and aid our understanding of computers as objects that serve as both

functional items and status symbols, with particular social, environmental, and even political implications.

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