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Greening academia: Use and disposal of mobile phones among university students

F.O. Ongondo, I.D. Williams *

School of Civil Engineering and the Environment, University of Southampton, Lanchester Building, University Rd., Highfield, SOUTHAMPTON, Hampshire SO17 1BJ, UK

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ABSTRACT

Mobile phones have relatively short lifecycles and are rapidly seen as obsolete by many users within little over a year. However, the reusability of these devices as well as their material composition means that in terms of mass and volume, mobile phones represent the most valuable electronic products that are currently found in large numbers in waste streams. End-of-life mobile phones are a high value (from a reuse and resource perspective), high volume (quantity), low cost (residual monetary value) and transient (short lifecycle) electronic product. There are very large numbers of higher education (mainly university) students in the world – there are >2.4 million in the UK alone, 19 million in Europe and 18.2 million in the USA – and they often replace their mobile phones several times before graduation. Thus, because of the potentially significant environmental and economic impacts, a large scale survey of students at 5 UK universities was conducted to assess the behaviour of students with regard to their use and disposal of mobile phones. Additionally, a small scale trial mobile phone takeback service at one of the universities was carried out. The findings indicate that many students replace their phones at least once a year; replacing broken phones, getting upgrades from network operators, remaining "fashionable" and a desire to have a handset with a longer battery life are the main reasons for such rapid replacement. Almost 60% of replaced phones are not sent to reuse or recycling operations but are stockpiled by students mainly as spare/backup phones. Approximately 61% of students own an extra mobile phone with male students replacing their phones more often than females. In particular, the results highlight the potentially huge stockpile of mobile phones – and consequently valuable supplies of rare metals – being held by the public; we estimate that there are 3.7 million phones stockpiled by students in UK higher education alone (29.3 and 28.1 million stockpiled, respectively, for Europe and USA). Although many students are aware of UK mobile phone takeback services, only a moderate number have previously used the services. Students' recycling of other waste materials such as paper and glass did not have a significant impact on their disposal actions for their unwanted mobile phones, although students who often recycled these waste materials were also the most willing to participate in mobile phone takeback services. Monetary incentives such as cash payments and vouchers have the greatest influence over students' willingness to utilise takeback services, followed by convenience and ease of use of the services. The paper discusses these findings as well as the outcome of the trial mobile phone takeback. It is suggested that universities should partner with established takeback operators to conduct event-based mobile phone takeback services primarily targeting students. Lessons from mobile phone takeback applicable to takeback services for end-of-life gadgets similar to mobile phones are also discussed.

1. Introduction

Mobile phones are the most ubiquitous electronic product on the globe. In 2009, it was estimated that there were 4.7 billion mobile phone subscriptions around the world, most of which were in developing countries (ITU, 2010). The rapid introduction of new and improved technology into mobile phones, coupled with increasing functionality such as cameras and music players, means that mobile phones have relatively short lifecycles and are rapidly seen as obsolete by many users within little over a year despite large numbers of such phones still being perfectly functional. It is reported that Europeans and consumers in other high-income countries typically replace their mobile phones at intervals of between 12 and 18 months (Bains et al., 2006).

In the UK, it is estimated that 18 million handsets are replaced every year (Fonebak, 2008). In the European Union (EU), mobile phones are classified as waste electrical and electronic equipment (WEEE) at their end-of-life (EoL) (European Union, 2003). Due to their relatively small sizes, mobile phones can be easily stored and forgotten or thrown out with the general waste (Darby and Obara, 2005; Canning, 2006). The act of routinely storing obsolete

* Corresponding author. Tel.: +44 2380 598755; fax: +44 2380 678606.
E-mail address: idw@soton.ac.uk (I.D. Williams).

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electrical and electronic equipment (EEE) is variously referred to as hoarding or stockpiling (see Wagner, 2009). It is reported that at their EoL, many mobile phones are not disposed of properly (through reuse or recycling) but are instead stockpiled (Geyer and Blass, 2009). Globally, Nokia Corporation reports that approximately 44% of retired phones are stockpiled (Nokia, 2008). In the UK, it has been estimated that there are more than 90 million unused mobile phones in households with only a quarter of unwanted phones returned to takeback schemes leaving over 11 million phones each year unused or in landfill (Bains et al., 2006). Although the percentage of mobile phones thrown in the general waste is relatively low, typically 4% (Nokia, 2008), mobile phones still represent perhaps what is in terms of mass and volume, one of the most valuable electronic products that are currently found in large numbers in waste streams (Bains et al., 2006). This value stems from the reusability of mobile phones as well as their material composition (Tanskanen and Butler, 2007; Geyer and Blass, 2009).

Mobile phones can contain over 40 elements, including metals such as copper and tin, special metals including antimony and indium, and precious metals such as gold and palladium which are required for the device to function properly. On average, metals account for 23% of the weight of a phone (Meskers and Hagelüken, 2009) whilst plastics account for ~50% of the weight (UNEP/GRID-Arendal, 2006). Fig. 1 shows the typical material composition of a mobile phone.

Recently, the EU prepared a list it termed as "potentially critical raw materials" in relation to the dwindling reserves, accessibility and affordability of those resources. Included in the list are the above mentioned metals found in mobile phones which are also vital in various key industries, including telecommunications, aerospace and other hi-tech sectors such as the manufacture of electric cars and renewable energy technologies (see European Commission, 2008). Hence, from a resource point of view, the material composition of mobile phones makes them a high value product.

1.1. Previous studies

One of the earliest studies on mobile phones was by Wright et al. (1998), who conducted a life-cycle energy study of a pilot mobile phone takeback initiative by the European Telecommunications and Professional Electronics Industry association (ECTEL) in Sweden and the UK in 1997. Taking into account all pertinent factors, it was concluded that from an energy perspective, the takeback and recycling of mobile phones were in general beneficial to the environment. A report by Fishbein (2002) assessed the potential waste problems posed by mobile phones and other wireless devices and the possibilities for remedying those problems at their source. A follow-up report (see Most, 2003) examined the key mobile phone collection, reuse and recycling schemes in the US. Although the report concluded that the impact of the takeback programmes was still negligible, it identified four key factors for the success of mobile phone takeback services, namely: the collection method used by the schemes; its convenience to potential donors; public awareness of the service as a result of promotion and advertising; and customer incentives provided to encourage phone returns. The study also observed that university students often replace their mobile phones several times before graduation (Most, 2003). Selian (2004) looked at the sex and age differences in relation to the use of mobile phones among students in the US, investigating aspects such as ownership, use and perceptions of potential health side-effects. Though not specifically addressing mobile phones, Darby and Obara (2005) analysed household recycling behaviour and attitudes in relation to the disposal of small WEEE in the UK. The authors argued that a one-size-fits-all approach is not appropriate when designing WEEE recycling and instead called for the integration of such services with other, more prevalent recycling services to take account of local and individual needs. Other researchers have: described the role of key actors in the development of circular supply chains for mobile phones (Canning, 2006); developed a generic remanufacturing plan for mobile phones and proposed an optimisation model for the planning of remanufacturing capacities and production programmes (Franke et al., 2006); addressed the management of EoL mobile phones in developing countries (Hugh and Berry, 2007) and considered their potential environmental impacts (Osibanjo and Nnorom, 2007); considered the economics of mobile phone reuse and recycling and concluded that reuse offers a bigger monetary profit margin compared to recycling which is in essence a by-product of reuse (Geyer and Blass, 2009); and analysed consumer behaviour towards EoL mobile phones and their willingness to participate in waste mobile phones recycling as well as their willingness to pay for a more environmental friendly mobile phone (Nnorom et al., 2009). More recently, Silveira and Chang (2010) gave a synopsis of mobile phone recycling programmes currently available in the

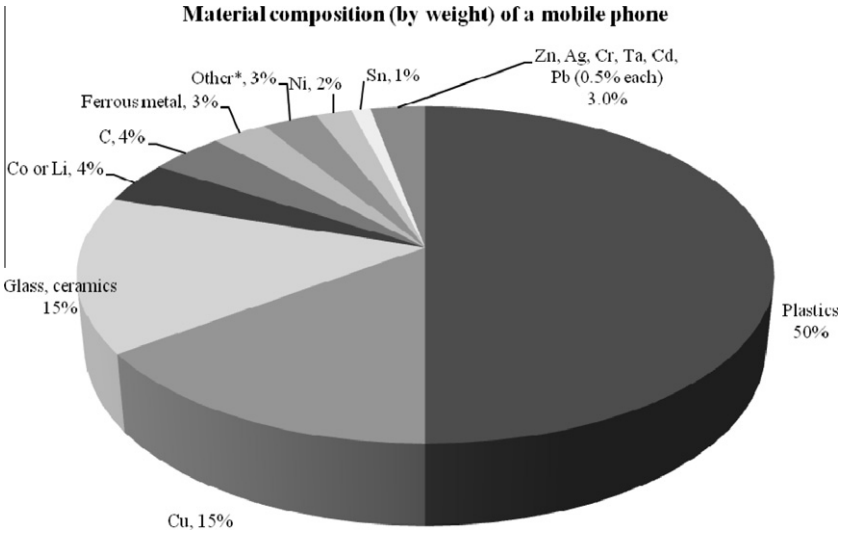

Fig. 1. Typical material composition of a mobile phone. Adapted from UNEP/GRID-Arendal (2006).

US and simultaneously analysed the present recycling situation and possible recycling alternatives for Brazil. The authors proposed a deposit/refund/advance-recycling fee-based mobile phone recycling system for Brazil based on the US experience and the principle of extended producer responsibility (EPR). Ongondo and Williams (2011) assessed and evaluated the voluntary mobile phone takeback network in the UK and recommended future actions to improve the management of EoL handsets and related accessories. These issues highlight the importance of getting back unwanted mobile phones from consumers and channelling them to reuse or recycling in order to avoid any potential negative environmental impacts as well as recovering vital resources embedded *n* the phones.

Several issues highlighted in the literature informed the subject of this present study, namely: the short lifecycle of mobile phones (Bains et al., 2006); the frequency with they are replaced by university students (Most, 2003) and the quantities stockpiled (Geyer and Blass, 2009; cf. Saphores et al., 2009); the importance of incentives and other factors to influence returns of handsets (Most, 2003; Ongondo and Williams, 2011); the relationship between recycling of other waste materials such as paper and plastics and the disposal of small WEEE (Darby and Obara, 2005); and in relation to students, the potential associations between sex and age, respectively and the patterns of mobile phone usage (Selian, 2004).

EoL mobile phones are an example of a high value (from a reuse and resource perspective), high volume (quantity), low cost (residual monetary value) and transient (short lifecycle) EEE. Using university students as a case study of young people, the overall aim of this study was to assess the behaviour of university students with regard to their use and disposal of mobile phones. The specific objectives were to:

(1) Identify, analyse and evaluate the consumption patterns and disposal of mobile phones among university students.
(2) Identify and assess factors that influence the use and disposal of mobile phones among university students.
(3) Estimate the quantities of mobile phones stockpiled by students in UK higher education.[1]
(4) Assess and evaluate any potential association between recycling of other waste types and disposal of small WEEE.
(5) Establish and analyse the factors and incentives that influence students' willingness to utilise mobile phone takeback services.
(6) Conduct and evaluate a small-scale trial takeback service for EoL mobile phones at a UK university.
(7) Identify and discuss important lessons from the use and disposal of mobile phones among university students and assess their potential applications to the takeback of similar WEEE.

This paper reports and critically analyses the outcomes from this study, including lessons from takeback of mobile phones that are potentially applicable to the management of other similar small WEEE.

2. Methods

The first phase of the study involved a large scale regional survey of university students whilst the second involved a small scale trial mobile phone takeback service at the University of Southampton.

[1] In the UK, higher education refers to college or university education. See http://www.direct.gov.uk for further details.

2.1. Survey of university students

An internet survey of students at 5 universities (with a combined population of 79,029 students in the academic year 2008/2009) was conducted between November 2008 and August 2009. The universities surveyed were: Southampton, Southampton Solent, Reading, Winchester and Portsmouth.

A questionnaire was developed to assess students' attitudes and behaviour with respect to their use and disposal of mobile phones. Questions were formulated to establish the following:

Note: the texts in parentheses indicate the question type.

- Students' frequency of replacing mobile phones (multiple choice with single answer) and the underlying reasons for those actions (*multiple choice with multiple answers including an open-ended alternative response*).
- Methods students used to dispose of their most recent unwanted mobile phones (*multiple choice with single answer including an open-ended alternative response*).
- Number of extra phones stockpiled/kept by students (*multiple choice with single answer*) and the related reasons (*multiple choice with multiple answers*).
- Students' awareness of (*multiple choice with single answer*) and experience with UK mobile phone takeback services (*multiple choice with multiple answers including an open-ended alternative response*).
- Students' willingness to recycle unwanted phones at prospective university mobile phone takeback services (*likert scale*).
- The effect of incentives on students' willingness to use prospective university mobile phone takeback services (*likert scale*).
- The questionnaire also collected information about students' age, sex and level of study (i.e. undergraduate/post-graduate).

The questionnaire was piloted among a group of 100 students at the University of Southampton as an online survey. The final questionnaire was administered as an Internet survey and made accessible to all the students within the selected universities once contact had been established with the relevant authorities and permission sought to survey the students. Information about the study including separate links to the surveys for each of the universities were posted on the respective students' university Internet portals, easily and exclusively accessible to only the students at each university. To help avoid multiple survey submissions, students were asked to enter their university email addresses. Entry into a prize draw with the possibility of winning brand new mobile phones and cash payments was offered as an incentive to boost the response rate.

2.2. Projecting the number of extra mobile phones owned by higher education students in the UK

Respondents were asked to specify the number and the brand(s) of the extra mobile phones they stockpiled. The latter were classified according to four main mobile phone manufacturers in 2007/2008, i.e. Nokia, Sony Ericsson, Samsung and Motorola (see Gartner, 2008). All other brands were classified under a category denoted "other". This information was used to compute the per capita number of phones stockpiled classified by ownership according to the number and manufacturer of phones kept. Ownership was designated into 6 groups ranging from 1 to 5 phones stockpiled plus a category for more than 5 phones, i.e. 5+(conservatively counted as 6 phones in calculations). Using the 2008/09 figures for the number of students in UK higher education institutions (i.e. 2396,055 students), estimated quantities for the number of phones stockpiled by students in higher education in the UK were computed.

2.3. Statistical analysis

2.3.1. Age and sex

Chi-Square[2] tests were conducted to test for association between age and sex, respectively and the following factors:

- Frequency of replacing mobile phones.
- Methods used to dispose of most recent unwanted mobile phones.
- Number of phones stockpiled.
- Awareness of UK mobile phone takeback services.
- Whether the students had previously used UK mobile phone takeback services.
- Students' willingness to recycle mobile phones at potential university mobile phone takeback services.

Where necessary, the sub-categories of the variables being tested were collapsed into other categories in order to satisfy the requirements[3] of Chi-Square.

2.3.2. Recycling of other waste materials

Chi-Square analyses were conducted to test for association between recycling of paper, plastic, cans/tins and glass, respectively and the following factors:

- Methods used to dispose of most recent unwanted mobile phones.
- Number of phones stockpiled.
- Students' willingness to recycle mobile phones at potential university mobile phone takeback services.

These tests were limited to include only those students who stated that they had access to a local council kerbside or university recycling facilities/services for the above mentioned waste materials. Where necessary, the sub-categories of the variables being tested were collapsed into other categories in order to satisfy the requirements of Chi-Square. When analysing for an association between the methods the students had used to dispose of their most recent unwanted mobile phones and the recycling of other waste types, the various responses for the former were grouped into 3 categories, namely: "stockpiled"; "reused/recycled"; and "disposed in general waste". When testing for association between frequency of recycling of the various waste materials and the number of mobile phones stockpiled, the responses for the frequency of recycling were aggregated into new categories as follows: "never" and "sometimes" = "less frequent recycling"; and "frequent" and "always" = "more frequent recycling". Additional Chi-Square tests were carried out to check for confounding variables. In the case of testing for association between recycling of the various waste materials and students' willingness to recycle mobile phones at potential university takeback services, the latter's responses were collapsed into 3 categories as follows: "not at all willing" and "not very willing" = "less willing"; "somewhat willing" = "more willing"; and "very willing" and "extremely willing" = "most willing".

2.3.3. Influence of incentives on willingness to recycle unwanted mobile phones

Using a 5 point Likert scale, respondents were asked to state how much each of the following incentives would influence their willingness to recycle unwanted mobile phones at prospective university mobile phone takeback services: Environmental incentives; a contribution to charity; ease of use of the service; conveniently located recycling points; entry into a prize draw; vouchers; free mobile phone ringtones; free mobile phone texts; free mobile phone airtime; discounted MP3[4] downloads; free MP3 downloads; and cash payments.

At the analysis, the ordinal response categories denoting the respective magnitude of influence of the incentives were ranked as follows: "Not at all" = 1; "A little" = 2; "A fair amount" = 3; "much" = 4; and "very much" = 5. Friedman's ANOVA was used to test for differences between the effects of incentives on willingness to recycle mobile phones at potential university takeback services. Additionally, Kendall's *W* analysis was carried out to test for the agreement between respondents regarding the effect of incentives on willingness to recycle mobile phones. Finally, using Wilcoxon signed-rank tests, post hoc analyses were carried out to compare the effect of the various incentives with each other. A total of 66 paired tests were carried out comparing the 12 incentives with each other. A Bonferroni correction was applied to the results (Field, 2009). Hence, all comparisons are reported at a critical level of $p = 0.001$.

In all statistical analyses, missing data was treated using pair-wise deletion.

2.4. Case study: pilot mobile phone takeback service

A two-day event for the collection of unused/unwanted mobile phones and related accessories targeting students was piloted at the University of Southampton in May 2010. The aim of the trial was to assess the influence of various factors and incentives (see Section 2.3.3) on students' participation in prospective university mobile phone takeback services/schemes. The factors and incentives included: a monetary contribution to a selected charity; ease of use of the service; a conveniently located recycling point; promotion and advertising of the service; and entry into a prize draw (with the possibility to win brand new mobile phones, cash and supermarket vouchers). Prior arrangements had been made to pass on collected phones and accessories to a UK mobile phone reuse, refurbishing and recycling company. For all collected phones, the company was to make a cash donation to a selected charity based upon the monetary value of the phones.

A few days before the trial, posters about the event were put up in strategic places around the University's main campus (Highfield). In addition, approximately 3000 flyers were distributed at two University of Southampton campuses (Highfield and Avenue campuses). The event was also advertised on the Students' Union website as well as the University's students' Internet portal.

Over the 2 days of the event, a recycling point was set up near the Students' Union building on a square normally frequented by students. A special labelled container was used to collect the phones with 5 event assistants on hand to receive phones and assist with any queries. In addition, music was played to attract students to the event. On both days, mobile phones were collected between 10 am and 3 pm.

3. Results

A total of 2287 useable questionnaires were completed with male students accounting for 52% of the respondents. However, since pair-wise deletion was used to deal with missing data, in

[2] Chi-Square statistic determines if a distribution of observed frequencies differs from the theoretical expected frequencies. See http://cnx.org/content/m13487/latest for further information.

[3] Not more than 20% of the cells should have expected cell frequencies of less than 5 and no cell should have an expected frequency of less than 1.

[4] MP3 is a popular digital audio encoding format for music as well as other types of audio files (see www.mpeg.org). The term is also commonly used to denote a music MP3 file. In this paper, this is the intended meaning.

the results presented in this section, the reported samples sizes on which analyses were carried out (depicted as *N*) vary.

3.1. Use and disposal of mobile phones

3.1.1. Replacement of mobile phones

Although most students declared that they do not replace their phones every year, a substantial number (28%) replace their phones annually. The frequencies with which students replace their mobile phones is summarised in Fig. 2.

The students offered various reasons for replacing their mobile phones. These are summarised in Fig. 3. The most prolific reason for changing mobile phones is to replace a broken phone followed by upgrades from network operators (i.e. new phone provided by network operator during and/or after the contractual period). No information was collected in relation to how the phones broke or the extent of the damage.

Fig. 4 summarises the methods the students used to dispose of their most recent unwanted mobile phones. These results indicate that more than half of the students stockpiled their most recent unwanted phones (~56%) whilst slightly less than one fifth passed the phones to other people as gifts.

3.1.2. Stockpiling of mobile phones

Approximately 61% of students reported owning extra mobile phones (*N* = 2150). The number of extra mobile phones stockpiled by students is summarised in Table 1. Working out the average, there is at least 1 mobile phone stockpiled for every student. The Nokia brand accounted for the highest number of phones stockpiled (1615) and ownership of "1 extra phone" accounted for the largest share of phones stockpiled (1545).The students who reported owning extra mobile phones cited several reasons for stockpiling. These are presented in Fig. 5.

Although a majority of the students stockpiled phones in case they needed a spare handset, it is instructive to note that 30% of them did not know what else to do with their extra phones.

3.2. Awareness of and experience with UK mobile phone takeback services

Approximately 69% of the students (*N* = 2136) were aware of UK organisations or companies that operate mobile phone takeback services. Among those who were not aware of such organisations, ~30% also reported not knowing what to do with their unused phones (cf. Fig. 5). Television (TV) seems to be the most important

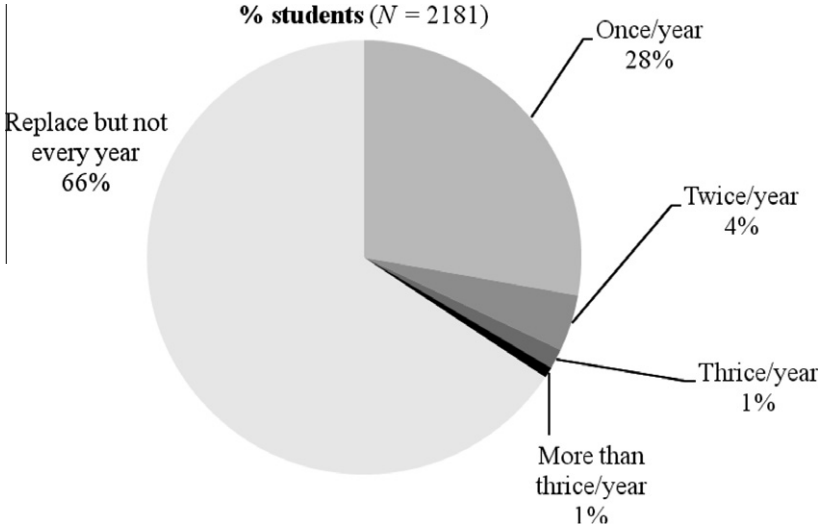

Fig. 2. Frequency of replacing mobile phones among students.

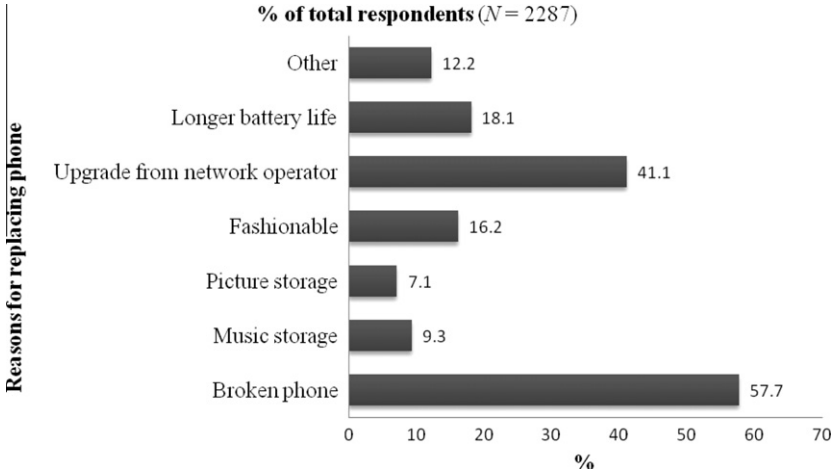

Fig. 3. Students' reasons for replacing mobile phones.

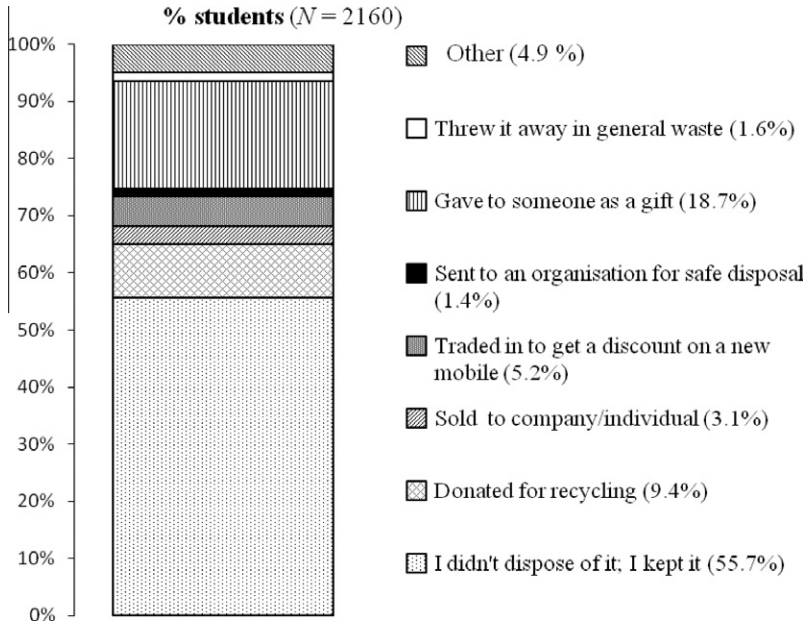

Fig. 4. Methods used by students to dispose of most recent phone.

Table 1
Quantities of extra mobile phones stockpiled by students.

	Ownership of phones						Total phones (by brand)
	1	2	3	4	5	5+	
Nokia	511	564	336	108	30	66	1615
Sony Ericsson	400	224	54	36	0	12	726
Samsung	348	118	45	12	0	12	535
Motorola	286	106	24	4	0	6	426
Other*	–	–	–	–	–	–	203*
Total phones (by ownership)	1545	1012	459	160	30	96	(by brand) 3505

The figures for the respective brands of mobile phones show the quantities of stockpiled phones classified according to ownership. For instance, the total number of Samsung phones stockpiled by students who stated that they each hoarded 3 of such handsets is 45 (i.e. 15 students each hoarding 3 Samsung mobile phones).
* No data available on distribution by ownership.

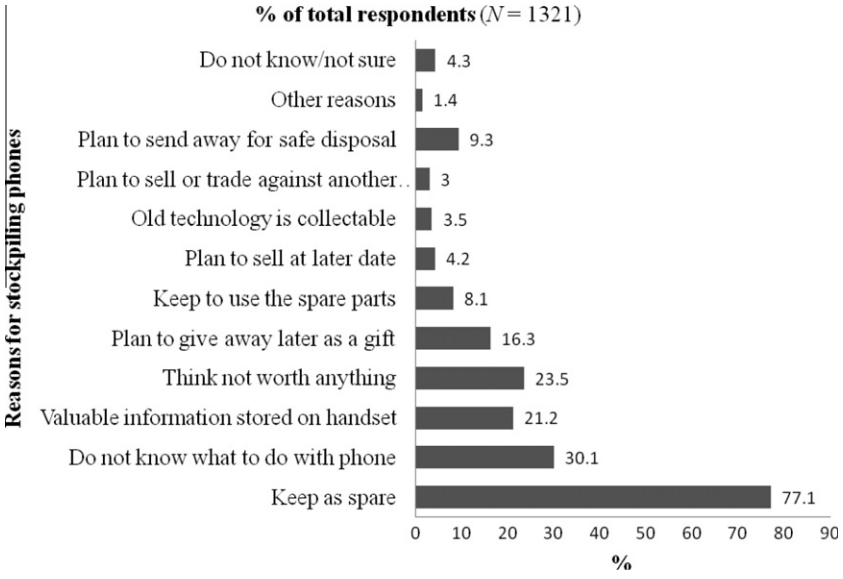

Fig. 5. Students' reasons for stockpiling mobile phones.

medium for creating awareness of such takeback services. Fig. 6 shows the various media through which the students became aware of the UK mobile phone takeback services.

Among the students who were aware of UK mobile phone takeback services, only ~27% of them (N = 1451) had ever recycled mobile phones using these services. Fig. 7 summarises the main reasons the students utilised specific takeback services.

The results in Fig. 7 indicate that incentives and ease of use are important factors that influence students' decision making regarding the use of mobile phone takeback services.

3.3. Recycling of mobile phones at potential university takeback services

3.3.1. Willingness to recycle mobile phones at potential university takeback services

The results presented in Fig. 8 indicate that majority of the students were at least "somewhat willing" to recycle their unwanted mobile phones at a prospective university takeback service.

3.3.2. Effect of incentives on willingness to recycle unwanted mobile phones at potential university takeback services

The students' reported that different incentives would have different effects on their willingness to recycle mobile phones at any future university mobile phone takeback services. As shown in Table 2, the prospect of a cash incentive attracted more willing students than any other factor. Conversely, the promise of free ringtones seemed to appeal to very few students.

3.3.3. Preferred drop-off locations for potential university mobile phone takeback services

Fig. 9 shows the distribution of students' preferred drop-off locations for prospective university mobile phone takeback services (these responses were for a multiple choice question with single answer including an open-ended alternative response). The Students' Union facilities and the library were the main preferred locations.

3.4. Projected quantities of extra mobile phones owned by higher education students in the UK

It is estimated that students in UK higher education are hoarding ~3.7 million mobile phones. Table 3 illustrates the projected quantities of extra mobile phones they own.

3.5. Statistical analysis

3.5.1. Association between age and various aspects of use and disposal of mobile phones

No significant associations were found between age and the following factors: frequency of replacing mobile phones; methods the students had used to dispose of their most recent unwanted mobile

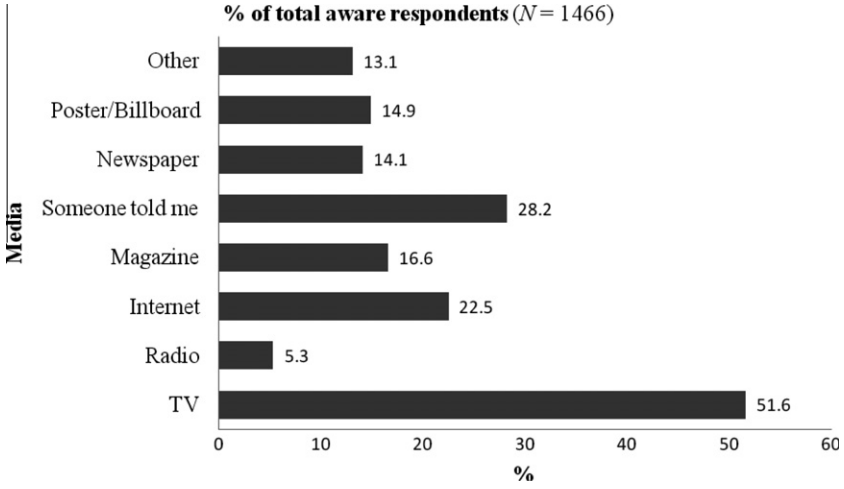

Fig. 6. Media through which students became aware of UK mobile phone takeback services.

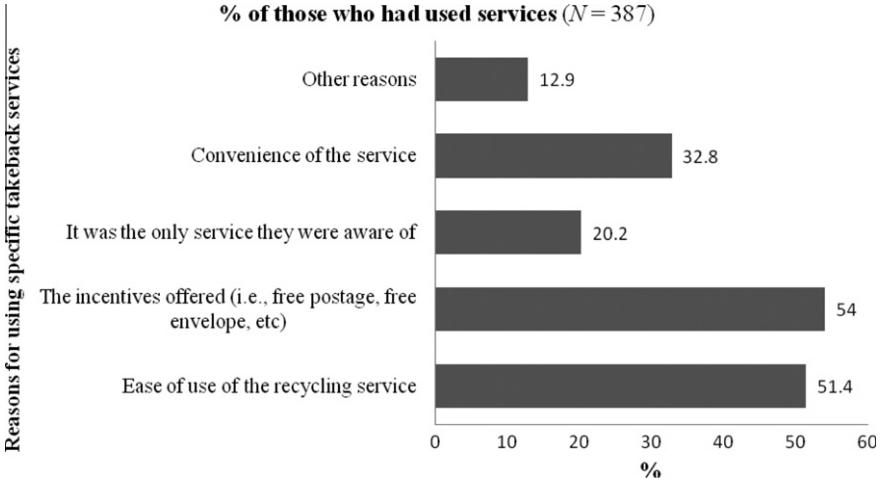

Fig. 7. Principal reasons students used particular UK mobile phone takeback services.

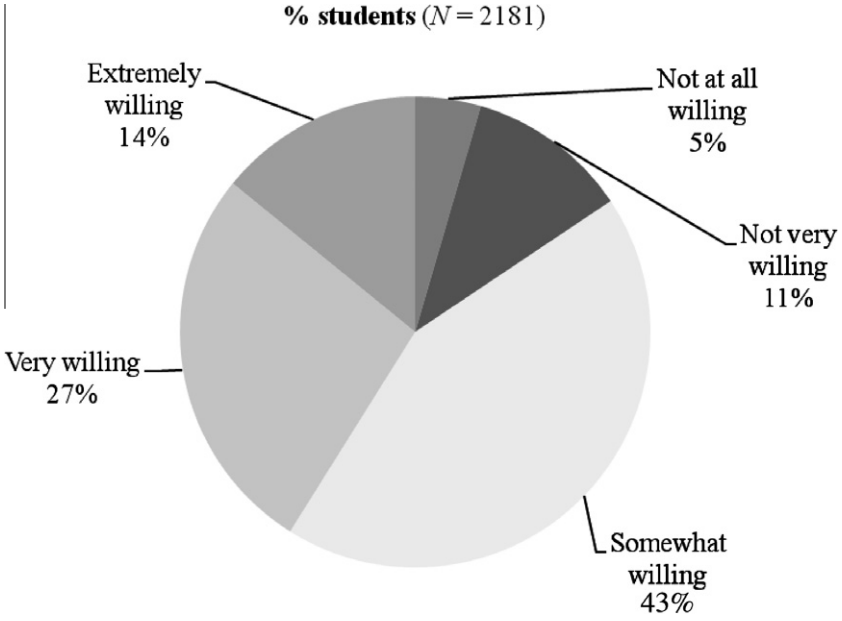

Fig. 8. Students' willingness to recycle mobile phones at prospective university takeback services.

Table 2
Effect of incentives on willingness to use university mobile phone takeback services.

	Effect on willingness (% students)					Total %
Incentives	Not at all	A little	A fair amount	Much	Very much	
Environmental incentive	10.7	27.7	28.5	17.6	15.5	100 (*N* = 1965)
Contribution to charity	6.9	23.4	29.4	24.1	16.2	100 (*N* = 1960)
Easy to use service	6.8	16.0	27.7	28.8	20.7	100 (*N* = 1954)
Convenient recycling points	6.9	16.4	28.5	27.9	20.3	100 (*N* = 1947)
Prize draw entry	10.8	24.0	25.7	25.2	14.3	100 (*N* = 1954)
Vouchers	6.8	15.3	26.8	30.0	21.0	100 (*N* = 1948)
Free ringtones	59.8	20.0	11.2	5.3	3.8	100 (*N* = 1953)
Free texts	32.4	20.5	18.8	16.0	12.4	100 (*N* = 1950)
Free airtime	27.2	18.2	20.2	19.0	15.4	100 (*N* = 1950)
Discounts to download MP3s	45.1	21.5	17.9	10.3	5.2	100 (*N* = 1943)
Free MP3 downloads	38.2	19.8	18.8	13.0	10.2	100 (*N* = 1949)
Cash payment	3.3	6.4	15.8	24.3	50.1	100 (*N* = 1969)

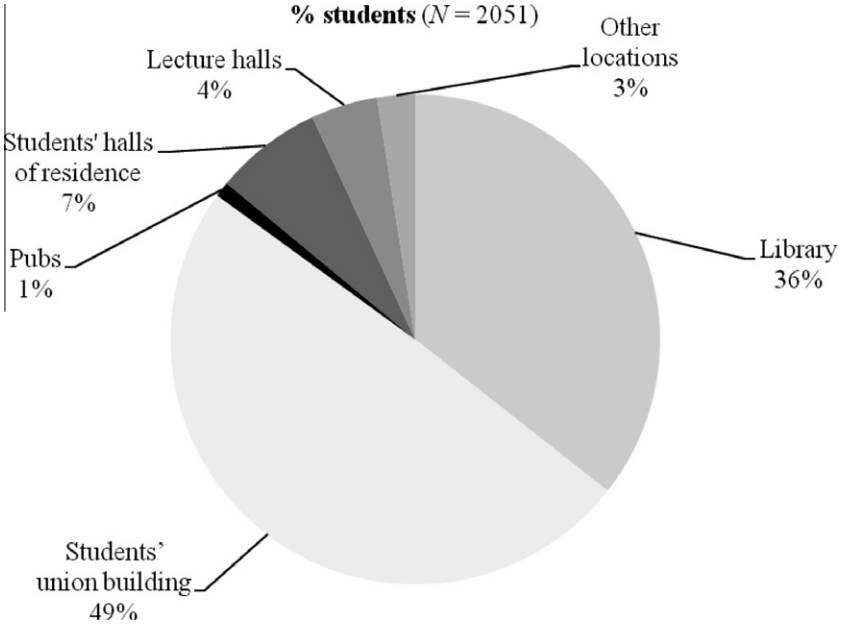

Fig. 9. Students' preferred drop-off locations for prospective university takeback services.

Table 3
Projected quantities of mobile phones stockpiled by students in UK higher education.

Ownership	Nokia	Sony Ericsson	Samsung	Motorola	Other	Total phones (by ownership)
1	535,367	419,074	364,594	299,638	–	1618,673
2	590,894	234,681	123,627	111,055	–	1060,257
3	352,022	56,575	47,146	25,144	–	480,887
4	113,150	37,717	12,572	4191	–	167,630
5	31,431	0	0	0	–	31,431
5+	69,147	12,572	12,572	6286	–	100,578
Total phones (by brand)	1692,011	760,619	560,511	446,314	212,680	3672,135

phones; number of phones stockpiled by students; and students' previous use of UK mobile phone takeback services.

A significant association ($p = 0.025$) was found between age and awareness of UK mobile phone takeback services (Table 4). The highest contributions (7.047 and 3.206) to the Chi-Square statistic came from the 25 to 29 year olds with the largest positive difference (21.77) between observed and expected counts recorded for those who were not aware of UK mobile phone takeback services. In addition, more students aged 24 years of age or less were aware of UK mobile phone takeback schemes compared to the older students.

Table 4
Chi-Square results for association between age and awareness of UK mobile phone takeback services.

	Yes	No	Total
Under 20	329 319.59 0.277	136 145.41 0.609	465
20–24	778 761.51 0.357	330 346.49 0.784	1108
25–29	126 147.77 3.206	89 67.23 7.047	215
30–34	66 68.04 0.061	33 30.96 0.135	99
35–39	48 47.42 0.007	21 21.58 0.015	69
40+	64 66.67 0.107	33 30.33 0.234	97
Total	1411	642	2053

Chi-Square = 12.840, DF = 5, $p = 0.025$.
For all age groups, top row figures are observed counts, middle row are expected counts and bottom row are Chi-Square contributions.

A significant association ($p = 0.000$) was found between age and willingness to recycle mobile phones at the potential university mobile phone takeback services (Table 5). Students aged 30+ years accounted for the two largest contributions to the Chi-Square, i.e. 9.111 and 10.933, respectively, for those who were "somewhat willing" and "extremely willing". The "somewhat willing" category had the largest (negative) difference (−33.24) between observed and expected counts, indicating that this category least described the willingness level of the 30+ years students. Most of the students who were aged 29 years or less were at most "somewhat willing" to recycle unwanted phones at the potential university takeback services whereas most of the older ones were at least "somewhat willing" to use such services.

3.5.2. Association between sex and various aspects of use and disposal of mobile phones

No significant associations were found between sex and: the methods the students previously used to dispose of their most recent unwanted mobile phones; and students' awareness of UK mobile phone takeback services.

A significant association ($p = 0.000$) was found between sex and the students' frequency of replacing mobile phones with males more frequently replacing phones compared to females (Table 6). Replacement of phones twice a year was the highest contributor to the Chi-Square for both sexes. However, the largest differences between observed and expected counts were attributed to those who indicated they did not replace their phones every year (−29.89 and 29.89, respectively, for males and females).

Table 7 shows that there was a statistically significant association ($p = 0.007$) between sex and the number of phones stockpiled by students. Although hoarding of 2 phones recorded the largest differences between observed and expected counts (−19.85 and 19.85 for males and females, respectively), the largest contributor to the Chi-Square was the hoarding of 3 phones category by female students (2.623) followed by males (2.531) in the same category. More females than males hoarded 1 or 2 mobile phones. However, the opposite was true when considering 3, 5 and 5+ phones; more

Table 5
Chi-Square results for association between age and willingness to recycle mobile phones at prospective university takeback services.

	Not at all willing	Not very willing	Somewhat willing	Very willing	Extremely willing	Total
Under 20	12 21.57 4.246	57 54.84 0.085	231 212.49 1.613	118 131.26 1.339	71 68.84 0.068	489
20–29	65 60.12 0.396	153 152.87 0	607 592.27 0.366	369 365.85 0.027	169 191.88 2.729	1363
30+	17 12.31 1.79	29 31.29 0.168	88 121.24 9.111	85 74.89 1.365	60 39.28 10.933	279
Total	94	239	926	572	300	2131

Chi-Square = 34.235, DF = 8, $p = 0.000$.
For all age groups, top row figures are observed counts, middle row are expected counts and bottom row are Chi-Square contributions.

Table 6
Chi-Square results for association between sex and students' frequency of replacing mobile phones.

	Once/year	Twice/year	Thrice/year	More than thrice/year	Not every year	Total
Male	300	57	18	14	680	1069
	293.44	42.74	14.59	8.34	709.89	
	0.147	4.758	0.795	3.842	1.258	
Female	263	25	10	2	682	982
	269.56	39.26	13.41	7.66	652.11	
	0.16	5.18	0.865	4.183	1.37	
Total	563	82	28	16	1362	2051

Chi-Square = 22.558, DF = 4, $p = 0.000$.
For both genders, top row figures are observed counts, middle row are expected counts and bottom row are Chi-Square contributions.

Table 7
Chi-Square results for association between sex and number of mobile phones stockpiled.

	1 Phone	2 Phones	3 Phones	4 Phones	5 Phones	5 + Phones	Total
Male	150	199	143	48	38	48	626
	160.83	218.85	125.2	48.86	33.59	38.68	
	0.729	1.8	2.531	0.015	0.579	2.246	
Female	166	231	103	48	28	28	604
	155.17	211.15	120.8	47.14	32.41	37.32	
	0.755	1.865	2.623	0.016	0.6	2.328	
Total	316	430	246	96	66	76	1230

Chi-Square = 16.086, DF = 5, $p = 0.007$.
For both genders, top row figures are observed counts, middle row are expected counts and bottom row are Chi-Square contributions.

males than females hoarded these number of phones. In total, male students stockpiled slightly more phones than females.

A significant association (Yates' correction applied; $p = 0.032$) was found between sex and the students' previous use of UK mobile phone takeback services (Table 8). More female students than males had previously used UK mobile phone takeback services and were the highest contributor to the Chi-Square (1.934).

Table 8
Chi-Square results for association between sex and experience with UK mobile phone takeback services.

	Yes	No	Total
Male	173	573	746
	191.02	554.98	
	1.7	0.585	
Female	186	470	656
	167.98	488.02	
	1.934	0.666	
Total	359	1043	1402

Chi-Square = 4.885, DF = 1, $p = 0.027$.
Yates' Chi-Square = 4.618, DF = 1, $p = 0.032$.
For both genders, top row figures are observed counts, middle row are expected counts and bottom row are Chi-Square contributions.

Table 9 illustrates that a significant association ($p = 0.000$) was found between sex and students' willingness to recycle mobile phones at potential university mobile phone takeback services. More females than males were either "very willing" or "extremely willing" to utilise a university mobile phone takeback service. The category "not very willing" highly contributed to the Chi-Square for both males (6.619) and females (7.238) as well as the largest difference between observed and expected counts (28.69 and −28.69 for males and females, respectively).

3.5.3. Association between recycling of other waste materials and various aspects of use and disposal of mobile phones

There were no significant associations between recycling of paper, plastics, cans/tins or glass, respectively, and the manner in which students' disposed of their most recent unwanted mobile phones. Similarly, with the exception of cans/tins, there were no significant associations between recycling of these waste types and the number of stockpiled mobile phones.

A statistically significant association ($p = 0.004$) was found between recycling of cans/tins and the quantities of mobile phones stockpiled by students (Table 10). The students who less frequently recycled cans/tins showed a propensity to hoard more than expected numbers of 3 or more phones. For those who more frequently recycled cans/tins, the same behaviour was observed

Table 9
Chi-Square results for association between sex and willingness to recycle mobile phones at prospective university takeback services.

	Not at all willing	Not very willing	Somewhat willing	Very willing	Extremely willing	Total
Male	60	153	485	282	131	1111
	49.1	124.31	482.63	298.25	156.7	
	2.42	6.619	0.012	0.886	4.215	
Female	34	85	439	289	169	1016
	44.9	113.69	441.37	272.75	143.3	
	2.646	7.238	0.013	0.968	4.609	
Total	94	238	924	571	300	2127

Chi-Square = 29.625, DF = 4, $p = 0.000$.
For both genders, top row figures are observed counts, middle row are expected counts and bottom row are Chi-Square contributions.

Table 10
Chi-Square results for association between recycling of cans/tins and number of mobile phones stockpiled by students.

	1 Phone	2 Phones	3 Phones	4 Phones	5 Phones	5 + Phones	Total
Less frequent recycling	43	68	63	20	14	20	228
	56.12	79.89	46.66	18.49	13.2	13.64	
	3.067	1.769	5.725	0.124	0.048	2.96	
More frequent recycling	212	295	149	64	46	42	808
	198.88	283.11	165.34	65.51	46.8	48.36	
	0.865	0.499	1.616	0.035	0.014	0.835	
Total	255	363	212	84	60	62	1036

Chi-Square = 17.557, DF = 5, $p = 0.004$.
For both recycling of cans/tins responses, top row figures are observed counts, middle row are expected counts and bottom row are Chi-Square contributions.

when considering 1or 2 phones stockpiled. The highest contributors (5.725) to the Chi-Square were the students who less frequently recycled cans/tins as well as hoarded 3 mobile phones.

Since the findings in Table 10 were deemed peculiar and to some extent similar to the results illustrated in Table 7 (i.e. more females than males hoarding 1 or 2 phones; and more males than females hoarding 3 or more phones), a follow-up Chi-Square test was carried out to check for confounding variables. The results revealed that there was a significant association between sex and recycling of cans/tins (as well as between sex and recycling of paper, plastics and glass, respectively); there was a propensity by female students to recycle cans/tins more frequently in comparison to the male students. This suggests that sex was a confounding variable contributing to the results in Table 10.

There were significant associations between recycling of paper ($p = 0.000$), plastics ($p = 0.000$), cans/tins ($p = 0.000$) and glass ($p = 0.012$), respectively and students' willingness to recycle mobile phones at prospective university mobile phone takeback services. For paper, cans/tins and glass, the highest contributions to the Chi-Squares (12.08, 9.264 and 4.734, respectively), came from the category of those who never recycled these items and were "less willing" to use the potential takeback services. In the case of plastics, the highest contribution (5.8) was from those who always recycled such wastes and were "most willing" to use the prospective takeback services. For all the assessed materials, the largest (positive) differences between observed and expected counts were recorded for the students who always recycled these waste materials and expressed "most willingness" to utilise the potential takeback services. Hence, the students who reported that they always recycled these waste materials were also the most willing to use a university takeback service for EoL mobile phones whereas those who never recycled or recycled less often were generally less willing to use such a takeback service. These results are presented in Table 11 (paper and plastics, respectively) and Table 12 (cans/tins and glass, respectively).

3.5.4. Influence of incentives on willingness to recycle unwanted mobile phones at prospective university takeback services

The Friedman's ANOVA test revealed that students' willingness to recycle mobile phones at potential university takeback services significantly varied depending on the incentives offered ($N = 1839$; Chi-Square = 5742.730; DF = 11; $p = 0.000$). In addition, the Kendall's W analysis showed a statistically significant weak agreement between respondents regarding the effect of incentives on their willingness to recycle mobile phones at the prospective university takeback services ($N = 1839$; Chi-Square = 5742.730; DF = 11; Kendall's $W = 0.284$; $p = 0.000$).

Using Wilcoxon signed-rank tests, the comparisons of the effects of the incentives on willingness to recycle mobile phones at prospective university takeback services revealed significant differences ($p = 0.000$) between those effects for all but 5 of the comparisons, i.e.:

- Prize draw entry versus environmental incentives.
- Prize draw entry versus a contribution to charity.
- Conveniently located recycling points versus ease of use of the service.
- Vouchers versus ease of use of the service.
- Vouchers versus conveniently located recycling points.

Based on the directions of the results as revealed by the Wilcoxon signed-rank tests, Fig. 10 depicts a comparison of the

Table 11
Chi-Square results for association between recycling of paper and plastics, respectively and students' willingness to recycle mobile phones at potential university takeback services.

	Recycling of paper versus willingness				Recycling of plastics versus willingness			
	Less willing	More willing	Most willing	Total	Less willing	More willing	Most willing	Total
Never	18	21	16	55	17	28	21	66
	8.1	24.03	22.86		9.69	28.65	27.66	
	12.08	0.382	2.061		5.512	0.015	1.602	
Sometimes	58	142	95	295	59	140	106	305
	43.47	128.89	122.64		44.79	132.41	127.81	
	4.855	1.333	6.228		4.512	0.435	3.721	
Frequently	90	313	237	640	84	275	234	593
	94.31	279.63	266.06		87.07	257.44	248.49	
	0.197	3.983	3.174		0.109	1.198	0.845	
Always	119	369	456	944	93	305	361	759
	139.11	412.45	392.44		111.45	329.5	318.05	
	2.907	4.577	10.295		3.054	1.822	5.8	
Total	285	845	804	1934	253	748	722	1723
Chi-Square = 52.074, DF = 6, $p = 0.000$					Chi-Square = 28.624, DF = 6, $p = 0.000$			

For all recycling of paper and plastics frequencies, top row figures are observed counts, middle row are expected counts and bottom row are Chi-Square contributions.

Table 12
Chi-Square results for association between recycling of cans/tins and glass, respectively and students' willingness to recycle mobile phones at potential university takeback services.

	Recycling of cans/tins versus willingness				Recycling of glass versus willingness			
	Less willing	More willing	Most willing	Total	Less willing	More willing	Most willing	Total
Never	21	34	19	74	22	41	32	95
	10.94	32.14	30.93		13.89	39.6	41.51	
	9.264	0.108	4.6		4.734	0.05	2.18	
Sometimes	54	141	116	311	44	131	118	293
	45.96	135.06	129.98		42.84	122.12	128.03	
	1.408	0.261	1.503		0.031	0.645	0.786	
Frequently	72	246	189	507	43	132	120	295
	74.92	220.19	211.89		43.13	122.96	128.91	
	0.114	3.026	2.473		0	0.665	0.616	
Always	115	349	417	881	65	192	250	507
	130.19	382.61	368.2		74.13	211.32	221.55	
	1.772	2.953	6.467		1.125	1.767	3.654	
Total	262	770	741	1773	174	496	520	1190
Chi-Square = 33.949, DF = 6, $p = 0.000$					Chi-Square = 16.253, DF = 6, $p = 0.012$			

For all recycling of cans/tins and glass frequencies, top row figures are observed counts, middle row are expected counts and bottom row are Chi-Square contributions.

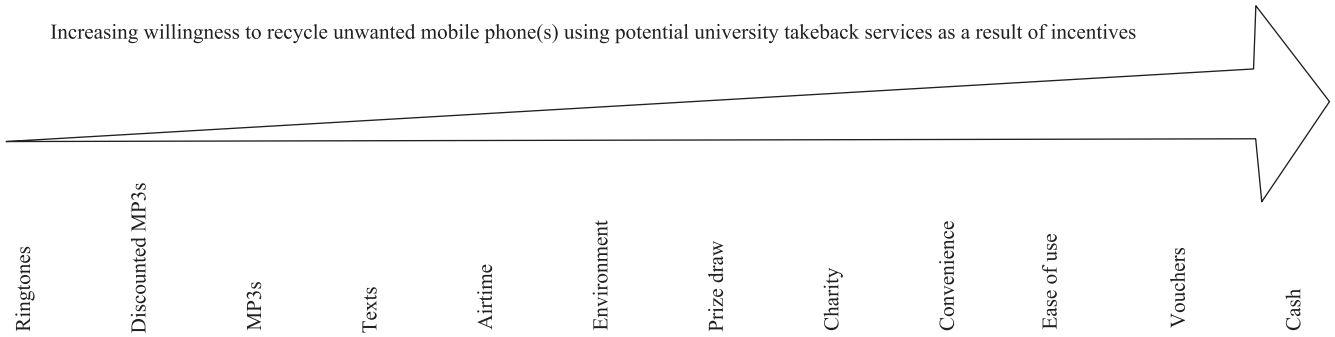

Fig. 10. Effect of incentives on students' willingness to recycle mobile phones at prospective university takeback services.

magnitude of the effects of all the 12 investigated incentives on students' willingness to recycle at prospective university mobile phone takeback services.

Fig. 11 depicts the typical mobile phone use and disposal flows of university students.

3.6. Case study: pilot mobile phone takeback service

The participation by students was low with only 11 students returning 14 mobile phones. Although the event was targeted at students, a further 40 phones were donated by the University staff members and one other external organisation bringing the total number of collected handsets to 54, some of which were accompanied by their battery chargers. The handsets and their accessories were passed onto the takeback company for valuation and safe EoL disposal.

4. Discussion

4.1. Use and disposal of mobile phones

4.1.1. Replacement of mobile phones

Although most students do not replace phones annually, a relatively large percentage (~28%) replaces their handsets every year. The possible reasons for these include broken phones and upgrades from network operator (see Fig. 3). These raise some important issues. According to the findings shown in Fig. 3, almost 58% of the students cited broken phones as the reason for replacing their handsets. That is quite a high percentage which leads to the question whether there is a link between broken phones and the relatively short life-spans of phones. For instance, does it mean that the design and quality of the mobile phones are bad? This is in contrast to the assertion that the technical life-span of a mobile phone is 10 years (Nokia, 2005). It could be argued that perhaps the lifestyles of young people play a great role in causing damage to their mobile phones.

A moderate proportion of the students (Fig. 3) replace mobile phones because it is fashionable to do so. This finding confirms the conclusions of previous studies (see Nokia, 2005; Bains et al., 2006). Since it is probably quite difficult to change such behaviour, it is probably more prudent to try and influence what the students do with phones once they replace them.

The findings in Fig. 3 show that 41% of the students reported replacing phones as a result of getting upgrades from network operators. The question can be advanced whether network operators are helping to promote a culture where relatively new technology is quickly perceived as obsolete. From a business point of view, upgrading is primarily an incentive by the network provider to help retain their customers.

The desire to have a phone with a longer battery life ranked modestly high as one of the reasons students replaced mobile phones (Fig. 3). Longer battery life is not only important for prolonged use without re-charging, but also vital for relatively energy intensive activities such as recording and/or watching video and, listening to music (see Palm, 2010).

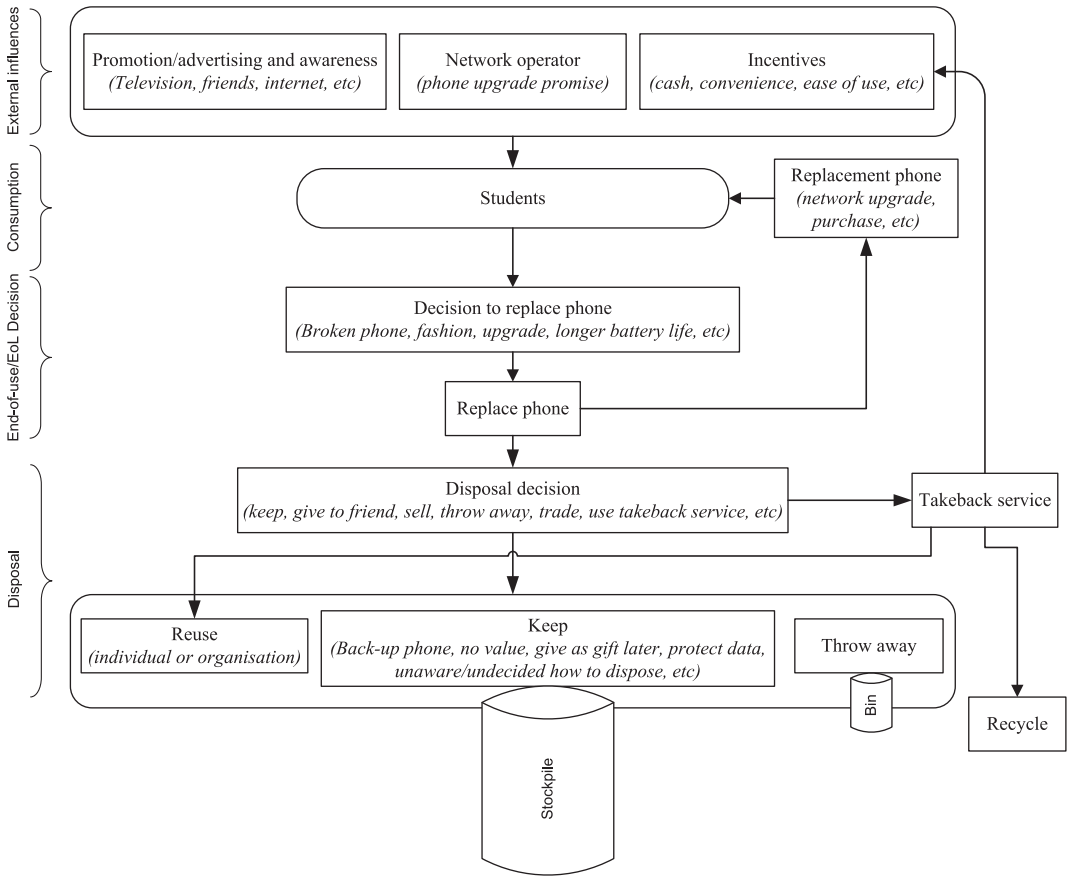

Fig. 11. Mobile phone flows among university students.

More than half of the students (~56%) stockpiled their most recently disposed phone (Fig. 4). This means that among young people in the UK, on average, more than half of retired phones will be stockpiled (almost 6 in 10 phones). A recent UK survey is in agreement with this finding; it reports that for those aged between 25 and 34, nearly 6 in 10 (59%) own at least one unused mobile phone. Considering all age groups, the study reported that 41% of people owned at least one mobile phone they no longer use (Netimperative, 2010). This phenomenon represents an unsustainable linear chain/trend where phones are:Acquired → consumed (short lifespan) → replaced (mainly due to damage or upgrade) → stockpiled.

Although the per capita capacity to stockpile phones was not investigated, if the trend continues and we assume an average 18-month replacement cycle, within a 5 year period the number of stockpiled phones would clearly be very high.

The number of mobile phones specifically destined for recycling was quite low (9.4%, Fig. 4). There is a possibility, however, that some of these handsets were channelled to reuse markets by the takeback organisations. The same case applies to the phones that were sold to companies or sent to organisations for safe disposal. Explicitly reported reuse was modest, with ~19% (Fig. 4) of the students passing on phones to someone else (Fig. 4).

Only a small number of the phones (1.6%) were thrown in the general waste (Fig. 4). This finding concurs with Darby and Obara's (2005) finding that small WEEE with a perceived value is not generally disposed with general waste. It is worth noting that perceived value may not necessarily be monetary; it could be sentimental or a concern to safeguard personal data (see findings in Fig. 5). Comparatively, the figure (1.6%) is lower than that reported by the global Nokia study (4%) (see Nokia, 2008). The differences between the findings probably stem from the characteristics of the survey sample. The Nokia study did not confine itself to a particular age group and incorporated results from several countries. On the contrary, this present study reports findings specific to a targeted group.

It is important to note that students may not necessarily continue to use the methods reported in Fig. 4 to dispose of their unwanted phones. This supposition is supported by the observation by the authors that a number of UK takeback companies have recently increased promotions of their services on TV and in newspapers.

4.1.2. Stockpiling of mobile phones

One and two extra phone ownerships account for the majority of mobile phones stockpiled (Table 1). Taking into account that most students stockpile phones since they need a spare handset, (Fig. 5) it may be difficult to convince students to give up all the extra phones they keep. However, students could be encouraged not to hoard more than 1 extra phone with takeback services specifically targeting such phones.

For majority of the students (77%), the main reason for stockpiling mobile phones is to have a backup handset (Fig. 5). This complements the finding shown in Fig. 3 that "broken phones" are the main reason why students replace their phones. The number of students (30%, Fig. 5) who stockpiled phones since they did not know what to do with them is quite high. In this group, approximately half of them were aware of UK mobile phone takeback schemes. However, the reasons why these specific students did not utilise the takeback schemes to dispose of their phones are unclear. It is probable that the unwanted phones they possessed were damaged and hence would be of little or no monetary value if sold or given away. In addition, they could have been indecisive

whether to keep the phones, or give them away or sell them. Almost a quarter of the students indicated that they stockpiled phones because they believed the handsets were not worth anything (Fig. 5). It is very likely that in this case, "worth" was equated with a monetary value. It is unclear, however, whether these students were aware of the "environmental value" of the phones, i.e. the importance of recycling in order to reclaim the resources embedded within the phone.

4.2. Awareness of and experience with UK mobile phone takeback services

Quite a high percentage of the students were aware of UK takeback services. This probably indicates that lack of awareness about the services is not a contributory factor to the low proportion of students who had previously used the services and further solidifies the finding that stockpiling of mobile phones mainly occurs due to other reasons. In contrast, a recent survey concluded that 75% of people in the UK are not aware of their options for either selling or trading in old electrical and electronic equipment (EEE) (Netimperative, 2010).

The important role of the media (especially TV and the Internet) in informing the public about the safe disposal options for their EoL EEE is exemplified by the results in Fig. 6. This is especially true for young people since they spend a considerable amount of time using these media. Word of mouth also seems to be an important avenue through which the students became aware of UK mobile phone takeback services (Fig. 6).

Only ~27% of the students had ever used UK takeback services to recycle their unwanted mobile phones. This is not surprising since, as demonstrated in Figs. 4 and 5, most students stockpile their phones. In fact, looking at EEE in general, a recent study found that only 14% of people in the UK had ever used a recycling or trade-in service for their unwanted electronic gadgets (Netimperative, 2010).

The findings in Fig. 7 show that ease of use, convenience and incentives were key factors that prompted students to use particular mobile phone takeback services. These results are in accord with previous studies (see Most, 2003; Darby and Obara, 2005; Ongondo and Williams, 2011).

4.3. Willingness to recycle mobile phones

Only 16% of the students were either "not at all willing" or "not very willing" to recycle unwanted handsets at prospective university takeback services (Fig. 8). On the contrary, a possible reason for the high proportion of those who were at least "somewhat willing" could be attributed to the perceived convenience that such a scheme would offer. In such a scenario, students would avoid the process of mailing their unwanted handsets to the Internet based takeback services (see Ongondo and Williams, 2011) hence possibly speeding up the takeback process and subsequent payment for returned phones. Alternatively, the students could have been expressing socially desirable responses (see Paulhus, 1991). For instance, instead of choosing the options "not at all willing" or "not very willing", they could have decided to go for the less assertive option "somewhat willing".

It should be noted that a majority of the students (43%) were only "somewhat willing" to use the prospective university takeback services. This suggests that the students were probably unsure of how such a service would operate, especially in relation to established UK takeback services that offer cash payments for returned handsets. Conversely, if the proportions of those who were "very willing" and "extremely willing" are summed up, the resultant percentage (41%) is quite close to the number of those who were "somewhat willing".

The findings in Table 2 verify that different incentives elicit different levels of willingness to recycle unwanted mobile phones. This confirms the conclusion by Ongondo and Williams (2011) that mobile takeback services need to carefully consider the type of incentives they offer their customers. The results also strengthen the argument that a monetary incentive is a compelling reason for a consumer to return their unwanted mobile phones (MPPI, 2006).

It is not unexpected that most of the students would prefer the Students' Union facilities or the library as drop-off locations for prospective University mobile phone takeback services (Fig. 9). These are places they would normally frequent hence would be convenient/fit in with their schedules. However, it is unclear why lecture halls were not a highly preferred drop-off point despite being locations that students would frequently visit as well.

4.4. Projected quantities of extra mobile phones owned by higher education students in the UK

The projected quantities of mobile phones hoarded by students in UK higher education are exceptionally high (~3.7 million, Table 3). Assuming that our data is broadly representative of the western world, using the reasonable assumption about ratio of phones to students in the UK, i.e. 3.7 million phones hoarded by 2.4 million students, we can project the quantities of mobile phones stockpiled by students in higher education in similar countries and regions. In 2008 there were 19 million[5] and ~18.2 million[6] students in higher education in the EU and USA, respectively. Applying the UK phone/students ratio, we estimate that higher education students in the EU and USA are hoarding 29.3 million and 28.1 million mobile phones, respectively. This huge stockpile of mobile phones highlights the potential valuable supplies of rare metals that are held by the public. In comparison, a recent study estimated that the British public are stockpiling 32 million phones (Netimperative, 2010). However, the veracity of these findings is questionable. A 2006 study estimated the quantity to be 90 million handsets (Bains et al., 2006). Though not a primary focus of this study, we suggest that there is at least 1 stockpiled phone for every member of the UK population (~60 million).

In the UK, takeback campaigns may have little success in recovering all the stockpiled handsets because of the reported desire to keep a spare phone. However, takeback operations targeting any phones over and above one spare handset should be encouraged.

4.5. Association between age and various aspects of use and disposal of mobile phones

More students aged 24 years of age or less were aware of UK mobile phone takeback schemes compared to the older students (Table 4). Although it could be hypothesised that there is a relationship between age and the frequency of replacing mobile phones (hence the reason for this age group being more aware), no such significant relationship was found. It is therefore not clear why this younger age group was more aware compared to their older colleagues.

Most of the students who were aged 29 years or less were at most "somewhat willing" to recycle unwanted phones at potential university takeback services (Table 5). Coupled with the findings presented in Table 4 which show that those 24 years or less were more aware of UK mobile phone takeback services, to some extent, their moderate willingness can be attributed to their perceived benefits of using the established services they are already familiar with. On the contrary, for the students aged at least 30 years, fewer

[5] http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Tertiary_education_statistics

[6] http://nces.ed.gov/fastfacts/display.asp?id=98

than expected said they were "somewhat willing" to use potential university takeback services whereas more than expected reported being either "very willing" or "extremely willing" to utilise such takeback services. This too complements the results in Table 4 which show that those aged 25 years or more were less aware of UK takeback services and, subsequently, less familiar with potential incentives of using such established services. Hence, for those aged 30 years or more, unlike their younger counterparts, the established UK takeback services would not mitigate against their willingness to use potential university takeback services.

4.6. Association between sex and various aspects of use and disposal of mobile phones

The Chi-Square results displayed in Table 6 indicate that more than expected males replaced their mobile phones at least once a year whilst for female students the opposite was true. There is no clear reason for this observation. However, anecdotal evidence suggests that men are generally keener on acquiring new/latest gadgets in comparison to women.

The results in Table 7 show that more than expected female students were hoarding 1 or 2 mobile phones compared to male students. However, when considering 3, 5 and 5+ phones, more than expected numbers of males, compared to females, were stockpiling phones. A recent study concluded that young men aged 25–34 were the biggest hoarders of unused mobile phones (Netimperative, 2010). However, it is not clear what the study meant by "biggest hoarders", i.e. whether this referred to the categories of ownership akin to this present study (3, 5, 5+ phones, etc.) or if it referred to total number of phones, respectively, stockpiled by the two genders. Although there are no clear reasons for the mixed results in Table 7, a possible explanation for more female students than males stockpiling 1 or 2 mobile phones could be that they are more emotionally attached to their phones (see CPW, 2007). In the case of more male students than females hoarding 3 or more phones, a probable reason is that they replace phones more often (Table 6). In addition, the data displayed in Fig. 5 may provide some insights into the results shown Table 7. Female students may have hoarded 1 or 2 phones with the intention of sending them away for reuse/safe disposal at a later date. If this is true, the net result could mean that more males than females would be stockpiling 1 or 2 mobile phones. In contrast to this possible explanation, further analysis of the results presented in Fig. 5 also revealed that ~3% more female students than males stockpiled phones since they did not know what to do with them.

More female students than males had previously used UK mobile phone takeback services (Table 8). A possible reason for this may be that females were more altruistic, and by recycling their mobile phones, would support charity work and/or environmental campaigns. In addition, previous studies on recycling of wastes have shown that females are generally more pro-recycling compared to males (Darby and Obara, 2005). This position supports the finding that more females than males were either "very willing" or "extremely willing" to utilise a university mobile phone takeback service. Conversely, more than expected males compared to females were "not at all willing", "not very willing" and "somewhat willing", i.e. exhibited a proclivity towards being unwilling to recycle at such a service (Table 9).

4.7. Association between recycling of other waste materials and various aspects of use and disposal of mobile phones

Although no significant association was found between recycling of other waste types and the disposal of the most recent phones the students possessed (Section 3.5.3), there are a number of comparatively interesting observations in relation to a previous study. Darby and Obara (2005) suggested that *"the act of recycling other household items such as paper, tins, glass and plastics impacts on the way that small WEEE is disposed of"*. Whereas the present study did not find any statistically significant association in this regard, there are a number of important differences between the two studies. Firstly, Darby and Obara (2005) did not report that they used a statistical test to analyse the significance of their findings. Secondly, the authors analysed their respondents' behaviour of recycling small WEEE in relation to disposal in the general waste versus disposal at civic amenity (CA) sites (which can be considered as an intention to recycle). In comparison, this present study analysed 3 disposal options, namely, stockpiling, reuse/recycling and disposal in the general waste. Thirdly, the previous study examined small WEEE in general whereas this study specifically investigated mobile phones. Finally, there are differences between the two studies in relation to the age groups of the respondents surveyed; this study analysed the behaviour of comparatively younger people. It is likely that these differences contributed to the seemingly dissimilar results between the two studies.

There was no obvious explanation why a significant association was found between frequency of recycling cans/tins and the number of mobile phones stockpiled by students (Table 10). However, the follow-up Chi-Square test results reported in Section 3.5.3 strongly suggest that the findings reported in Table 10 were affected by the sex of the respondents; female students more frequently recycled cans/tins (as well as the other waste types) compared to males (a finding congruent with the argument that females are more pro-recycling compared to males). Hence, it can be concluded that there is no direct significant relationship between frequency of recycling cans/tins and the number of mobile phones stockpiled. However, despite the findings of the follow up Chi-Square tests, it is not apparent why similar results to those in Table 10 were not observed for the other 3 waste types. One possibility, flagged by Martin et al. (2006), is that people may feel it is acceptable to continue with unregulated consumption of goods provided that they can be recycled once discarded or stored for future reuse/recycling.

Whereas in Section 3.5.3 the results indicate that no significant association was found between the frequency of recycling other waste materials and students' past disposal actions with regard to their most recent unwanted mobile phone, the results in Tables 11 and 12 suggest that there is an association between recycling of other waste types and willingness to recycle unwanted handsets at potential university takeback services. The students who reported that they always recycled the other waste materials were also the most willing to use a university takeback service for EoL mobile phones. There are several explanations to these seemingly contradictory results in Section 3.5.3 and those reported in Tables 11 and 12. Firstly, the findings reported in Section 3.5.3 were in relation to analysis of past behaviour whereas those in Tables 11 and 12 were in relation to planned (future) behaviour. Students' attitudes may have changed since they disposed of their most recent phones. Secondly, there may be other confounding factors that affected the results. For instance, in relation to the planned behaviour, most of the students could have expressed a willingness to use the suggested university takeback services because of the perceived convenience such a service would offer. In addition, the results in Table 9 which illustrate the relationship between sex and willingness to recycle mobile phones at potential university takeback services suggest that sex could have been a confounding variable in these instances as well.

4.8. Influence of incentives on willingness to recycle unwanted mobile phones at prospective university takeback services

The Friedman's ANOVA test established that there was a significant variation in students' willingness to recycle at prospective

university takeback services dependent on incentives offered. However, according to the Kendall's W analysis, there was no complete unanimity among the students with regard to the effect of incentives on their willingness to use such services (Section 3.5.4).

Among UK mobile phone takeback services, probably the 5 most common incentives/attributes for consideration by prospective consumers are cash payments, ease of use and convenience of the service, a contribution to charity and environmental incentives (see Ongondo and Williams, 2011). The finding that cash payments ranked highest among the various incentives (Fig. 10) is not surprising. It is to be expected that students' would want some form of financial return in order to part with their unwanted handsets since they perceive the phones would have some residual value (see MPPI, 2006). Additionally, in general, university students have limited finances and recycling their phones for cash would help in this regard. Finally, with almost 70% of the students aware of UK companies/organisations that operate mobile phone takeback services (see Section 3.2), it follows that the students know these companies make a monetary profit from returned phones of which they would want a share. Hence, it is to be expected that in order to compel the students to participate in any prospective university takeback service, a monetary incentive would have to be offered. Similar arguments could be advanced for vouchers (ranked second highest; see Fig. 10) since in essence these have a specific guaranteed monetary value.

Although students most likely care about the environment, compared to financial needs, it is very probable that it is a less pressing issue for them. A recent survey concluded that the UK public perceived the economy to be the most important issue facing the government with environment coming in third after unemployment (DEFRA, 2009) (since the survey was conducted at a time the UK economy was in recession, the results should be treated with caution). It is surprising, however, that environment ranked least among the 5 most common incentives/attributes of UK mobile phone takeback services (Fig. 10). However, it is possible that different results would have been observed if students were asked to indicate how different environmental incentives would affect their willingness to recycle mobile phones, for instance, "plant a tree", "contribution to a climate change fund" and "help save an endangered species". Specifically in relation to a contribution to charity, since charity work is an important aspect of the UK society (see Hyndman and McMahon, 2010), it probably explains why this incentive was ranked higher than an environmental incentive.

Convenience and ease of use ranked highly amongst the incentives. This is consistent with previous studies (see Most, 2003; Darby and Obara, 2005). These factors are important ingredients to the success of recycling schemes. In addition, it is likely that students regard the two factors as essential since they are complementary to their fast and busy lifestyles.

As depicted in Fig. 10, free airtime, texts, MP3s and ringtones ranked lowest amongst the incentives. In the UK, many mobile phone service contracts include a complimentary number of free texts and free airtime (see MSE, 2010). Hence, for those students on such contracts, the offer of free texts and airtime is not an attractive proposition. In the case of ringtones, many modern phones come with several pre-installed ringtones. Additionally, it is possible in many modern mobile phones to use music files such as MP3s saved on the phone as ringtones. Hence, free ringtones would possibly not appeal to the majority of students. With respect to MP3s, the evidence suggests that many young people are involved in internet file sharing of music files (see DeVoss and Porter, 2006). It is therefore unlikely that the promise of free or discounted MP3 music files would arouse the interest of many students in relation to their willingness to recycle mobile phones.

It is possible that for an older age group, the order (and perhaps the inclusion) of the incentives/factors as illustrated in Fig. 10 might be different. A study comparing the effect of incentives on willingness to recycle mobile phones (and by extension small WEEE) would be of interest. It can be posited that takeback services that do not offer a monetary incentive (cash, vouchers, etc.) are at a competitive disadvantage compared to those that offer such incentives.

4.9. Case study: pilot mobile phone takeback service

The data shown in Fig. 8 indicate that the majority of students were at least "somewhat willing" to recycle unwanted handsets at prospective university takeback services. Isolating the University of Southampton responses indicates no change in this finding. Hence, if apathy and general lack of interest are eliminated as the main reasons for the low student turnout at the pilot takeback event, several other reasons can be advanced. First, there was a significant time lapse (ca. 1 year) between the time when the students were surveyed regarding their willingness to participate in a prospective takeback service and the time the event was undertaken. It is plausible that the students could have changed their minds during the time lapse. It is also possible that students preferred to return unwanted handsets to established UK takeback services that would guarantee cash payment for their phones (assuming they had a residual value) as compared to the pilot takeback event which offered entry into a prize draw with no such guarantees. Further, the pilot event was unavoidably undertaken close to the University's examinations period. Hence, many students could have stayed away in order to revise for their examinations. Finally, holding the event over a two-day period may not have been sufficiently long to maximise participation by the students. Similar events would probably be more successful if they were held over a longer time period and piggyed-back on established and/or well-known events at the University such as "environment week".

A spin-off occurrence was the participation of the University's members of staff who donated more phones than the students. This indicates that recycling events such as the pilot takeback have the potential to attract unintended participants with positive outcomes.

The concept of universities as takeback hubs raises at least one important question. Although universities facilitate the congregation of a considerable number of people, hence offering an opportunity to target their ubiquitous EoL products such as mobile phones, the exact role that these institutions should play in this regard is debatable. Universities could either play the role of facilitator or operator of takeback services. We suggest that it may be more beneficial to them if they assumed the role of facilitator. In such as a case, universities would function as a host as well as facilitate communications to students about takeback events but invite established takeback operators to run the events, dealing directly with the students and offering their normal incentives for participation. Hence, universities would assist in "greening academia" by bringing an important service conveniently closer to an important target group. Apart from the practicalities of organising such events, other tangible benefits to the universities would have to be discussed between the concerned parties.

5. Lessons applicable to takeback of similar small WEEE

There are a number of lessons to be learnt from the use and disposal of mobile phones among students that are applicable to the takeback of similar handheld small WEEE such as iPads, music players (such as iPods and other MP3 players) and game consoles.

The frequency with which consumers replace mobile phones, especially in developed economies, is a key challenge to managing EoL handsets. Any takeback specifically designed for similar WEEE

will have to assess a similar issue. However, with the possible exception of music players, it is likely that no other handheld device is replaced as often as mobile phones. Further, the reasons for replacement for such similar devices might be different in comparison to those for mobile phones. In addition, any attempt to replicate the success of mobile phone takeback strategies to the takeback of other similar EEE should at the very least include some form of incentive to encourage the participation of consumers. From a reverse logistics and business point of view, takeback activities for other handheld devices could piggy-back on existing mobile phone collection networks. Most importantly, to duplicate the achievements of mobile phone takeback programmes, similar WEEE must have a residual worth, primarily a reuse value. A discussion on how such a value can be stimulated or created is beyond the scope of this paper. However, it can be assumed that the laws of demand and supply would be applicable in this case. Despite these challenges, we posit that in future there will be thriving reuse and recycling markets (similar to the current ones for mobile phones) for other handheld small WEEE such as iPads, music players and game consoles.

6. Conclusions

This study has highlighted the potentially huge stockpile of mobile phones – and consequently valuable supplies of rare metals – being held by the public; we estimate that there are 3.7 million phones stockpiled by students in UK higher education alone. The behaviour of university students (as representatives of young people and important and immediate future consumers) with regard to their use and disposal of mobile phones has been evaluated and the study has established that many students replace their phones at least once a year, often replacing broken phones or getting upgrades from network operators. Remaining "fashionable" and a desire to have a handset with a longer battery life are other main reasons for the rapid replacement of phones among students. Almost 6 in 10 replaced phones are not sent to reuse or recycling operations but are instead stockpiled by the students with "keeping a backup phone" as the main reason for this practice. If this behaviour continues, as the students grow older, a situation could arise whereby they would be in possession of substantial numbers of unused phones. In addition, a considerable proportion of the students did not know what to do with their unwanted phones. A substantial number of students own an extra mobile phone with 1 or 2 extra mobile phone ownership accounting for the largest share of extra phones. Hence, not surprisingly, the estimated quantities of phones stockpiled by students in UK higher education are exceptionally high. Despite this, takeback campaigns may have little success in recovering all these handsets because of the students' desire to keep a spare phone. However, takeback campaigns specifically targeting extra phones over and above the one spare phone may prove successful.

Male students replace their phones more often although both genders stockpile phones with females accounting for the larger share of 1 or 2 phones stockpiled and males the main hoarders when considering 3 or more phones. Despite the high proportion of students who are aware of UK mobile phone takeback services, only a moderate number of them had previously used the services, majority of who were female students. In addition, younger students aged 24 years or less were more aware of the services. Awareness about the services is mainly created by TV, Internet and "word of mouth".

There seems to be no association between recycling of other waste materials (paper, plastics, cans/tins and glass) and students' disposal actions concerning their unwanted mobile phones although students who often recycled other waste materials were also the most willing to participate in mobile phone takeback services. However, sex and various incentives and factors are the overarching factors influencing willingness to use such services with female students expressing greater willingness to use the services. Incentives with a monetary element such as cash payments and vouchers exert the greatest influence over students' willingness to utilise mobile phone takeback services, followed by convenience and ease of use of the services.

A number of external factors may have hampered the success of the trial mobile phone takeback reported in this paper although a positive outcome of the pilot event was the participation by the University staff and an external organisation. Carrying out a repeat exercise with the problematic issues resolved may provide more insights into the viability of using universities as hubs for the collection of EoL mobile phones. However, universities could play the role of facilitator and partner with established takeback operators who would run such services.

To be successful, takeback services for WEEE similar to mobile phones should offer potential donors incentives to encourage their participation and wherever possible utilise existing takeback networks. However, such WEEE would need to have a residual worth, principally a reuse value.

There is need for further study to explore the potential value of metals embedded in stockpiled mobile phones.

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