

Washroom behaviour and users' perceptions of "novel" water-efficient appliances

S. Hills and R. Birks

Thames Water Research and Technology, Spencer House, Manor Farm Road, Reading, UK, RG2 0JN

Abstract A variety of washroom appliances are available which claim to be water efficient. However there are a number of "human" factors, which may adversely affect the water savings actually achieved when the appliances are installed. These were investigated as part of Thames Water's "Watercycle" project at the Millennium Dome, where a range of water efficient devices, such as infra-red controlled taps, waterless urinals and dual-flush toilets, were installed in the washrooms and compared to standard appliances. As well as monitoring actual metered water usage, to help understand how users interacted with the range of appliances, the work also involved a survey conducted by interview and an observational study of water using behaviour in the washrooms. The results highlighted significant differences between males and females, for example females were more likely to wash their hands following toilet use. With respect to "novel" dual flush toilets and waterless urinals, both fairly unusual in the UK, they were well received by users. In contrast, the infra-red controlled taps were found difficult to use and least likely to be accepted for use in the home. Relevant signage and labelling was found to have a positive effect on conservation and user opinions.

Keywords Perception; water conservation; water efficiency

Introduction

Various washroom appliances are available which claim to be water efficient, ranging from infra-red taps to waterless urinals. However, the potential water savings may be influenced by the ease of operation of the appliance, and hence the users' perception and willingness to accept it. The behaviour of individuals and groups in a public washroom environment may also be significant. These issues were investigated as part of Thames Water's "Watercycle" project at the Millennium Dome in London.

Method

Set-up of washrooms

The Millennium Dome contained one of the largest in-building recycling schemes in Europe, designed to supply up to 500 m³/d of reclaimed water to flush 837 WCs and urinals, catering for over 6 million visitors in the year 2000 (Hills *et al.*, 2001). For experimental purposes the washrooms in each of the six "core" buildings within the Dome (identified by odd numbers 1 to 11) were equipped with a variety of water-efficient devices for comparison, ranging from infra-red taps, waterless urinals and dual-flush WCs (in the "super-efficient" core), to more conventional appliances, (in the "control" cores) which were all comprehensively metered. In two of the core buildings (the "behaviour" cores) a different amount of signage was installed to investigate the effect of information on user behaviour – one core contained extra educational messages about water saving whereas the other did not. The apparatus in these two cores gave users the chance to conserve water by their actions (i.e. using the low flush button on the dual-flush WC, turning off the taps after washing hands). Table 1 provides details of the appliances installed in the various core buildings.

Table 1 Summary of the appliances evaluated in each core building (numbers of each appliance shown in brackets)

Core Use	1 "Super efficient"	3 and 5 "Behaviour"	7, 9 and 11 Controls
WCs	<i>Dual flush (6/3 litres) [59]</i>	<i>Dual flush (6/3 litres) [118]</i>	<i>Single flush (6 litres) [160]</i>
337	Different flush volumes actuated by pressing buttons	As with super efficient core but the 2 cores had different levels of user information (labelling)	Traditional siphonic flush toilet with low volume flush
Urinals	<i>Waterless [29]</i>	<i>Flushing – PIR control [58]</i>	<i>Flushing – PIR control [78]</i>
165	No water was used, a modified trap prevents odour escaping	A passive infra-red sensor (PIR) activated flush when use was detected or for pre-programmed hygiene flushes	A passive infra-red sensor (PIR) activated flush when use was detected or for pre-programmed hygiene flushes
Taps	<i>Passive-infrared tap [48]</i>	<i>Swivel top tap [96]</i>	<i>Push top tap [134]</i>
278	Sensor detects hands under the tap and flows for a set period	User controlled tap manually, the 2 cores had different levels of user information (labelling)	Tap was actuated and flowed for a set period

Surveys

Two types of survey were undertaken to help establish the "human" factors involved with water conservation measures, an observational study of visitors' behaviour in the washrooms (the observation study) and a market research interview of visitors (the visitor survey).

Observational study. The habits of washroom users were assessed by carrying out an observation study, the objective of which was to characterise washroom behaviour and help to more accurately calculate appliance water use. This study was carefully planned because of the sensitivity of observing users in a washroom environment. Thames Water employees were simultaneously positioned in the male and female washrooms of a each particular core to observe specific washroom practices. Specially designed forms were used to record user behaviour and assess:

- the age of the visitor (estimate)
- whether they used the WC or urinal
- whether they used the taps/washbasins
- if they had difficulty using the tap
- whether they used soap
- any other relevant comments.

Observation of users in a washroom environment required a sensitive approach so care was taken that the study was carried out in an ethical manner. Washroom users were notified on entry of the study taking place so those uncomfortable with the situation could use alternative facilities. Staff carrying out the surveys were clearly identifiable and were positioned as discretely as possible.

Visitor survey. Face to face interviewing was conducted at the Dome from late November until late December 2000. Interviewers were located outside the washrooms (in the core buildings) to interview people on their exit from the washroom, after using the facilities. There was also a control group – a sample of visitors who had not used any of the washrooms.

Table 2 Interview questions related to acceptability of washroom appliances

A	I found the flushing mechanism hard to use
B	I found the signs which explained how to flush the toilets useful
C	In my home I would be happy having this type of flush
D	I found the taps easy to use
E	In my home I would be happy having this type of tap
F	I think the appliances in these toilets are a good way of saving water

In total, 1,055 interviews were carried out, spread relatively evenly across the washrooms of the core buildings and the control group. Interviews were conducted seven days a week. Men and women were interviewed, spread across all age groups, including those under 16 years of age when possible. No demographic quotas were applied to the interviewees, as the demographic profiles of visitors were not known and could have varied from core to core because of the different attractions nearby. However, the interviews were quotaed to provide an even split between males and females, and a spread by age and class was attempted at each interviewing point.

The questions (24 in all) covered a range of issues connected to the Watercycle project including attitudes to the use of reclaimed water as well as demographic data on the respondent. The specific questions concerned with the water efficient appliances are shown in Table 2. Respondents were asked to score their answers on a 5 point scale, ranging from “strongly agree” to “strongly disagree” to a range of statements about the appliances.

The questionnaire was piloted for a day to ensure that it was fully understood by the interviewers and respondents, that the flow of the questions was correct and that it could be accomplished within an eight minute duration, to cause minimum disruption to visitors.

Results

Washroom behaviour from observational study

One aim of the observational survey was to calculate a “correction factor” to apply to the metered water use data, to account for the fact that not all visitors registered entering the washrooms (by breaking the beam on an infra red counter) necessarily used all of the appliances. The data was obtained by observations and entered onto forms. Statistical analysis (Pearson’s chi-squared test) confirmed that no significant difference in behaviour was found in any of the cores in terms of the frequency of washroom appliance usage for the sample surveyed, in other words visitors were behaving similarly in all washrooms and valid inter-core comparisons could be made.

Analysis of the data (shown in Figure 1) revealed that on average, 76% of males used the urinals when they visited the washrooms and only 23% used the WCs. An average of 2% of males used the washrooms for “preening”, i.e. not using the washroom facilities themselves

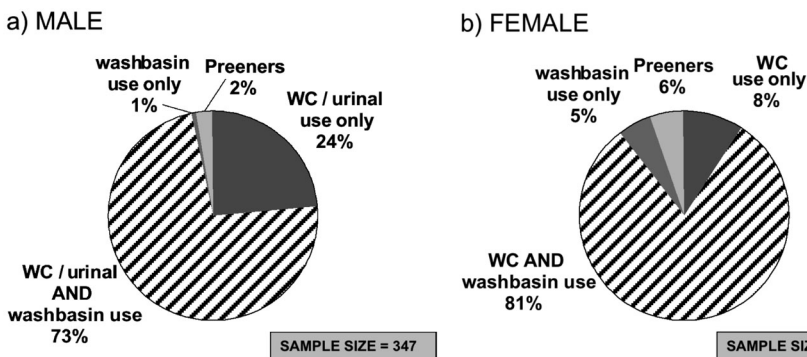


Figure 1 Washroom activity in the Dome – an average of all the cores; a) male; b) female

(i.e. accompanying others) or just using the mirror etc. This is in comparison to the women where 6% were “preeners” and, on average, 89% used the WCs.

The data also shows washbasin use by the sexes in the cores, and as with toilet use, the statistical analysis showed that the data is comparable between the cores. Overall 86% of females use the washbasins compared to only 74% of males. There was also a significant differences between male and female hygiene behaviour as 81% of females washed their hands following toilet use, compared with only 73% of men.

The observation survey also provided addition information to supplement the analysis of the visitor survey and water usage data. For example visitors using the infra-red taps were observed experiencing difficulties with their operation and children were observed playing with them. Multiple operation of the push-top and infra-red taps was also noted, which corresponded with metering data that suggested that water wastage was occurring as these taps were not set up to deliver the optimum quality per use.

On average, more males used soap than females when washing their hands and in all cases soap users were more likely to activate the push-top or infra-red taps more than once (using more water) compared to non-soap users. This was expected, as more water would be required to wash the soap off. Therefore, as would be predicted, the use of soap increases the volume of water required for hand washing and products such as foam soaps etc, which reduce the volume of water required may be beneficial. Additionally, from the Dome visitor numbers and the infra-red counters it was estimated that the average visitor went to the washrooms at least two times during the day.

Attitudes to “novel” WCs from the visitor survey

The users’ opinions of the WCs and urinals were gauged from the visitor survey. The questions examined a range of issues from whether the recipients found the flush mechanisms easy to use, found the instructional signage useful and would be comfortable to have such equipment in their own homes. The base results for WCs are shown in Figures 2 and 3.

It can be seen from Figure 2, which shows the results of responses to the statement “I found the flushing mechanism easy to use” that the washrooms in the control cores (Cores 9 and 11) with the standard siphonic flush WCs installed, surprisingly, caused more problems with users than the dual-flush WCs installed in the other core buildings (the washrooms in Cores 1, 3 and 5). Overall 83% of respondents strongly agreed that the dual flush toilets were easy to use compared to only 58% of the siphonic WC users (91% and 65% for

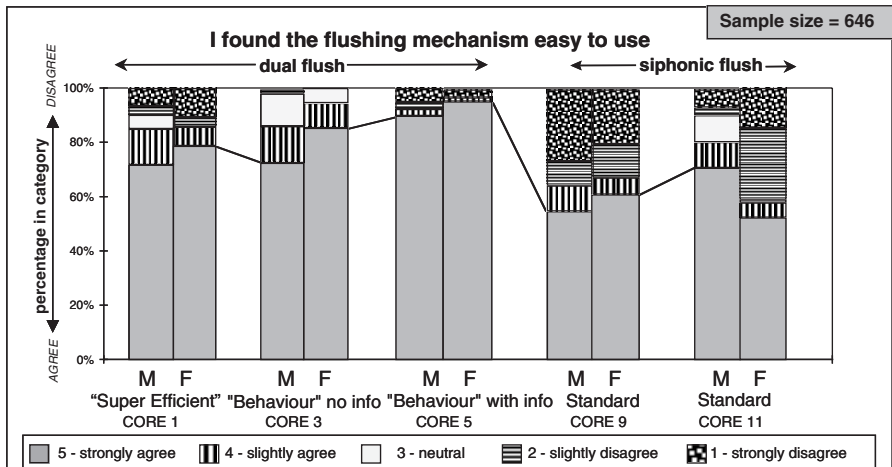


Figure 2 Levels of agreement for the statement “I found the flushing mechanism easy to use” (results of the question asked reversed for easier comparison)

dual flush and siphonic flush respectively if both those that strongly and slightly agreed with the statement are considered). In general, respondents found the dual flush toilets significantly more easy to use than the siphonic systems (at the 99% confidence level). Moreover, many of the respondents from Cores 9 and 11 (installed with siphonic toilets) strongly disagreed with the statement that the flushing mechanism was easy to use (on average, 17% compared to an average of 4% in the dual flush toilet cores).

This was an unexpected result as UK users are more familiar with siphonic flush technology. One reason postulated for this was that the flush button in the siphonic WCs was very small and required substantial force to depress it to activate flushing (compared with the more common lever). Core 5 (the behaviour core) with additional information, was also seeing a more positive response.

The ease of use of they appliance also affected the visitors willingness to have the appliance installed at home, as can be seen from Figure 3 which shows responses to the question “at home I would be happy to have this type of flush”. Users of the conventional siphonic WCs (in the washrooms of Cores 9 and 11) were significantly less happy to have this type of WC installed at home. Respondents from the washrooms in Core 5 were happier to have dual-flush at home than respondents from Core 3 (with standard signage). This was true for both males and females and shows that the extra information was influencing users to be more positive about the dual flush WCs.

The same finding concerning the positive effect of additional signage in Core 5 was observed in the answer to the statement “signs explaining how to flush the toilets were helpful”. The extra signage included posters behind the toilet doors explaining how the dual flush operated. Respondents found the additional signage in Core 5 significantly more helpful compared to any of the other cores (at the 99% confidence level) see Figure 4. The comparison with cores 1 and 3 (where dual-flush was also fitted) is most relevant here.

Other analysis was undertaken to examine if any other factors were affecting user attitudes to the appliances. All the washrooms contained information about water conservation. For WCs in all cases if users had seen this education material or visited the Watercycle exhibit (the recycling plant) they were more positive about the appliances. As an example, acceptability for use at home – those who claimed to have seen the material in the washrooms gave a higher score (63% vs 44% strongly agreed), as did those who had visited the Watercycle exhibit (recycling plant) (69% vs 57% strongly agreed). Interestingly ease of use was also affected by the signage, as those who claimed to have noticed the material (i.e. signage) in the washrooms appeared to have fewer problems than those who had not noticed it when asked if they found the flushing mechanism easy to use (79% disagreed

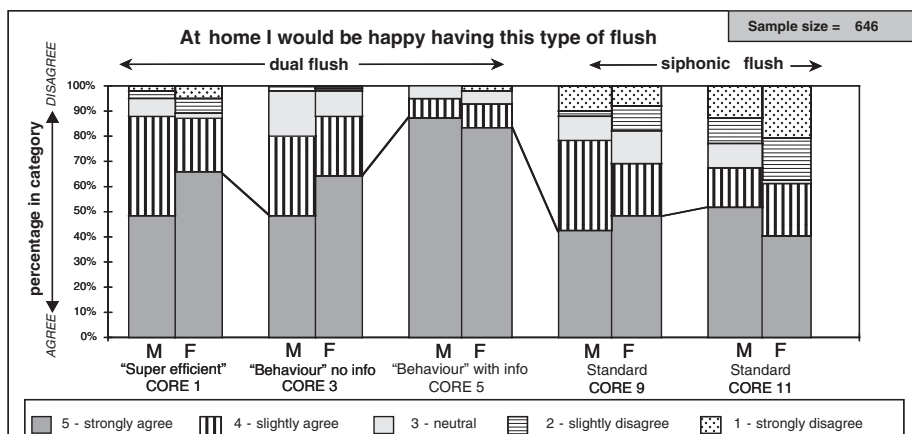


Figure 3 Mean scores for responses to “at home I would be happy to have this type of flush”

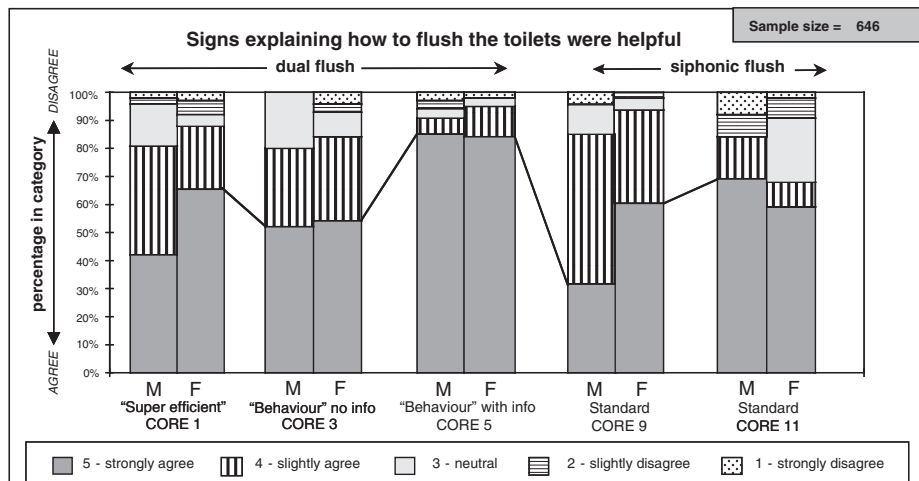


Figure 4 Levels of agreement for the statement "Signs explaining how to flush the toilets were helpful"

strongly with the statement who had seen the signs compared to only 60% who had not) and those who claimed they had read the signs about reclaimed water also had fewer problems than those who had not read them (75% v 64%). Perhaps this indicated that they were more aware of their surroundings.

Attitudes to waterless urinals from the visitor survey

Although there were no specific questions to visitors on their acceptability of the waterless urinals there were no adverse remarks received about them when given the opportunity to comment. At least 10% of male respondents from Core 1 specifically mentioned that they had noticed the waterless urinals. Operational and cleaning staff at the Dome preferred the waterless urinals to the flushing types as they found them easier to maintain and keep clean.

Attitudes to "novel" taps from the visitor survey

When responses were split into the users of each type of tap type (Figure 5) for the statement "I found the taps easy to use" it was revealed that only 44% of respondents strongly agreed that the infra-red taps were easy to use compared to 71% of the swivel top tap users

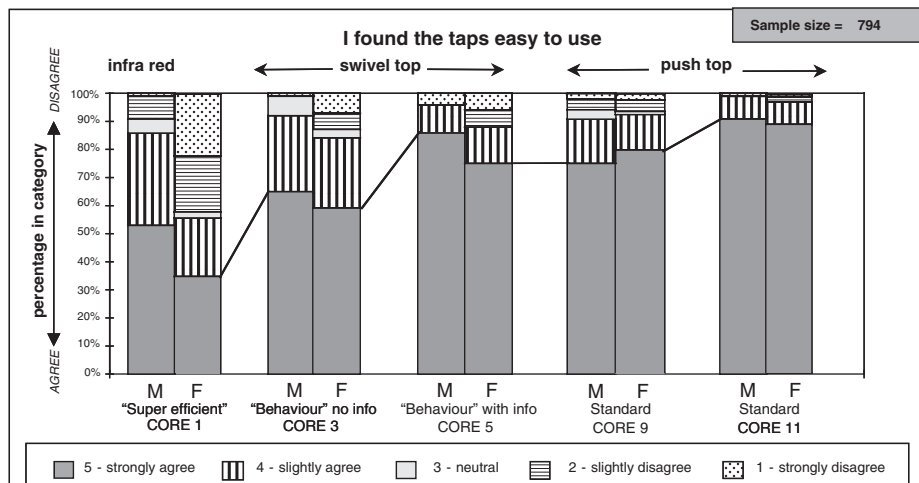


Figure 5 Levels of agreement for the statement "I found the taps easy to use"

and 83% of the push-top tap users (71%, 90% and 95% for infra red, swivel top and push top respectively if those that strongly and slightly agreed with the statement are considered). Therefore, visitors from the cores installed with the push-top taps were the most positive in their response to the *ease of use* of the taps and the infra-red taps were the least popular tap type with 12% strongly disagreeing (22%, if females alone are considered).

There was no significant difference in the responses by males and females from the cores installed with the push-top taps. However, in all of the other cores (installed with the infra-red and swivel-top taps) males found the taps easier to use than females (at the $\geq 95\%$ confidence level). Users of the swivel-top taps found greater ease of use in Core 5 compared to Core 3 (at the 95% confidence level), again indicating an effect of the enhanced labelling.

When responses to this statement were split into those who had previously visited another washroom and those that had not, it was revealed that, in Cores 1 and 3 (where fewer respondents found the taps easy to use compared to the other cores), if users had not been to another washroom they were more likely to find the taps easier to use, i.e. if they had not experienced a tap that was perhaps easier to use, they would not have been influenced in their answer. The over-60 age group were having the greatest problem with any of the taps.

Figure 6 shows the levels of agreement by respondents for the statement “I would be happy having this type of tap at home” split up core by core and by sex.

As with the WCs, the ease of use of the appliance affected users’ willingness to have it at home. When responses were split into the users of each type of tap, it was revealed that only 27% of respondents strongly agreed that they would be happy having infra-red taps installed at home compared to 64% of the swivel-top tap users and 65% of the push-top tap users (44%, 83% and 82% for infra-red, swivel-top and push-top respectively if those that strongly and slightly agreed with the statement are considered). Therefore, respondents would be least happy having the infra-red taps installed in the home (with 20% of respondents strongly disagreeing with the statement). Visitors from Core 5 installed with the swivel-top taps were the most positive in their response to having the taps at home (on average 77% of respondents strongly agreed with the statement). This would be expected as this was the type of tap they would be most likely to have at home anyway, and so was surprising that similar taps in Core 3 were not well received, but was explained by the fact that the additional labelling in Core 5 was aiding understanding of the tap mechanism. The push-top taps were also favoured for installation at home and on average 66% of respondents strongly agreed with this statement.

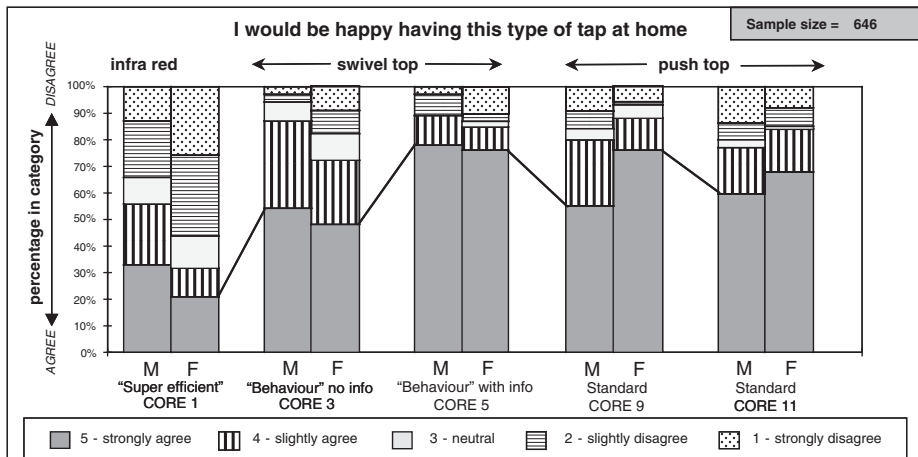


Figure 6 Levels of agreement for the statement “I would be happy having this type of tap at home”

Males responded significantly more positively to the “high-tech” infrared taps (at the $\geq 95\%$ confidence level), however females responded more positively than males to the push-top taps in Core 9 (at the 95% confidence level). In the other two cores no significant difference in the responses by males and females was observed.

When responses to this statement were split into those who had previously visited another washroom and those that had not, it was revealed that, in Cores 3 (where respondents found the taps more difficult to use compared to the other cores), if users had *not* been to another washroom they were more likely to be *happy to have the taps at home*, indicating that exposure to a variety of tap types in other cores was causing confusion.

Figure 7 shows the levels of agreement by respondents for the statement “The appliances in this washroom are a good way of saving water” split up core by core and by sex.

Overall, visitors were very positive in their response to this statement, on average (over all of the cores) 76% of respondents strongly agreed that the appliances in the washroom they just visited were a good way of saving water (94% of respondents, when both strong or slight agreement are considered). Respondents from Core 5 and 11 were the most positive to this statement (at the $\geq 95\%$ confidence level). The positive response from Core 5 can be attributed to the enhanced labelling in this core. Responses from both Core 9 and 11 were very positive (overall in the push-top taps cores, 81% of respondents strongly agreed with the statement), which was assumed to be a favourable opinion of the push-top taps which are a standard water-saving device. Interestingly, the high-tech water-efficient devices installed in the “super efficient” core were the least favoured out of all of the cores, however 65% of respondents still strongly agreed with this statement. Overall it would appear that infra-red taps were having a bigger negative impact on users than the positive impact of the dual-flush WCs. Significantly more positive responses came from Core 5 when compared to Core 3 (at the 95% confidence level), indicating the enhanced labelling affecting user attitudes.

ANOVA (analysis of variance) multivariate technique confirmed the significance of some of the factors affecting attitudes. For example, overall positive responses were dependent on whether visitors had seen the reclaimed water signs and educational material. Also it confirmed that sex had a significant effect on responses to ease of use of taps, women found them significantly harder to use than men. Those who had used another washroom at the Dome found it slightly harder to use the taps, presumably because they had experienced a different tap in a washroom they had previously visited.

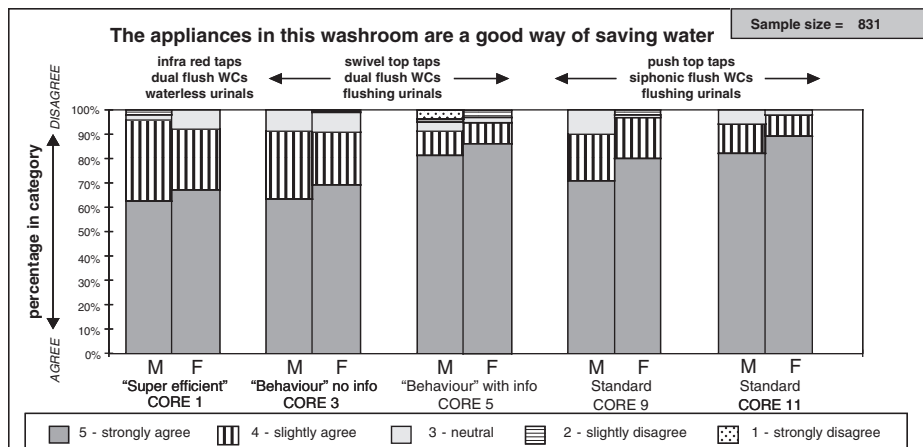


Figure 7 Levels of agreement for the statement “Appliances in the washrooms are a good way of saving water”

Discussion

Observational study

The Observational Study was a unique way to gain information about water-using habits in public washrooms that could not be inferred from metering data alone. It confirmed that there were significant differences between male and female behaviour. It also provided information to help explain the differences in metered water use from the various appliances (Figure 8), for example, excessive water use by infra-red taps in part explained by observed multiple operation.

WCs. In the UK dual-flush WCs are rare but the type installed at the Dome, with large easy to use and clearly labelled flush buttons were well received (Figure 8). Interestingly they were more readily acceptable than the standard siphonic flush, which was probably because the latter were activated by a small button that was difficult to operate, rather than the more familiar lever. Ironically the metering data showed that the dual flush were prone to malfunction and wasted water, as has been found by other studies (Pennell, 1997; Griggs *et al.*, 1997). This information would have undoubtedly had an effect on user perception if they had been aware.

Urinals. From the data collected during the year of operation it would appear that male users had no problems or adverse attitudes to the waterless urinals. Significant water was saved, as has been found in other studies (BSRIA, 1999). This is an encouraging finding as odour and blockage have been cited as problems in previous studies. A longer trial may have identified more problems but this was not possible as the Dome was only open for one year.

Taps. As with the WCs, ease of use strongly affected opinions of the taps. The infra-red taps were the most disliked. Users could not easily work out how to operate them. They had not been well set-up, the time of flow was often either too short and resulted in multiple operation or too long resulting in water wastage. The study showed that it would have been advantageous to provide signage to explain how to use the taps. From the water metering data it was proved that these type of taps were the most wasteful.

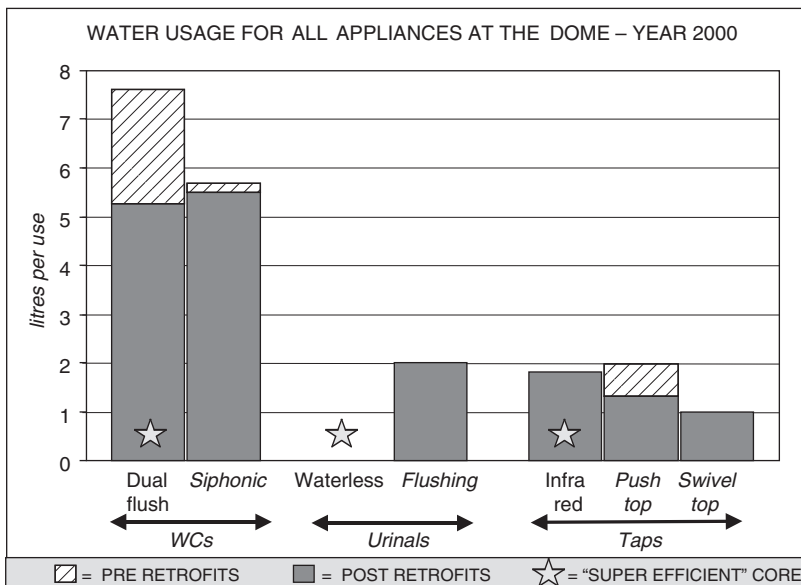


Figure 8 Summary of mean annual water usage per use of each appliance



Figure 9 The Geberit dual-flush WC

Surprisingly the conventional swivel-top taps were the most water efficient of those trialed, showing that users were able to choose the exact amount of water required for their personal hand-washing preference. These would have been the type of tap mechanism that most users would be familiar with in their own homes. Interestingly these swivel-top taps were of a very modern design (as were the buttons for the siphonic toilets) which caused a problem for some of the users as they appeared to confuse them with other tap mechanisms. This was particularly apparent from answers to the questionnaires where respondents who had visited other toilet blocks previously and been exposed to other types of tap mechanism. Encouragingly, from water usage figures and observation there was no evidence that users left taps running – which has been one of the main concerns leading to the use of more novel and water-saving taps.

The push-top taps were generally liked by users. However as was seen from the observation study and the metering data, it was important that they were set up with the appropriate flow durations to prevent multiple application and water wastage.

Signage and labelling. One of the key and consistent findings was the considerable impact of information and signage on user opinions. Analysis showed that if visitors had actively engaged (read/noticed) the general signage about the recycling project and water conservation measures they were significantly more likely to give positive responses towards the appliances. Additionally the extra signage in Core 5, signs behind toilet doors and at taps (Figure 10) had a significantly positive impact on users when compared to core 3 (with identical appliances but less signage). This showed that even a minimum amount of additional information was useful.

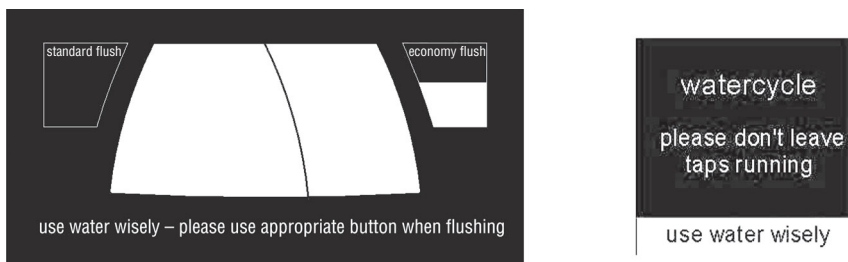


Figure 10 Additional labelling in toilets and next to taps in Core 5

Overall attitudes. With respect to all washroom appliances, the key aspect would appear to be “ease of use” when novel appliances are being considered. Overall when users were asked their opinions of all of the technology in the washrooms (WCs, urinals and taps) it would seem that their experiences with the taps, where they actively interact with water, was likely to be the strongest influence on their views. This was particularly obvious for the “super efficient” core which had the most negative response, most strongly influenced by users’ bad experiences with the infra-red taps.

Conclusions

The research identified a range of “human” factors that can affect the water-saving potential of washroom appliances. In general “ease of use” of appliances is a very important factor in the correct operation and acceptance of appliances and hence the likelihood that they will be more widely adopted and actually save water. The highlighted the need for efficient, robust, ergonomic and practical design of appliances. Some differences between male and female washroom behaviour, hygiene practices and attitudes towards novel appliances were observed which may also merit consideration for future washroom design. The “water efficient” dual-flush WCs and waterless urinals were very well received by visitors to the Dome washrooms as they were easy to use and perceived as water-saving (the fact that the WCs often malfunctioned was not appreciated by the users). In contrast, users of the purported “water efficient” infra-red taps were observed experiencing problems with operation and their opinions were very negative. They could see that water was wasted when the taps did not stop when their hands were removed from the infra-red beam. Of the self-closing taps, the cheaper, push-top taps were preferred by users. The conventional, manually operated swivel-top taps were, surprisingly, the most water efficient and washroom users were observed to behave responsibly and not leave them running.

The study also highlighted the importance of information and labelling in washrooms to aid water conservation. This has the dual benefit of both providing instruction on the correct usage of unfamiliar appliances and raising awareness and acceptance of water conservation issues.

Therefore, in addition to the importance of correct installation and set up of washroom appliances, plus a comprehensive metering system to actually monitor water usage (Hills *et al.*, 2002), good product design plus user information are important ways to optimise water savings and prevent water wastage in washrooms.

Acknowledgements

The New Millennium Experience Company, Greenwich, UK

Sample Surveys Ltd, Mount Offham, Kent, UK

Reading University Statistical Services, Reading, UK

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