D 5.4 FINAL VISUALIZATION AND FEEDBACK INTERFACES

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EXECUTIVE SUMMARY

This document contains the enCOMPASS deliverable D5.4 “Final visualization and feedback interfaces”, which according to the DoA comprises: “Final design of the mappings from consumption data to persuasive visual metaphors, with adaptation to client device, user profile and role, activity context, and building usage and type.”

Following the description from the DoA, this document presents the final visualizations for energy saving and their implementation in the encOMPASS awareness application. In addition, although not required by the deliverable description, a preliminary analysis of users’ interaction with the visualizations in the awareness application is presented. The document first presents the final versions of the metaphorical visualizations for energy saving and impact which have been adapted based on user feedback to those initially proposed in *D5.3 First visualization and feedback interfaces and behavioural game concept*. Second, the document discusses the implementation of the adapted visualizations in the enCOMPASS awareness application according to user profile and role, activity context and building usage and type. This is followed by presenting how the visualizations were technically implemented in the enCOMPASS awareness application for the different types of devices used in the pilots: Android and iOS. Although not initially promised in the DoA, in this deliverable we give a preliminary report of how users interacted with the awareness application in general and the developed visualizations in particular, in the three pilots adapted for the context of households, schools and public buildings to show the effectiveness of the developed visualizations.

The relationship of this deliverable to other ones can be summarized as follows:

D2.2 Final requirements (Report, M12) provides the requirements for the development of the Awareness application. In the deliverable is determined how the application is going to be adapted for use in the schools and the public buildings.

D5.3 First visualization and feedback interfaces and behavioural game concept (Report, M15) has provided the first versions of the visualizations and feedback interfaces as well as the results of their formative evaluation with a set of users through crowd-tests.

It is important to notice than even though D5.3 discussed both the design of the visual metaphors and the board game, in this document there is no discussion of the board game because there is a dedicated document accompanying a demonstrator deliverable that discusses it (*D5.5 Final behavioural game concept*).

D7.3 First validation report and data set (Report, M24) has a preliminary interim evaluation of impact, however it only shows the awareness application usage data in the first four months since the start of the pilot.

Overall the deliverable shows that the visualizations have been successfully developed and implemented in the enCOMPASS awareness application. The awareness application and the visualizations have been adapted to the school and public building context. They have been technically implemented on two systems: iOS and Android and in four languages. The application usage data shows that overall the users are logging in regularly into the awareness application and they are actively interacting with the main pages of the app, as depicted in Table 1. The table reveals that 60-78% of users across all pilot locations are regularly (at least once every month) logging in to the enCOMPASS awareness application, which is a good result considering that the application needs to be integrated with their daily life.

At the same time, the pages the users of the awareness application interact most frequently are: **Tips** page where they can read energy saving tips, **Savings and Goal** visualization page where they can set and monitor their energy savings goal with the specifically developed energy savings visualization and **Comfort** page where they can view their comfort in relation to the achieved savings. The Table 1 below reveals that household users are using these pages in a range of 9-20 times a month depending on the pilot, the school users are quite variable with a range of 2-50 times a month, and public building users in a range of 4-24 times a month. Overall, the activity is comparable across household pilots in the various locations, the school pilot in Germany seems to be most active, as well as the public building pilot in Switzerland. Overall these results show that the users are indeed using the developed visualizations to monitor their consumption and save energy, i.e. that they are considered useful (a detailed analysis and evaluation including the comparison of the achieved energy savings is subject of D7.4 *Final overall validation and impact report*).

Table 1 Selected summary statistics of usage of the main pages of the enCOMPASS awareness application

	Germany			**Switzerland**			**Greece**		
	Households	School	Public	Households	School	Public	Households	School	Public
Regular Users (%)^	71%	78%	78%	72.4%	56.7%	71.1%	61.1%	62%	60%
Avg. tips page per month*	13	34.7	5.5	10	1.3	6.4	19.7	3.3	6.8
Avg. access Savings & Goal visualization page per month *	12.4	24.8	4.4	14	1.7	19.5	13.7	1.9	5
Avg. access Comfort page*	8.9	51.1	5.3	10.7	0.6	23.8	14.6	2.4	5.8

^shows the average % of users who logged in to the application at least once each month since the start of the pilot
*shows the average number of times the users accessed the page per month over the course of the pilot

1 INTRODUCTION

Metaphorical visualizations of energy saving and energy impact serve as a basis for motivating users to save energy with the help of the awareness application. The visualizations have been developed in a user-centered design process and first included the mock-ups presented in *D2.2 Final requirements*, which were further developed into preliminary designs which were reported and tested with users in *D5.3 First visualization and feedback interfaces and behavioural game concept*.

This deliverable takes the user feedback collected during the crowd tests and presented in *D5.3 First visualization and feedback interfaces and behavioural game concept* as well as end-user interaction with the visualizations of the awareness application to propose final versions of the metaphorical visualizations for energy saving and energy impact. We also show how the visualizations are integrated into the awareness app, as well as how they are adapted based on user profile and building type. The technical details of implementation of the visualizations depending on user device are described. The usage analysis shows how users are using the awareness application and interacting with the visualizations.

2 FINAL VISUALIZATIONS

Here we review the visualizations proposed in *D5.3 First visualization and feedback interfaces and behavioural game concept*, and report changes in case some were made based on the user feedback obtained during the evaluation phase reported in *D5.3 First visualization and feedback interfaces and behavioural game concept*. We specifically focus on the energy saving and impact visualizations as these comprised one of the main parts of the awareness application allowing users to save energy and were developed in an iterative user-centered design process.

2.1 ENERGY SAVINGS

One of the main aims of the enCOMPASS application is to allow the users to set a saving goal and be able to monitor their achievement of this goal. This functionality is supported by the energy saving visualization located on the screen “Saving goal”. In this visualization, the users of enCOMPASS can monitor their monthly energy consumption in comparison with the consumption of the same month of the previous year using the metaphor of a battery, as displayed in Figure 1. On this screen users can also set their energy saving goal and see the disaggregated energy consumption by device. The default energy goal is set to 20%, the user has until 8th day of the month to change to a custom energy saving goal in a range from 10% to 30% in 5% increments.

The metaphor of the battery is used to make understanding easier. The battery is full at the start of the month, as the user has not yet consumed any energy. As the user consumes energy, the battery depletes. By setting a goal in a month to use X% less electricity, the visualization provides an indicator to the user up to which point in the battery the user can consume energy. Once the user consumers more electricity than the goal (s)he has set, the colour of the battery changes from green to orange to warn not to consume more than in the same month of the previous year. When the user consumes more energy as in the previous year, then the battery turns red. While the month is active, the user receives a motivational message encouraging him/her to meet the goal. At the end of the month, the user can see the savings and the feedback on how (s)he has performed: the smiley next to the savings (if any) and a feedback message either congratulating or encouraging to perform better next month.

Overall, the visualization is slightly different while the month is still ongoing showing the amount of electricity left to reach the saving goal (see Figure 1 (a)), or the amount by which the goal was missed (see

Figure 1 (b, c)); and providing the feedback to the user once the month is over how much savings were achieved (see Figure 1 (d, e)), or 0 if there were no savings (see Figure 1 (f)).

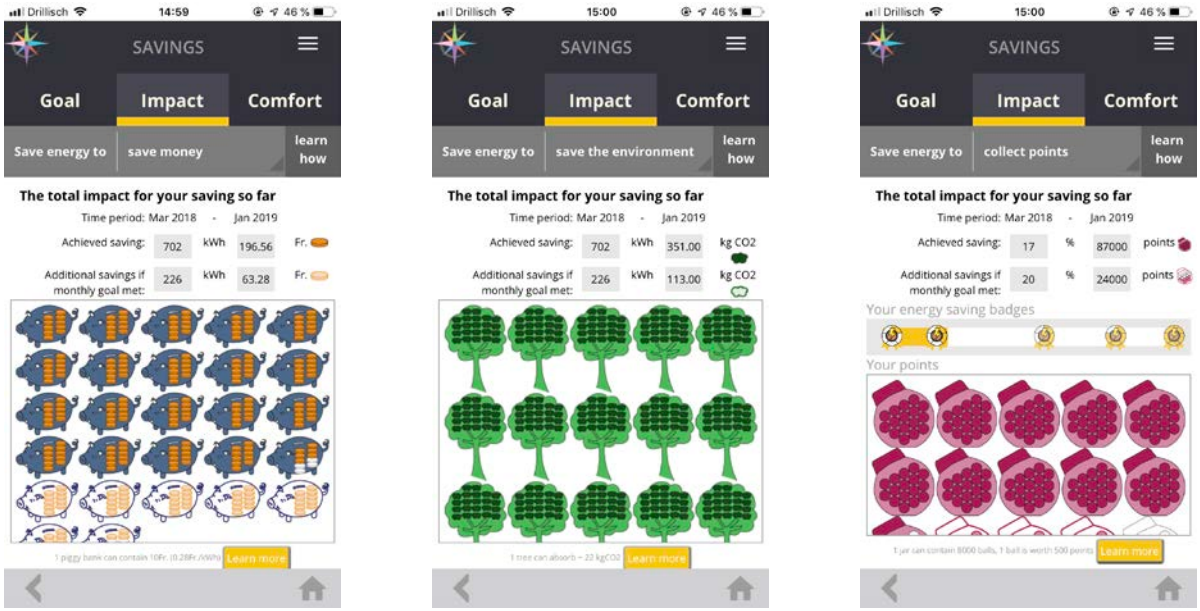
Figure 1. Energy savings goal visualization. On the top the visualization which is provided to the user during the course of the month when (a) the user is still able to reach the goal (b) the user won't reach the goal but is still using less energy than in the previous year (c) the user has consumed more energy compared to the previous year. On the bottom the visualization is provided once the month has finished: (d) the user has met the energy saving goal; (e) the user has saved energy, but did not reach the goal; and (f) the user has used more energy than in the same month of the previous year.

In response to the user's comments to increase understandability of the overview visualization provided in *D5.3 First visualization and feedback interfaces and behavioural game concept*, we made several changes. First, we updated the names of the labels in the visualization to make them more intuitive to the users, for

example, “Aug 2016” was changed to “Consumption in Aug 2016” or “Monthly use” to “Already used”. We also changed the colour of the battery from yellow to grey as this was disturbing to some users. We also added the scale points on the battery so that the user has the orientation as to how much energy has been used. Some users explicitly mentioned that they would like to reason not only in terms of the amount of energy used in the same month last year, but rather how much energy is left to the saving goal. Therefore, we added a button stating how much energy they still have available until their goal which appears when the month is still ongoing. After the extensive tests with the users regarding the direction of the battery, reported in *D5.3 First visualization and feedback interfaces and behavioural game concept*, we did not find any significant preference for one or the other visualization and therefore chose the one which was slightly more preferred by the participants.

2.2 ENERGY IMPACT

To help users relate energy savings to more tangible things which are important to them, the impact visualizations present the impact of achieved energy savings using three different metaphors: monetary, environmental and hedonic. The theoretical motivation for this type of visualization has been explicitly described in *D5.3 First visualization and feedback interfaces and behavioural game concept* and overall relates to the goal framing theory. Monetary and environmental impact visualizations show the cumulative savings that the users have achieved translated into EURO and CO_2 values, respectively; whereas the hedonic impact visualization shows the points that the users have achieved for saving energy. In the awareness application the user is shown one of the three impact visualizations, depending on the preference (s)he indicated in the beginning which motivation is more important to him/her. However, the user can also switch between the various impact visualizations easily.



(a) (b) (c)

Figure 2 Impact visualizations: (a) monetary; (b) environmental; (c) hedonic impact of energy savings.

For the monetary impact presented in Figure 2 (a) we use the metaphor of a piggy bank filled with coins. Once the user saves a certain amount of energy in kWh, this is transferred into a monetary value (by approximating an average cost for electricity in a specific country[1]) and displayed as the appropriate number of coins in the piggy bank. Once the users have saved energy as equivalent to 10EUR, the piggy bank is full, and then then the users go on to fill the next one. This metaphor shows to the users at a glance

[1] For each pilot, the average price of energy in the country is used to calculate savings in monetary terms.

how much money they have saved due to their energy saving activities and it is proposed that this more tangible representation will increase their motivation to save energy. As the savings can be realized only in the end of the month, in this visualization the users additionally can see the savings they will get if they reach their monthly saving goal: such piggy banks are not coloured, but are represented with a blue outline. We propose that additionally visualizing this information will increase user's motivation to meet their saving goal in the month.

For environmental impact presented in Figure 2 (b) we use the metaphor of a tree filled with leaves. The intuition behind this metaphor is that the more energy the user saves, the less CO_2 needs to be absorbed by the trees. Once the user saves a certain amount of energy in kWh, this is transferred into the amount of CO_2 that would have been emitted if the energy has not been saved. An average tree can absorb 22kg CO_2, once the user has saved the amount of electricity equivalent to this, the tree is "saved" and the user goes on to save the next tree. This metaphor shows at a glance how many trees the user "saved" as a result of consuming less energy. Similarly, as with the piggy banks, in this visualization the users can additionally see how many trees they would save if they met their monthly saving goal (those with a green outline). Again, we propose that by having this information, the users might be motivated to meet their monthly goal.

For hedonic impact presented Figure 2 (c) we use the metaphor of the points that the user collects by saving energy. The intuition behind this metaphor is to link it to the gamified goals of the enCOMPASS application. Here the logic is slightly different from the monetary and environmental visualization as it is connected to the gamified goals of the application. Once the user has achieved a savings goal, (s)he receives points, if the user did not achieve the goal, but achieved at least 10% savings, (s)he receives half of the points. Each ball is equal to 500 points, and each jar fills up with 16 balls. Once the user has received enough points for reaching savings goals to fill the jar, (s)he goes on to fill up the next one. Here, similarly the jars with an outline additionally indicate how many points the user would receive if (s)he meets the saving goal of the month. The feedback obtained from the users indicated that they do not see the direct connection between the hedonic visualization and the kWh of energy saved, so to make this connection clearer, we connected the logic of obtaining points to the existing gamified goals of the application as well as included the energy saving badges that the users receive in the awareness app to this visualization.

As a result of integrating user feedback collected during the user testing in *D5.3 First visualization and feedback interfaces* to increase the understandability of the impact visualizations, we have made all the elements to be of a similar size. In the first version, the current element being filled up was larger than the rest, which caused confusion among the users: *"I don't understand why one of the piggy banks is larger than the others".* Some minor changes were additionally made such as adjusting the coin presentation in the monetary impact visualization, and including more information about CO_2 calculations in the environmental impact visualization, as well as making the trees and clouds a bit more unified with regards to colour and alignment.

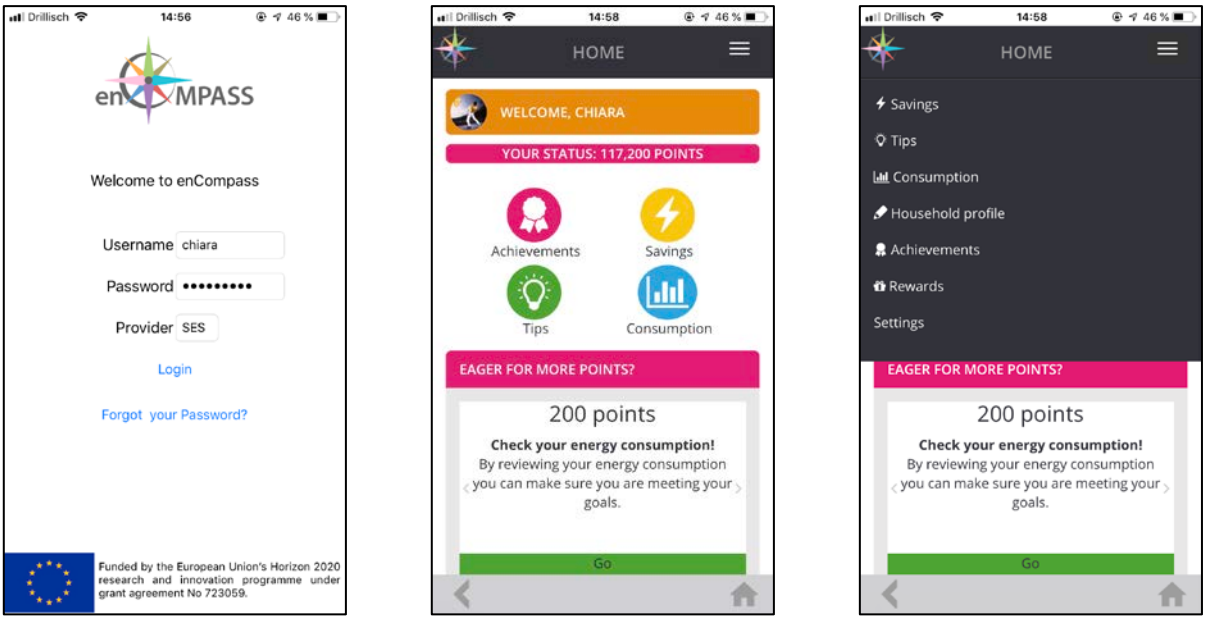
From the feedback we obtained during the user testing reported in *D5.3 First visualization and feedback interfaces and behavioural game concept* we saw that some people preferred the monetary impact visualization due to its short-term orientation (42% of respondents indicated this) and the fact that it is more tangible (30% of respondents mentioned this reason), whereas other people preferred the environmental visualization because they feel that humans need to protect the environment (30% of respondents) and because they felt it was more aesthetically pleasing (27% of respondents). These results confirm that there is no uniform preference among users with regards to motivation for energy saving and as such confirm the necessity to develop several visualizations that show the impact of energy saving to the users as proposed by the goal framing theory.

3 FINAL ADAPTED VERSION OF THE INTEGRATED AWARENESS APP

Here we present the final version of the integrated gamified awareness application and its adaptation to the building type and user role. There are three building types that are addressed in the pilot: residential, schools and public buildings. What concerns user types, in residential buildings there are only household users. In the school, there are classes as users. Lastly, in public buildings there are two types of users: employees and visitor users. First, we present the visualizations and the screens from the awareness app for household users who comprise the majority of users of the Awareness App. In this section, we present the final version of the application which includes the features of release 2. The following section presents the visualizations and the screens for school users, followed by the employees of public buildings and the last section is for public building visitors. Please note that as the visualizations for energy saving and impact have been described in the previous section (Section 2), in this section we don't show them again unless they are different or required to explain the context of the awareness app usage.

3.1 BUILDING & USER TYPE: HOUSEHOLD USERS

When the user downloads the Awareness application from the Google or Apple store, (s)he is confronted with the log-in screen presented in Figure 3 (a) where the user introduces username and password and selects the energy provider. Once the user has logged in, the main screen of the application presented in Figure 3 (b) where the user can select one the four main sections: Achievements, Savings, Tips and Consumption by clicking on the four icons. By clicking on the three horizontal bars in the upper right corner opens the main menu presented in Figure 3 (c) where the user can access the four main sections of the app, plus three additional sections: Profile, Rewards and Settings.



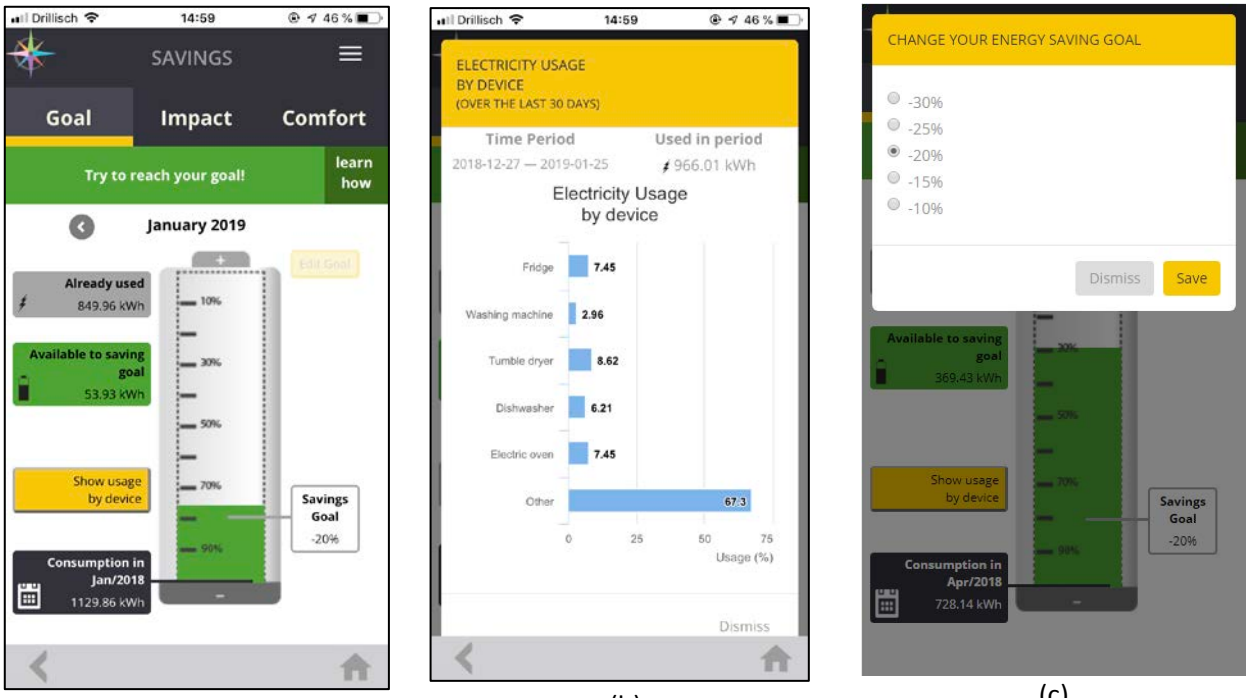
(a) (b) (c)

Figure 3: (a) Login screen of Awareness App. (b) Home page of the awareness App. (c) Main menu of the awareness App.

The "Savings" section has three main visualizations: the goal, the impact and the comfort. The goal visualization presented in Figure 4 (a) was described in Section 2.1. Overall the purpose of this visualization is for the user to set and monitor his/her savings goal achievement. In order to help the user meet the goal, by reducing the energy consumption, an additional visualization is offered: disaggregated consumption by device. To access this visualization, the user has to click on "show usage by device" button. The disaggregated consumption visualization is presented in Figure 4 (b) which shows the percentage of energy

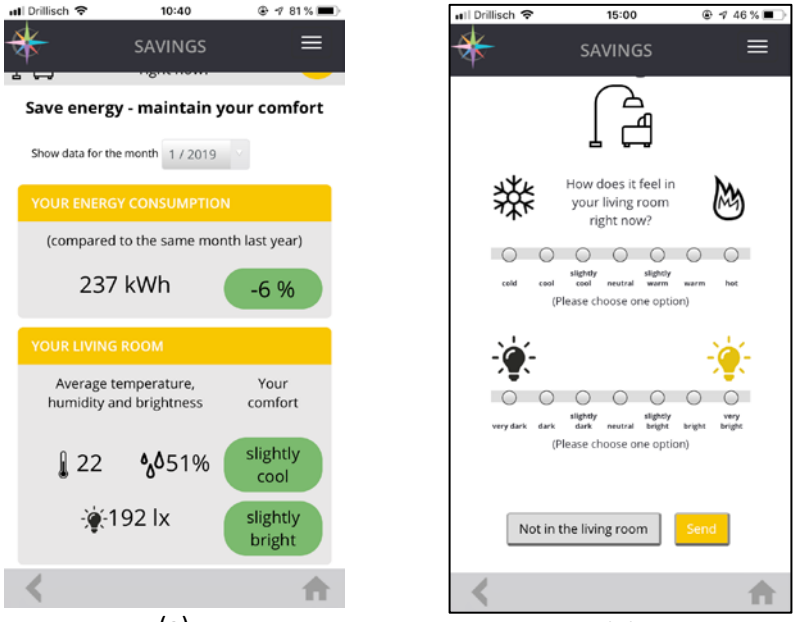
used by the various home devices and allows the user to determine which of the devices (s)he owns consumes the most electricity. Another option on the goal savings visualization is to set an energy saving goal, which is shown in Figure 4 (c): the user can choose a goal of 10 – 30% in 5% increments. If the user does not change the goal (which is possible until the 8th of each month), the default goal is set to 20%.

The impact visualizations have already been described extensively in Section 2.2 so we do not go into details of these here.



(a) (b) (c)

Figure 4: (a) Goal saving screen; (b) viewing the disaggregated energy consumption by device; (c) setting an energy saving goal

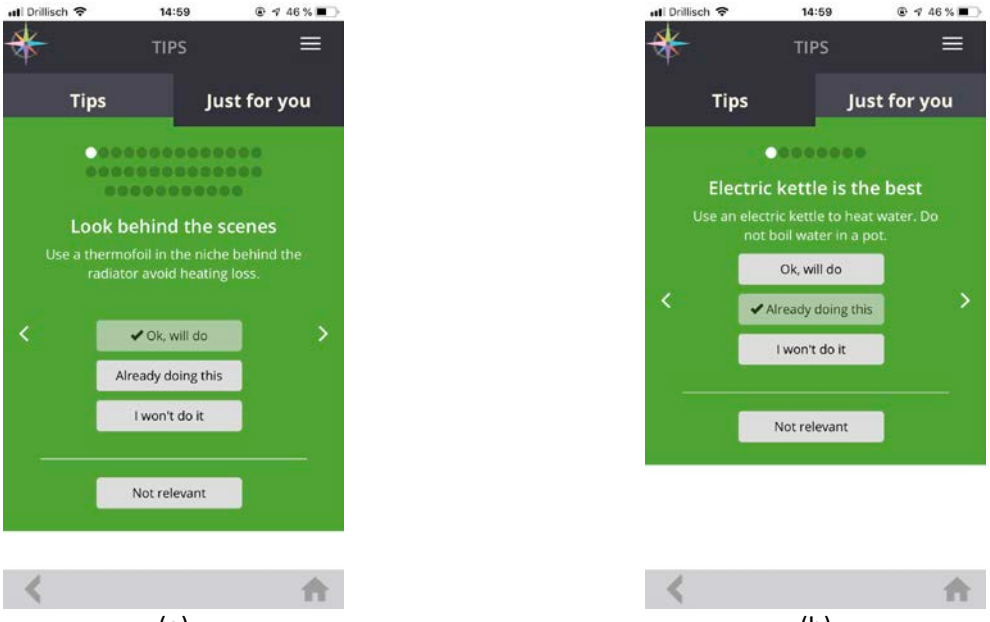


(a) (b)

Figure 5: (a) Comfort view, (b) Comfort input

The comfort visualization is another important feature of the awareness application. The idea of the enCOMPASS application is to allow the users to save energy without compromising their comfort level. For this, in the visualization presented in Figure 5 (a) the user can see how much energy (s)he has used in the previous month and whether the saving has been achieved compared to the same month in the previous year. In the case presented in the figure one can see that the user achieved a saving of 6% and therefore the number is in a green box. If the user did not achieve a saving, the colour of the box would be red to provide to him/her an additional warning signal. At the same time this visualization shows the average temperature, humidity and luminance values which were transmitted through the sensors installed in user's home. Next to these values the average comfort level of the user is indicated, e.g. in the example presented in the figure for temperature it was slightly cool and for luminance – slightly bright. Both of these values are positive, and therefore they are in the green boxes (if the values were negative, e.g. too cold or too hot, then the boxes would be red to provide a warning signal to the user). In order to receive the feedback from the user, regarding how comfort is perceived, the user is asked to provide comfort feedback through the screen presented in Figure 5 (b). On this screen, the user is asked how his/her living room feels at the moment and later this information is used to determine the average comfort level.

The "Tips" section has two main screens: Tips and Recommendations which can be seen in Figure 6 (a) displays the tips on how to save energy and is the same for all users. The users are prompted to give feedback to the tips whether they will perform them, they are already performing them or they will not perform them (due to any reason) or whether the tip is not relevant. This information is used to identify a personal profile of the user and to later provide him/her with the tips which are most relevant. Figure 6 (b) shows the personalized recommendations that are tailored to the profile of the user, which are provided to him/her based on the feedback she/he has given and also on his/her occupancy profile.



(a) (b)

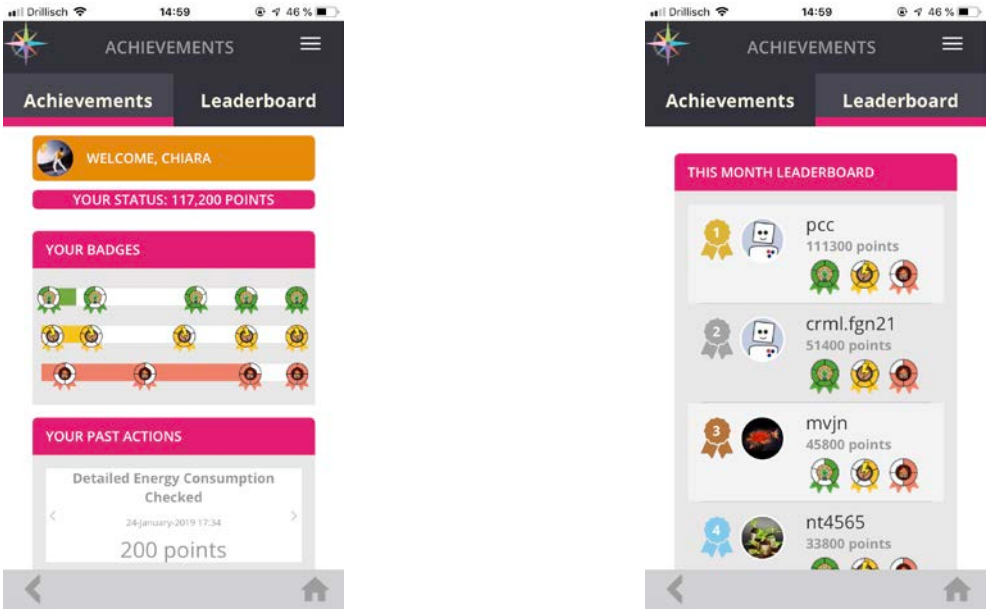
Figure 6: (a) General tips; (b) personalized recommendations

The "Consumption" section displayed in Figure 7 shows the energy consumption of the user's household. The user can choose between the different granularity of the data, and also decide on the timespan for which the consumption data can be shown. Additionally, the user can display average values to identify times at which consumption was below/above average. The data displayed in Figure 7 (a) shows the daily consumption values for the period of one month, and the data displayed in Figure 7 (b) shows the weekly consumption data for the same time span. The user can change the timespan to 3 or 6 months, and set granularity to monthly.

(a) (b)

Figure 7: Energy consumption. (a) daily. (b) weekly

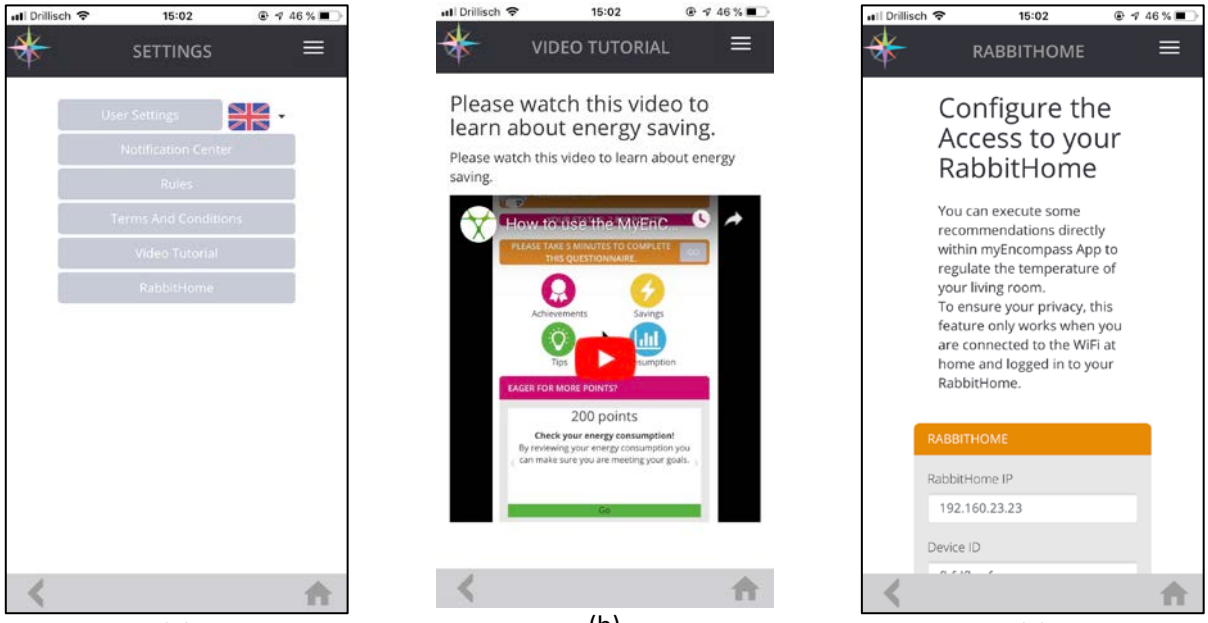
The "Achievements" section is shown in Figure 8. This section visually displays the gamified aspect of the Awareness application: for all the actions the users perform in the application, they obtain points. The points allow them to earn badges, as displayed in Figure 8 (a), which are distributed over three sections (each with several levels): Learning (green badges) which are obtained for learning how to save energy, Energy Saving (yellow) which users get if they achieve their energy saving goals, and Profiling (red) are achieved for providing information about their household and for filling out the surveys. The progress bar indicates how far are the users on the way to obtain the next level of the badge. In order to motivate the users to use the awareness application and save energy, based on the scores that the users obtain they are listed in the leaderboard presented in Figure 8 (b) which shows the users with most points in this month and also the users with most points since the start of the trial period. The users who get the most points every month receive tangible rewards and thus are motivated to use the application to achieve energy savings.



(a) (b)

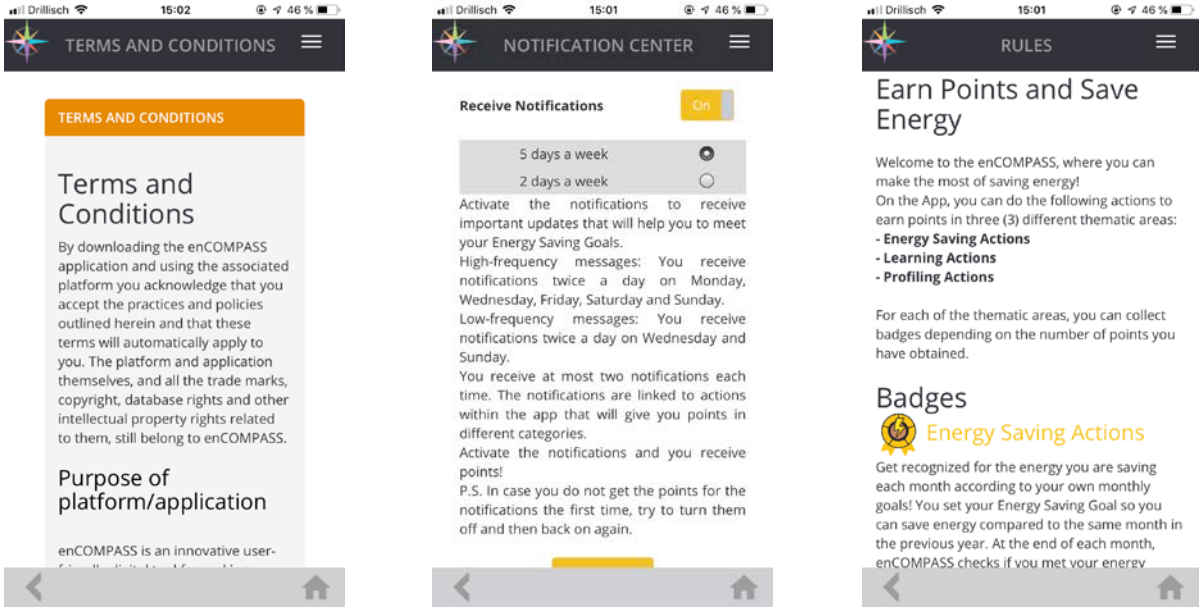
Figure 8: Achievements section. (a) Shows the obtained badges. (b) Shows the leaderboard.

We now present the three additional sections of the Awareness application: Profile, Rewards, and Settings which can be accessed through the sandwich menu. Settings options are shown in Figure 9 and Figure 10. Figure 9 (a) displays settings options which are: Notification Centre, Rules, Terms and Conditions, Video Tutorial and Rabbit home[2]. In Figure 9 (b) includes a video which shows how to use the enCOMPASS application. Figure 9 (c) shows the configuration screen for the RabbitHome for the German pilot which is a device used for the semi-automatic execution of recommendations. Figure 10 (a) shows the Terms and Conditions of enCOMPASS, Figure 10 (b) the configuration for notifications; and Figure 9 (c) shows the rules that describe the gamification of the app to the users (e.g. how many points they can obtain for each action and how many points are required to receive each badge).



(a) (b) (c)

Figure 9: Settings Menu. (a) Shows the settings menu. (b) Instruction video. (c) RabbitHome for the German Pilot.

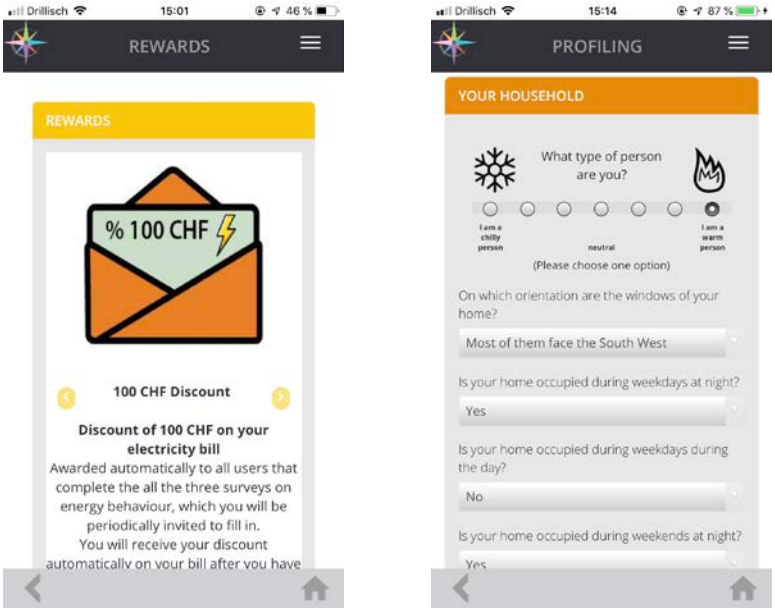


(a) (b) (c)

Figure 10: Settings menu. (a) Terms and Conditions. (b) Notifications. (c) Rules of the Gamification.

[2] - only available for the German pilot

Figure 11 shows the screens of the other two sections: Figure 11 (a) shows the rewards users receive for winning the monthly competition which differ between the pilots; whereas Figure 11 (b) shows the profiling form for users where they can provide more information about their household.



(a) (b)

Figure 11: (a) Rewards. (b) Profiling.

3.2 Adaptation to Building & User Type: School – Teacher/Student

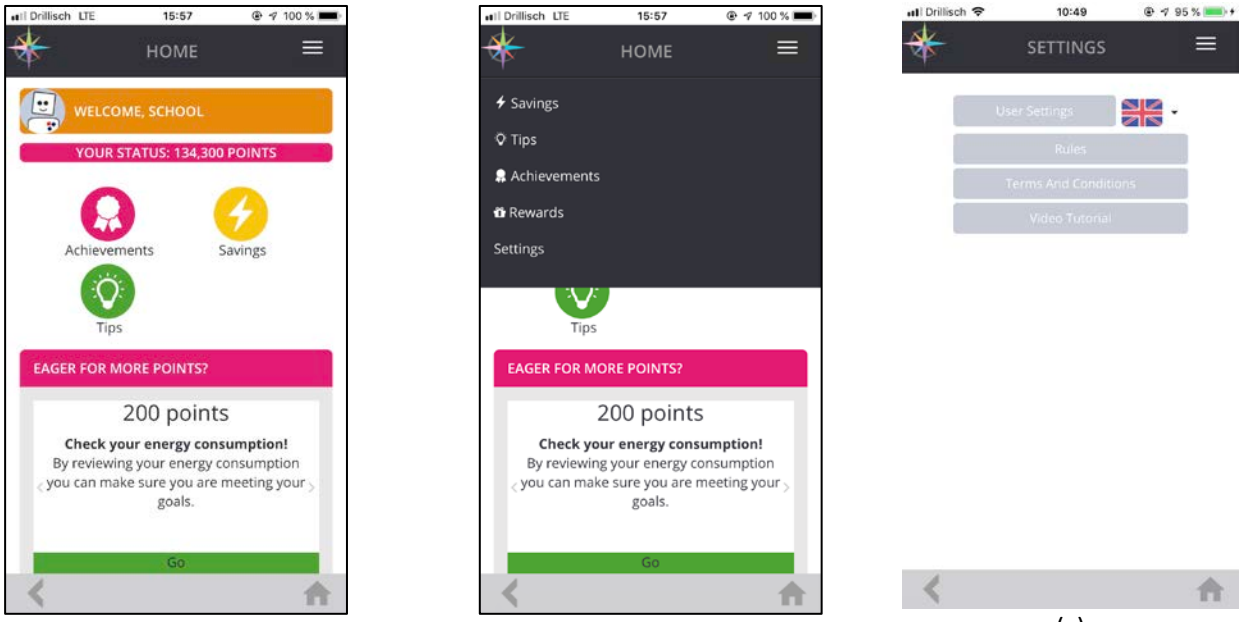
In this section, we will show how the awareness application has been adapted to be used by the school users. In the schools the application is installed one per classroom so that the students can use it under the supervision of the teacher in Germany and Switzerland as the pilot is taking place in a primary school, and the teachers and students can use it together in the vocational school in the Greek pilot. The idea behind using the awareness application in the school is to promote energy saving already from an early age by showing the students how to save energy in their school and also transferring the energy saving attitudes and behaviours to their home.

In order to seamlessly integrate the use of the enCOMPASS application into the classroom, specific strategies were developed in close collaboration with the teachers (for this, two workshops were conducted described in detail in *D7.3 First validation report and data set*). The awareness application constitutes a part of the activities that the students perform in order to learn how to save energy, another not less important part is done with the help of applying the knowledge learned through the application or understanding the rationale behind the energy saving actions. For this, the teachers were given a guideline which contained information on all the energy saving tips, taught in the enCOMPASS app as well as suggestions of how to teach this knowledge to their class through a list of offline activities. For example, the students are required to write a letter to their grandmother explaining how to reduce her energy use, because the grandmother is complaining about a high energy bill. Thus by explaining the tips in their own words, the students can internalize them and thus they can stay in their long-term memory, ready to be retrieved when necessary. Alternatively, the students were asked to fill out a diary where they had to note all the appliances they use throughout the day that use electricity. This is done to increase awareness about daily energy use and to make it more conscious and less automatic, so that the behaviour change can instil

when necessary. [3] For each of these offline activities, the students would be awarded points, and the points would be adjusted based on their grade (so that younger students get more points for the same task than the older ones).

Additionally, in order to motivate the students to use the awareness application and to perform the offline activities, the school-wide competition was organized. For this, each classroom received a specially designed poster that allowed them to track their progress by filing out the points obtained through the enCOMPASS app as well as through the offline activities (Appendix 1). On this poster, the students could see their development of energy knowledge over time during the course of the pilot. Additionally, a special school-wide poster was developed to track the cumulative progress of each classroom and to enable the school-wide competition between the competing classes (Appendix 2). The concept defined in *D2.2 Final requirements* foresaw that every month the classes gather around the poster to fill in the points they have achieved in the awareness application and through offline activities, and to determine the winner who would be rewarded by a wandering trophy. The poster would also remind the students about the competition and would motivate them additionally to perform in the competition, and at the same time learn how to save energy.

In order to measure the progress of the students, in the beginning of the pilot a quiz was administered, which was aimed to measure their energy-related knowledge, which can be seen in Appendix 3. The quiz included questions of various difficulty designed with consideration of peculiarities of conducting tests with primary school students as described in *D7.3 First validation report and data set*. At the end of trial period the quiz will be administered again to check if the students achieved any progress in energy related knowledge, attitudes and behaviours.



(a) (b) (c)

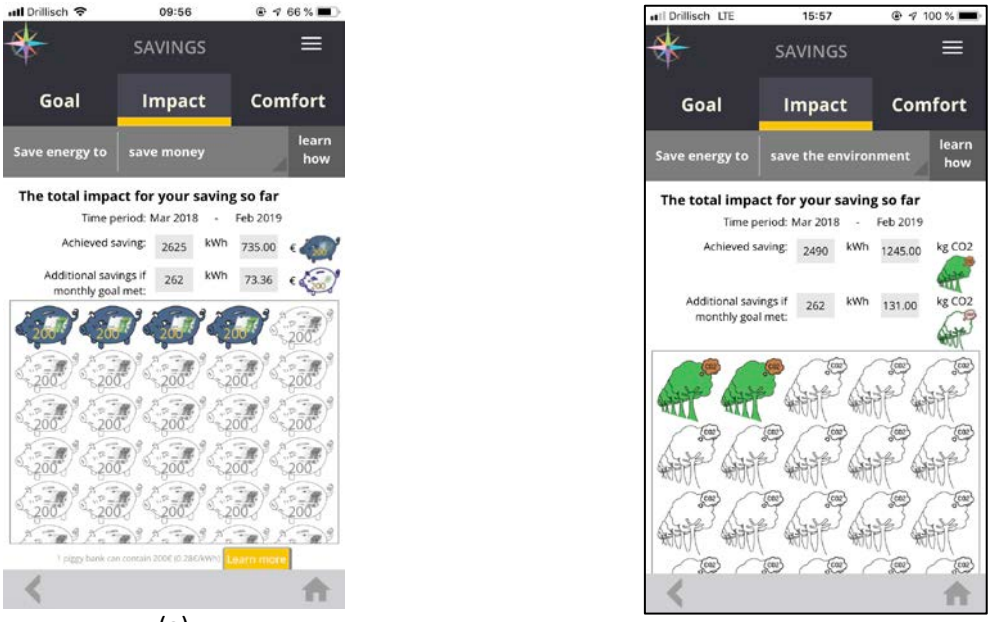
Figure 12: (a) Home page of the Awareness App for school users. (b) Main menu of the Awareness App for school users. (c) Settings menu.

The awareness application was also adapted to fit the needs of the school users. Figure 12 shows the updated homepage and main menu screens for school users. These users do not have access to the consumption of their school and they also do not have a profiling page. This is because the purpose of the awareness application in schools is not so much to monitor consumption, but to use this application as a

[3] - the guideline was written in German and then directly translated to Italian, so it cannot be attached to this deliverable, however it is available upon request.

tool to promote behaviour change from an early age. Also, schools do not receive notifications and do not have automatic execution of recommendations. This is because the application is used on a tablet and at irregular intervals, so the ability to receive notifications is limited.

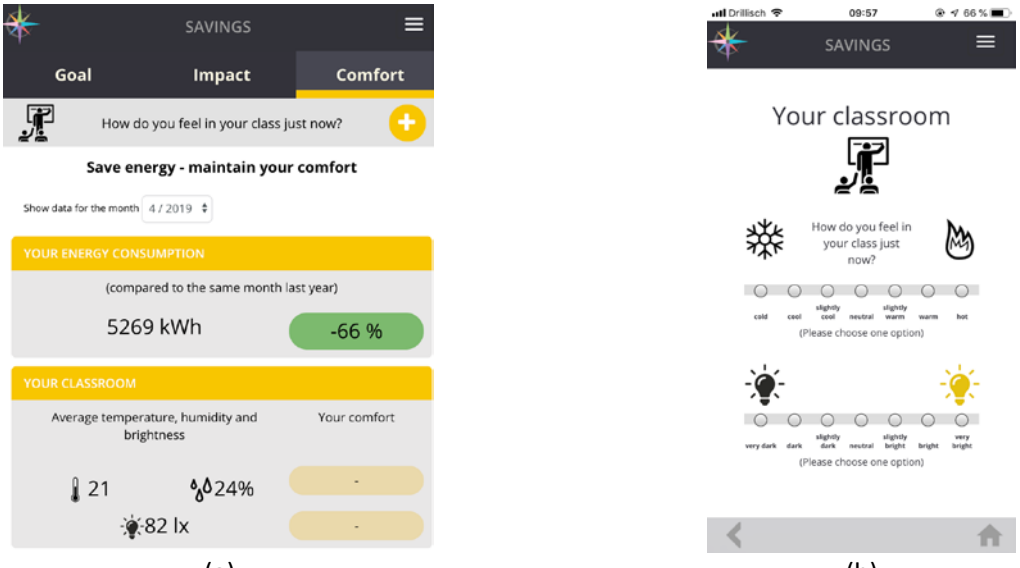
The metaphors for economic and environmental impact are adjusted for schools and public building/offices and can be seen in Figure 13. The main reason for the adjustment is that the consumption of a public building or a school is much higher in absolute terms than that of the household, therefore the savings are also expected to be higher. In Figure 13, the adjusted visualizations are shown. Thus, in the monetary visualization we do not use coins, and a piggy bank contains 200EUR. In the environmental visualization instead of a tree we present forests which include 22 trees, with a total absorption capacity of 500kg CO_2.



(a) (b)

Figure 13: Visulaizations for schools and public building users: (a) Monetary Impact. (b) Environmental impact

Additionally, the comfort visualization is adapted to reflect the location of the user as the users in the school are located in the classroom presented in Figure 14: both the comfort overview page (a) and comfort feedback visualization (b) are adapted.



(a) (b)

Figure 14: (a) Comfort view showing the level of comfort for the classroom. (b) Comfort input for the classroom.

The final change for the school users concerns the tips. First of all, the tips need to be formulated in a way to make them understandable for the children. Second, the tips need to be adjusted for the school context, but as the idea of the project is to transfer energy saving to the home as well, some of the tips that can be implemented at home should be included too. Third, some of the actions that follow from the tips cannot be performed by children alone, but they have to be supervised or performed only by parents (e.g. setting a thermostat or closing a window). Considering these recommendations, a specific set of tips was designed for the school users. In Figure 15 we show a tip which was specifically formulated for the school users: the framing of the tip as a question and also the reference to the parents reveal that. Another change here is that there are no personalized recommendations (because the application is not personalized, but used by a group of users) and there is only one option for feedback (for the same reason).

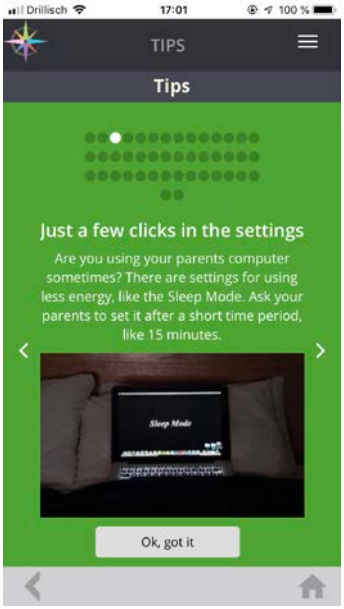


Figure 15: Tips for school users.

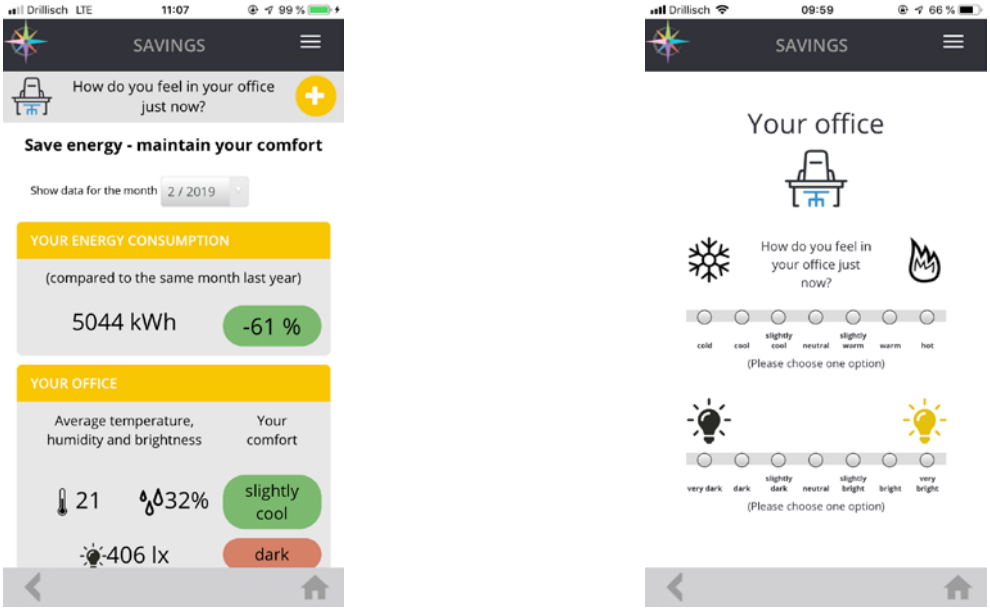
3.3 Adaptation to Building & UserType: Public Building – Employee

In this section, we show how the awareness application has been adapted to be used in the public buildings by the employees. For this type of users the application needs to be usable at their work premises. The challenge here is to design the application in such a way that it does not interfere with their usual working routine, yet can be remembered to be used in their free time. Due to the former reason, as with the application for the schools, there are no notifications. At the same time, the tablets in the public buildings are installed at the common areas, so that once the employees have free time, they can use them. Also in order to additionally stimulate the public building users to use the application, there is a competition between the teams, each month the teams get together to appoint the winner and award a rotating cup.

The application has been slightly adapted, however it is quite similar with regards to functionalities to the one used in the schools as these are both a type of a public building. As in the previous section, only those screens that are different from the ones used by the Household users are shown. The impact visualizations for the Public Building Employee users are the same as in schools, shown in Figure 13. There are two other adjustments specific for the public buildings.

First, the comfort page needs to be adjusted to reflect the location of the public building user: their office. In Figure 16 we show the comfort overview page (a) and comfort input page (b). Please note that in this case in the comfort overview page one can see that the users felt that 406 lx was slightly dark. In this way

by using the application the employees can determine and adjust their level of comfort (and possibly as a side effect of using the application increase their productivity).



(a) (b)

Figure 16: (a) Comfort view showing the level of comfort for the classroom. (b) Comfort input for the classroom.

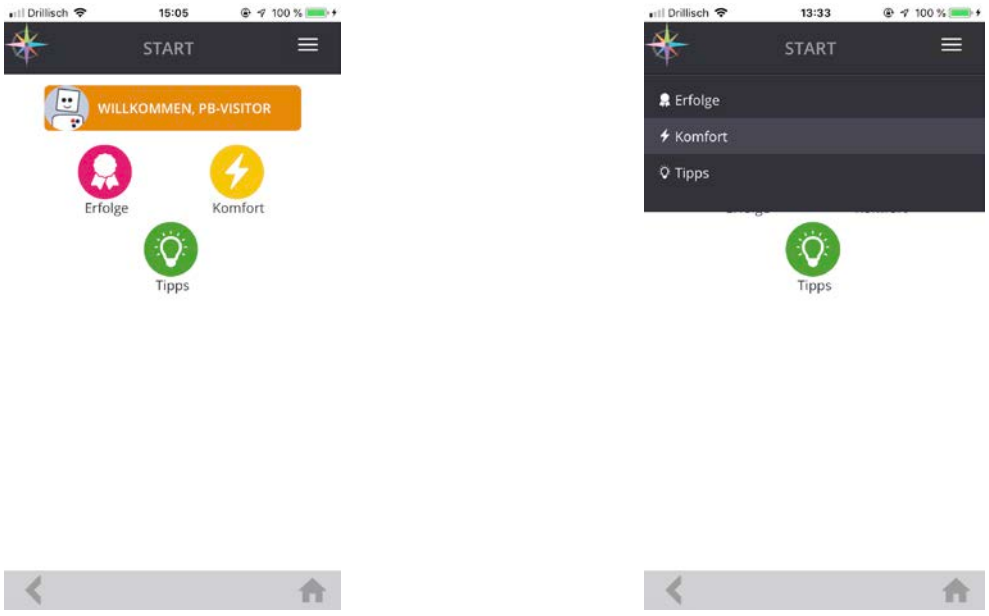
As the employees are in the public buildings, a specific set of tips was developed which is more applicable to them: for example, those relating to using their computers as shown in Figure 17. In this case, the users can provide various answer options, similar to the case with the households. At the same time, there is the same list of tips for all public building users and no personalized recommendations.

Figure 17: Tips for public building.

3.4 Adaptation to Building & User Type: Public Building – Visitors

Another type of users in the public buildings are the visitors. The awareness application can be also used by the visitors of the public buildings to increase the awareness of energy saving among a broader spectrum of users. Most of the buildings in the pilot are frequently visited by people: in Athens it is a public library,

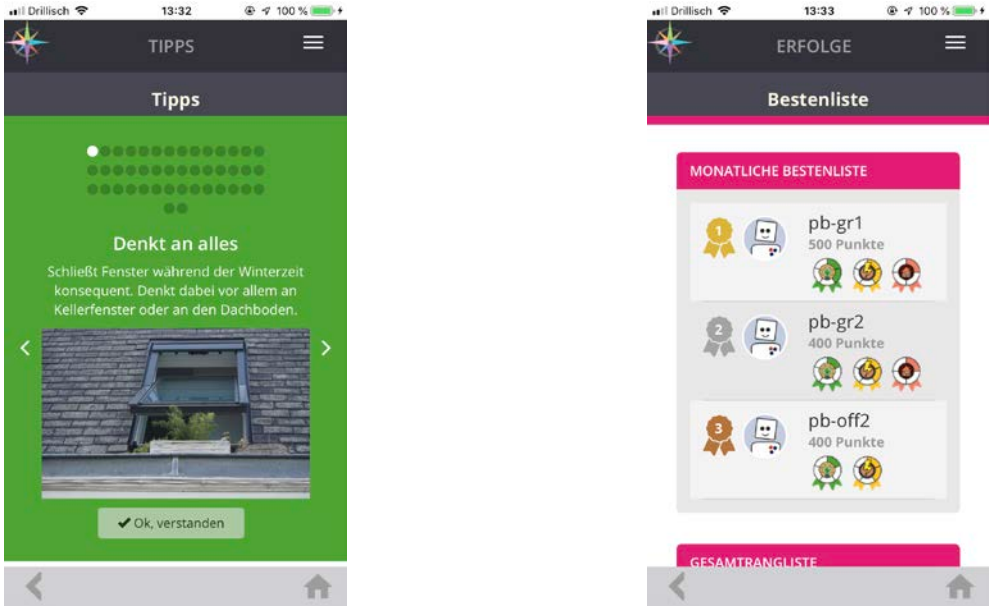
whereas in Germany it is a public office where a lot of people passes by every day. However, the visitors do not have enough time to get themselves acquainted with how to use the application, so the functionalities that are available to them are limited to the absolute necessary and the ones which can be interesting for them. Screens for Public Building visitors are available in the local language, and the user has no option to change the language of the app. The Homepage which can be seen in Figure 18 (a) only has three sections and the main menu does not provide access to any other section Figure 18 (b). Basically, the public building visitors can view the average energy savings and the comfort of the building, provide comfort feedback, read the energy saving tips and see how the teams in the building are performing in the achievements.



(a) (b)

Figure 18: (a) Homepage for Public Building Visitors. (b) Main Menu for Public Building Visitors.

Public building users can read the energy saving tips, as shown in Figure 19 (a) and they only have one option to give feedback. The tips are thought as an information for them so that they can possibly apply it in their home. In the achievements section the public building users only see the leaderboard of the teams in the buildings, as seen in Figure 19 (b) and they do not have access to the badges as they are not taking part in the competition.



(a) (b)

Figure 19: (a) Tips for Public Building Visitors; (b) Achievements section for Public Building Visitors

4 ADAPTATION OF THE USER INTERFACES TO THE DEVICE AND OPERATING SYSTEM

This section discusses how the visualizations were adapted to the target devices and operating systems. It starts by summarizing the most important limitations when developing mobile applications and presenting the technical overview; then the design decisions are discussed along with the technical challenges of the proposed approach and some examples of the common code adaptations required are explained, finally screenshots of the final visualizations running on different screen sizes are presented, to demonstrate the outcome of the approach.

4.1 DESCRIPTION OF THE IMPLEMENTATION

When developing for mobile devices there are some considerations to take into account, one of the most important is the effort of developing native applications for the most popular platforms (Android[4] and iOS[5]); each platform requires a specific set of tools and programming languages, none of those tools is compatible across the platforms and no code reuse is possible which doubles the effort, the time and the cost.

Another important consideration is the wide spectrum of versions, screen sizes and screen resolutions that exist in the market, for an application that features dynamic and interactive visualizations it presents a challenge to adapt at runtime to the screen size without losing resolution or stretching image, and even more complicated is to find a solution that works across the different versions of the platform.

In order to work around such problems, an approach that has been becoming popular in the recent years was implemented. It consisted in separating the app into 2 pieces: A Web application with Responsive Web Design (RWD) that handles the business logic, and a native client application for each platform wrapping the web application and enabling access to all the native features.

[4] https://www.android.com/
[5] https://www.apple.com/lae/ios/

A responsive web application adapts to the device where it is displayed, and provides several advantages:

- Automatically detects the rendering surface, the browser size or the display size.
- Grid and element sizes are set using relative units like percentages, rather than pixels or points used by mobile native tools.
- Images and media sizes use relative units as well, this ensures that despite its actual size they will not overflow the container element.
- The grid layout automatically adapts to the display, which allows tailor layout for phones, tablets and PCs.

Besides, developing a responsive web application requires only industry standard tools and knowledge such as Java, HTML, CSS and JavaScript which significantly reduces the learning curves; and it ensures that the application will execute and display correctly on any device with a modern web browser.

The client applications, on the other side, provide access to the native functions of the platform like notifications, safe storage of user and passwords, autologin, etc. to improve the user experience. It consists mainly of a WebView that enables access to the enCOMPASS web application; a WebView is a simple web browser which behaviour can be customized by the developer to limit or extend its functionality and the user actions.

Both Android and iOS provide their own implementation of a WebView component, Android implementation is based on Google Chrome[6] while iOS version is based on Safari[7], such difference imposes some technical issues that will be discussed in the next section, but the overall complexity of developing a relatively simple client app is considerably smaller when compared to a full-featured app.

Following this approach solved the 2 main problems describe above by moving the complexity of developing the visualizations to a domain where known and proven solutions already existed, and for which the learning curve was shorter. It also allowed exploiting all the advantages of native mobile applications such as notifications while keeping the complexity and effort at manageable levels.

4.2 DIFFERENCES BETWEEN ANDROID AND IOS IMPLEMENTATIONS

As mentioned in the previous section, Android and iOS platforms use different tools for the development of native applications, but there are also many differences internally that require some adjustments even for applications that run on a mobile browser or a WebView.

Android WebView is based on google chrome engine while iOS WebView is based on safari engine, these engines have different ways to interpret JavaScript and CSS which require the developer to include pieces of code specific for each of them. Furthermore, the WebView engine provides a visual representation for standard view components that might be different depending on the platform, here are some examples of the most common difference and adaptations required:

Input fields differences:

When a standard input field is used the WebView provides the native representation of such element, which has the same functionality across platforms, but its visual representation might be different.

Example of such case are some elements of the input forms like selection fields and radio buttons (Figure 20 and Figure 21).

[6] https://www.google.com/chrome/
[7] https://www.apple.com/lae/safari/

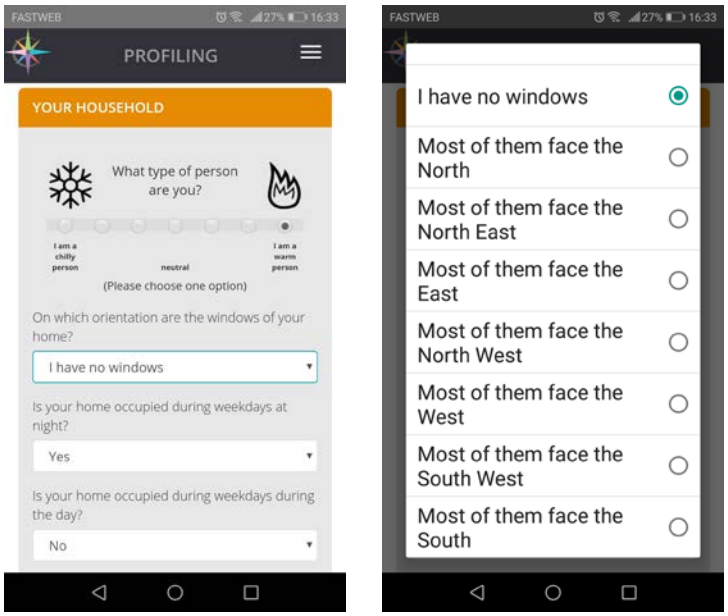


Figure 20 Example of native selection field and radio button visualization on an Android phone

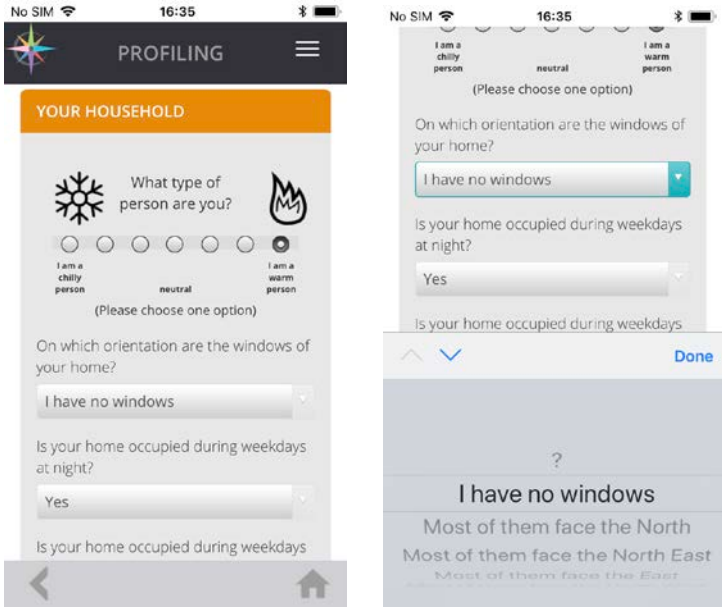


Figure 21 Example of native selection field and radio button visualization on iPhone, for comparison with Figure 24

CSS Adaptations:

There are several properties in CSS that are not interpreted in the same way across browsers, in such case the developer should include the specific property for each one of them, otherwise, the affected element will look or behave differently in different platforms.

Examples of this kind of problem are transition animations of toggle buttons:

```
.slow .toggle-group {
      transition: left 0.7s;
      -webkit-transition: left 0.7s;
}
```

In this case, the style was applied to generate a smooth state transition to the toggle button on the Notification Center page. The property "transition" is perfectly interpreted by chrome engine, but it is ignored by safari, to adapt the feature to safari we added the "-webkit-transition" property with the exact same values.

JavaScript Adaptation:

There are cases in which JavaScript instructions are interpreted in different way or order across browsers, in such cases developers should understand which platform the code is been executed and select the specific set of instructions that are required.

In the following example the platform is identified through the property "User Agent" of the browser, if the platform is iOS then the JavaScript code will set the value and the text of the motivation options (in the impact page of the enCOMPASS app) because safari requires both values to be set, while in other browsers only the value is required and used.

```
var deviceAgent = navigator.userAgent.toLowerCase();
var agentID = deviceAgent.match(/(iphone|ipod|ipad)/);
if (agentID) {
    $('#motivation option').each(function(  ) {
            $( this ).val($( this ).text());
            $( this ).text($( this ).attr('label'));
      });
}
else{
      $('#motivation option').each(function(  ) {
            $( this ).val($( this ).text());
      });
}
```

Several adjustments like this had to be made during the development of enCOMPASS, especially when mathematical functions were used.

In conclusion, the development effort to adapt the web application to both platforms was small when compared to the development of native applications, and most of the changes required were on the CSS and JavaScript components which are primarily for presentation purposes, no changes on the business logic or server-side components was needed.

4.3 Adaptation of the Awareness Application to the user's locale

An important requirement was the internationalization of the platform, since the pilots were deployed in 3 countries with different languages, and in the Swiss case also a different currency. WebRatio[8], the development platform that was selected for the project, provides tools to implement this feature in a simple and standard way.

The JSP Standard Tag Library (JSTL)[9], through the Core and Formatting and Localization (fmt) modules, provides several methods that allow to get the locale of the client application, and select labels and content from adequate for the locale. It also allows to set a different locale to the client application with the

[8] https://www.webratio.com/site/content/en/home
[9] https://www.oracle.com/technetwork/java/jstl-137486.html

corresponding labels and content, which is useful to allow the user to change the preferred language without changing the locale of their phone or computer.

The library works by assigning key names to the labels, such keys should be store in a properties file with the corresponding value, the values will be retrieved automatically by the application at run-time based on the client locale. For every locale a file should be created, and all key labels should be included in each file, in case of a missing key the default value will be display, usually English is set as default.

Here is an example of the contents of the bundle properties file in English and Italian:

ApplicationResources_en.properties	**ApplicationResources_it.properties**
comfort_1=cold comfort_2=cool comfort_3=slightly cool comfort_4=neutral comfort_5=slightly warm comfort_6=warm comfort_7=hot	comfort_1=freddo comfort_2=fresco comfort_3=un po' fresco comfort_4=neutro comfort_5=leggermente caldo comfort_6=caldo comfort_7=caldissimo

The JSP reference the label by its key as in the following example, and the library will select the appropriate locale.

```
<bean:message key="comfort_1"/>
```

Using such tools makes it easy to add, remove or change the translations of the platform labels, without modifying the code or affecting the business logic, this is also an advantage of the selected approach since Android and iOS have different tools for internationalizing apps, that would require an extra effort for every change in the translations.

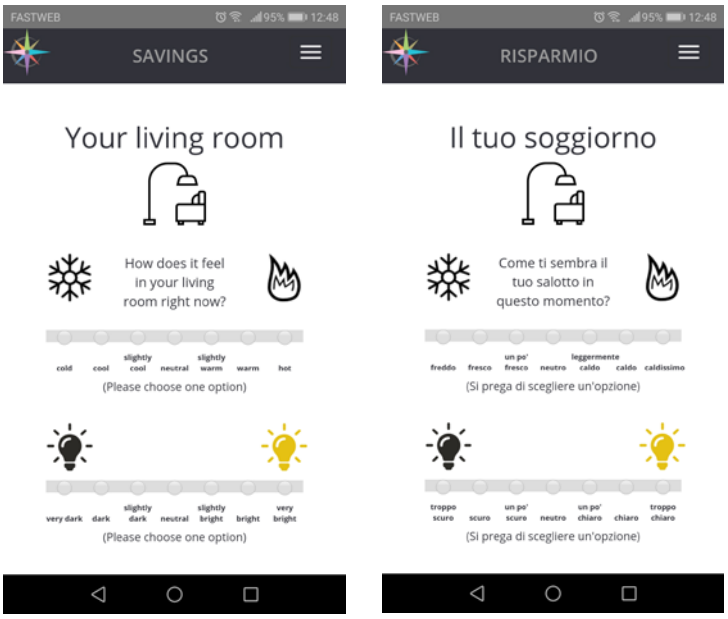


Figure 22: Comparison of Comfort feedback page in English and Italian.

5 AWARENESS APPLICATION USAGE IN HOUSEHOLDS, SCHOOLS AND PUBLIC BUILDINGS

In this section we provide intermediate descriptive analysis to illustrate how the different kinds of users (households, public buildings and schools) interact with the enCOMPASS application in general and the developed visualizaitons in particular. This allows us to get first insights into the suitability of the developed visualizations and application pages as reflected in actual real-world usage. First, we report how the household users interacted with the visualizaitons, then we show how the school users interacted with the visualizaitons and finally we conclude how the public building users interacted with them.

5.1 AWARENESS APPLICATION USAGE IN HOUSEHOLDS

This section is divided into three parts: first we report the usage statistics in the German pilot with SHF clients, then we show the usage statistics of the Swiss pilot with SES clients, and finally we condlude with the usage statistics of the Greek pilot with WVT clients. The analysis was performed using data until the 28.2.2019. The pilot started on 01.06.2018 in Germany and Switzerland and on 01.10.2018 in Greece.

For the analysis, only users that have logged-in in more than once to the application were considered for analysis who we consider active users. Those users who have signed up less than 3 months ago at the time of the analysis, however, were kept even if they logged in only once.

5.1.1 German Pilot- Household Users

In Germany, 107 household users have signed-up to the Awareness application; 12 of those users have logged in only once to the Awareness App since the start of the pilot, therfore we are only considering 95 active users. Figure 23 shows the frequency of new sign-ups per month, the number of active users each month (those who logged in more than once over the course of the pilot) and the regular users – those who logged in at least once in that month. From the figure we see that most users signed up in June, however users kept signing in until January 2019. At the same time we see that a majority of the active users (in a range of 60%-100% depending on the month) are regular montly users of the awareness application – which shows good engagement rates in the pilot.

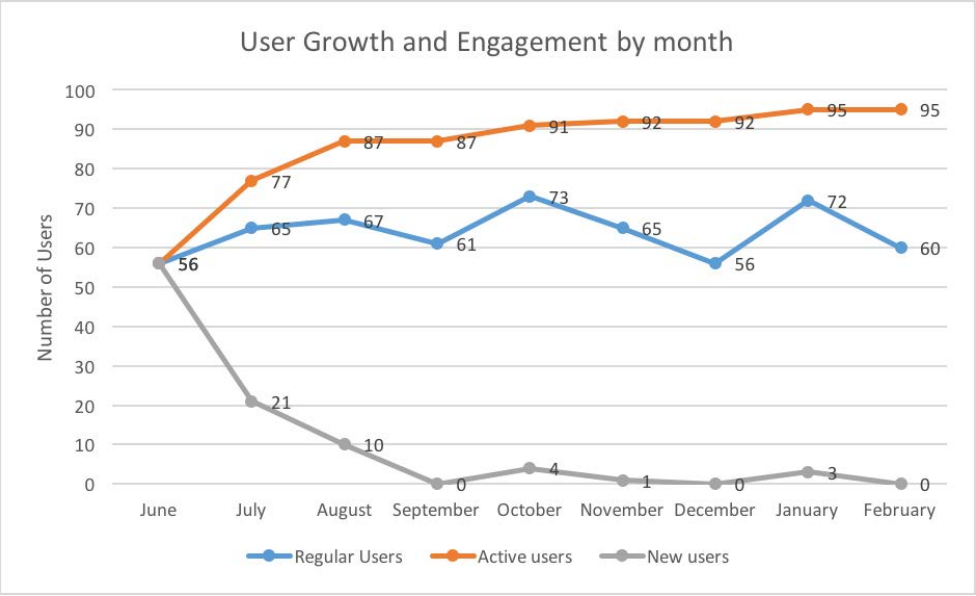


Figure 23: User Growth and engagement of household users in the German pilot.

Next, we wanted to see how frequently the users interacted with the main visualizations and screens of the awareness application described in Section 3.1 We calculated the monthly average frequency of interaction per user per month of awareness app membership[10]. The average interactions with the main pages can be seen in Figure 24. As we can see from the figure, the users interacted most frequently with the Tips page[11], followed by Savings & Goals visualization page. This can be expected as the Tips page contained a number of tips that could be viewed at a time and "Savings and Goal visualization" page allowed the user to monitor the achievement of the energy saving goal as described in Section 2.1. Users read on average over 13 tips a month, and accessed over 12 times a month the "Savings and goals visualization" page which we can consider a very good result. Further, the users were interested in achievements and comfort pages, which again can be expected as they wanted to see how they are progressing and whether their comfort is not compromised due to their energy saving. The Impact and Comfort Feedback pages have been accessed less, but this can be expected as accessing these pages requires more clicks since they follow after the higher-level visualization pages, thus it is also an expected finding that they would be used less than the higher-level pages of the app.

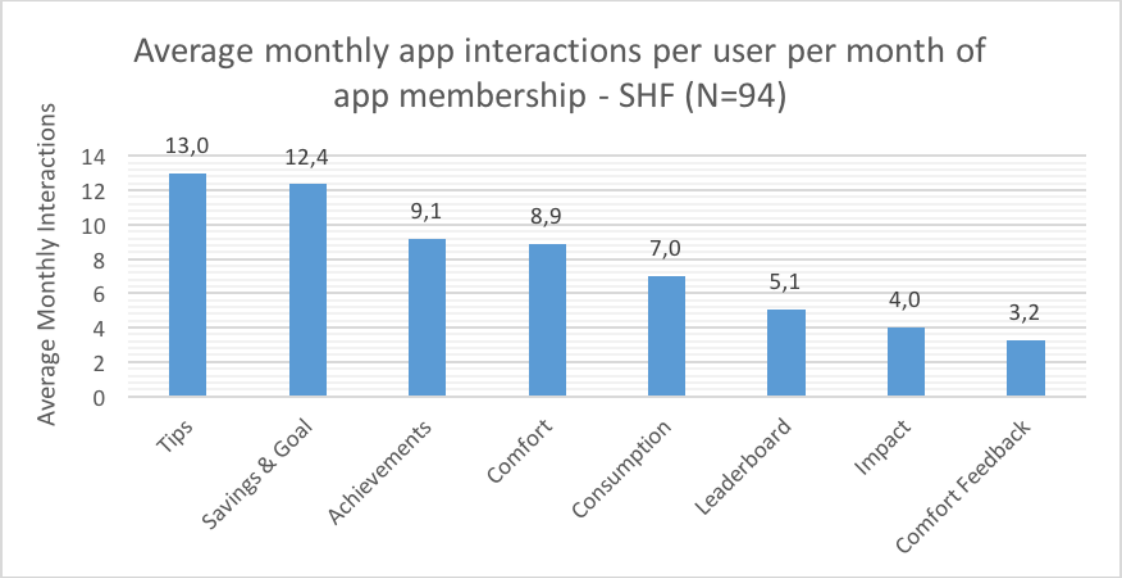


Figure 24: Average monthly interactions with the main pages of the Awareness Application of the household users in the German pilot (ordered by frequency)

To shed more light on the interaction with the impact visualizations as described in Section 2.2, we first show the distribution of the motivation for energy saving across the users in the pilot. The motivation of the household users for energy savings is shown in Figure 25. We see from the figure that the majority of users have the environment as their main motivation, followed by monetary and lastly hedonic motivation. This can be expected as people participating in the pilot most likely took part in it due to environmental or monetary reasons, however we also see that a few took part just for fun and as such we can confirm the need for inclusion of this type of motivation, as suggested by the goal-framing theory. As described previously, the motivation that the users indicated determined the default impact visualization that the user would see in the awareness application.

[10] The frequency was computed by dividing for each user the total frequency by the number of days between sign-up and the 28.2.19, multiplied by the average number of days in the months in the pilot.

[11] The tips page contains multiple tips that can be read by the user by swiping through them. Therefore, the number for this metric is calculated by adding the number of times a user has read the tips and the number of tips that were read by the user.

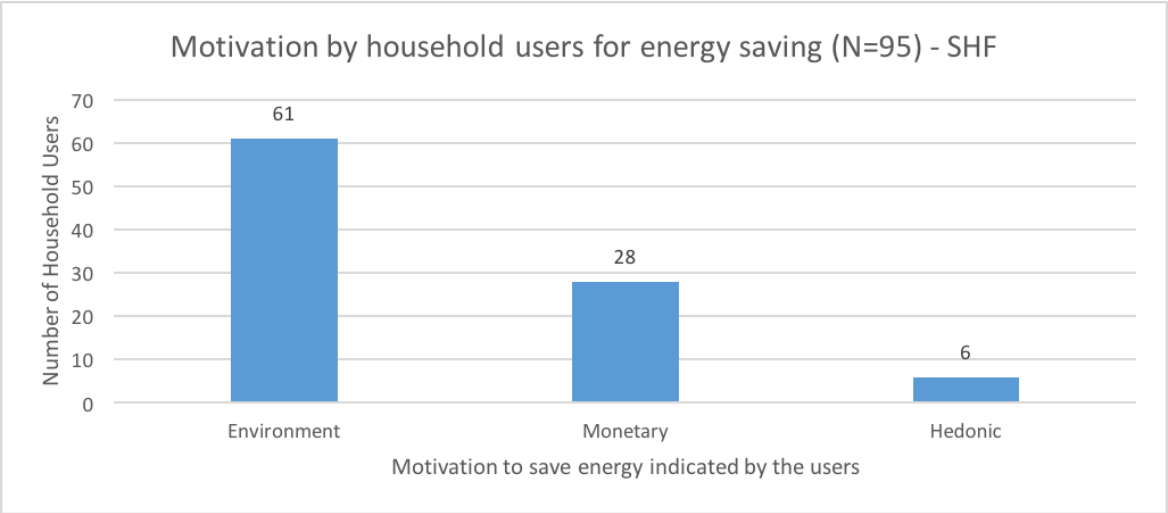


Figure 25:Motivation for energy savings of household users in the German pilot.

Next, in Figure 26 we show how many of these users accessed the default impact visualizations based on their stated motivation to save energy and how many of them have changed the default impact visualization to another one. In this figure the labels *Impact Environment/Money/Hedonic Entry, Impact Environment/Money to Hedonic, Impact Environment/Hedonic to Money, etc.* refer to the various interactions of the user with the visualizations. Specifically, on the example of the Environmental visualization (all others follow similar logic) described in Section 2.2 *Impact Environment Entry* refers to accessing the default impact visualization "Save environment", while *Impact environment to Hedonic* refers to the user changing the environmental impact visualization to the hedonic impact visualization, whereas *Impact Environment to Money* refers to changing the impact visualization to the monetary one, and finally *Impact back to Environment* refers to the user changing back to the environmental visualization.

We can see from the Figure 26, that most of the users who indicated their preference to save energy also accessed the impact visualization reflecting that preference at least once: e.g. 61 users stated environment as their preferred motivation in Figure 25, and 60 users accessed the environmental visualization in Figure 26. At the same time, as Figure 26 shows, some users who had environmental visualization as default changed their default visualization to a different one, specifically: 38% changed to monetary visualization and 41% changed to hedonic visualization at least once. A similar situation occurred with the monetary visualization: 42% changed it to environmental and 46% changed it to hedonic. This shows that although most people are motivated rather by the initial visualizations provided to them, others are also interested in other impact visualizations.

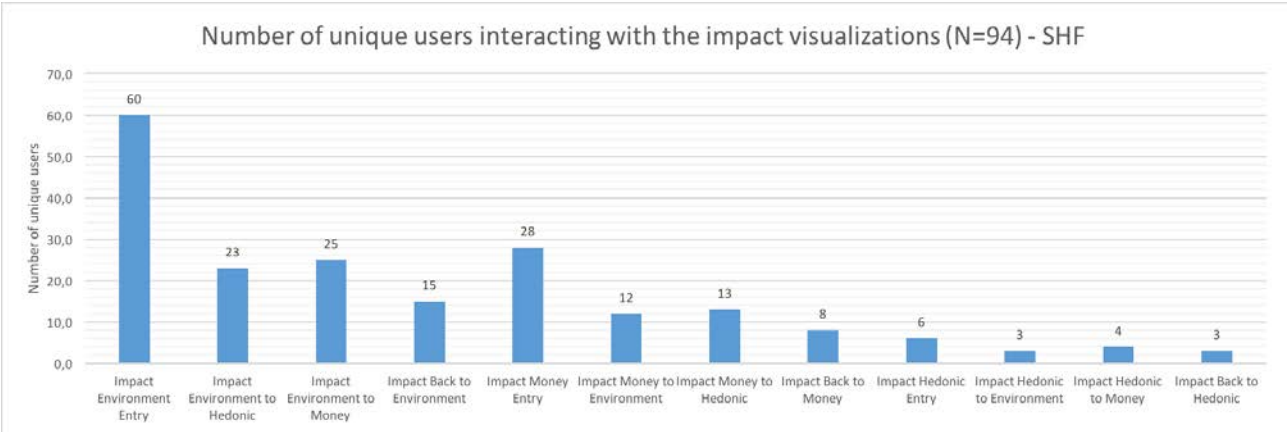


Figure 26: Number of unique users interacting with the impact visualizations in the German pilot

Users collect points for different actions that they perform in the application. Based on the number of points, users receive badges in three categories described in Section 3.1. Each can receive up to 14 badges, in Figure 27 the histogram of the % of badges obtained by users is presented. From the figure, we can see that most users are actively receiving badges for their interactions with the App: 21% of users already obtained more than 50% of possible badges, and another 40% have obtained more than 30% of available badges.

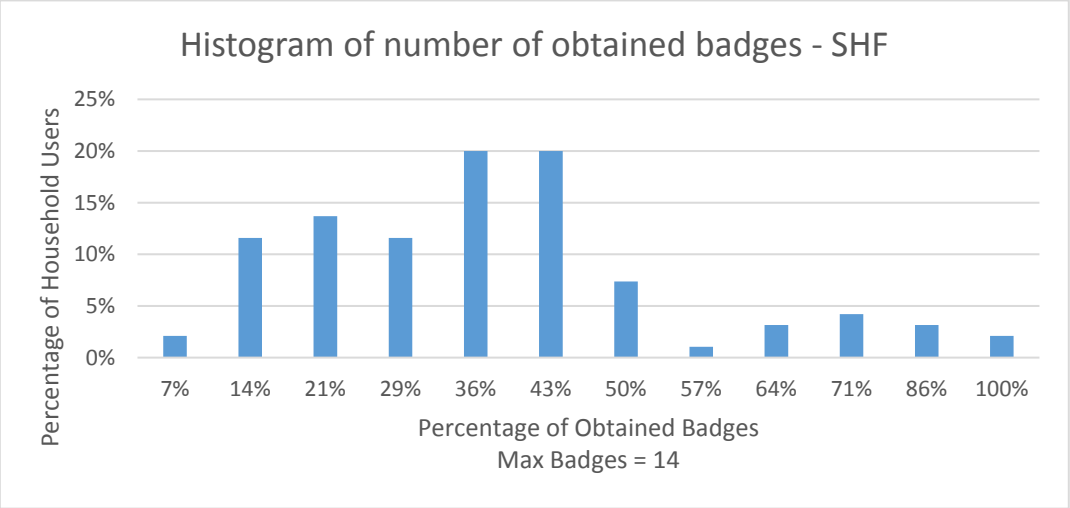


Figure 27: Histogram of % badges obtained by household users in the German pilot.

Next, we would like to see which badges are obtained by the users. The 14 badges that the users can receive are classified into three categories: Learning, Saving Energy and Profiling. In each category, the user can receive up to 4 or 5 badges. Badges of different categories can be obtained in parallel, while badges of the same category can only be obtained sequentially. In Figure 28 is shown which types of badges were obtained by the users. From this figure we see that most of the users have received the first badges in all of the categories: 97% the learning category, 79% in the energy saving category and 91% in the profiling category. Over half of the users have also obtained the second badge in each category and fewer are on the way to obtain further badges. Overall, the distribution of obtained badges across the user population shows a good impact of this element on supporting engagement, with the stratification common in such cases.

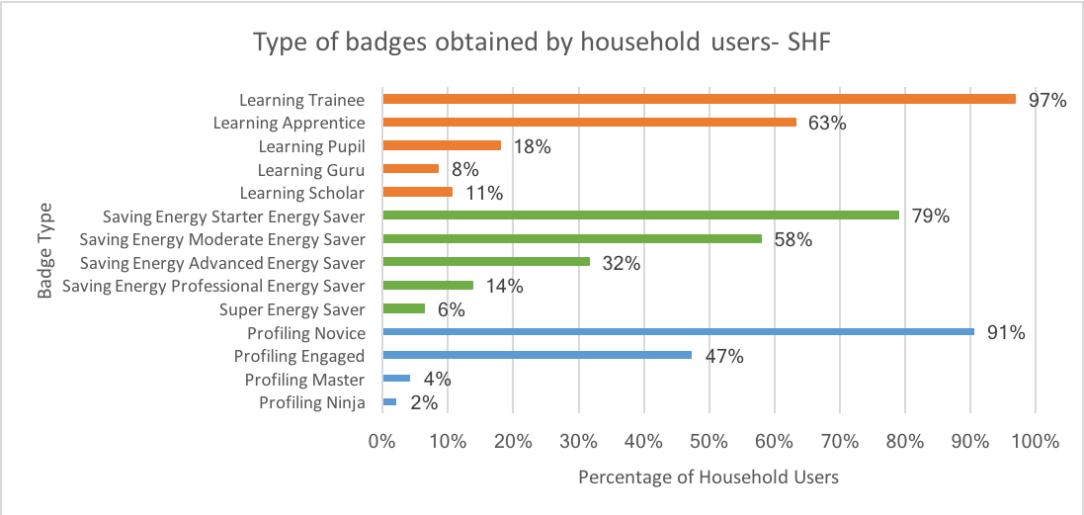


Figure 28:Type of badges obtained by household users in the German pilot.

5.1.2 Swiss Pilot – Household Users

In Switzerland, 66 users registered to the awareness application during the first two months of pilot, with 52 users having logged in more than once, so we consider them active users and take them for the analysis. Figure 29 shows the frequency of new sign-ups per month, the number of active users each month (those who logged in more than once over the course of the pilot) and the regular users – those who logged in at least once in that month. From the figure we see that most users signed-up during the first month of the pilot, and one other user registered in July. As it can be seen from the figure, a majority of the active users (in a range of 54%-100% depending on the month) are regular users logging in to the Awareness application at least once every month – which shows good engagement in the pilot.

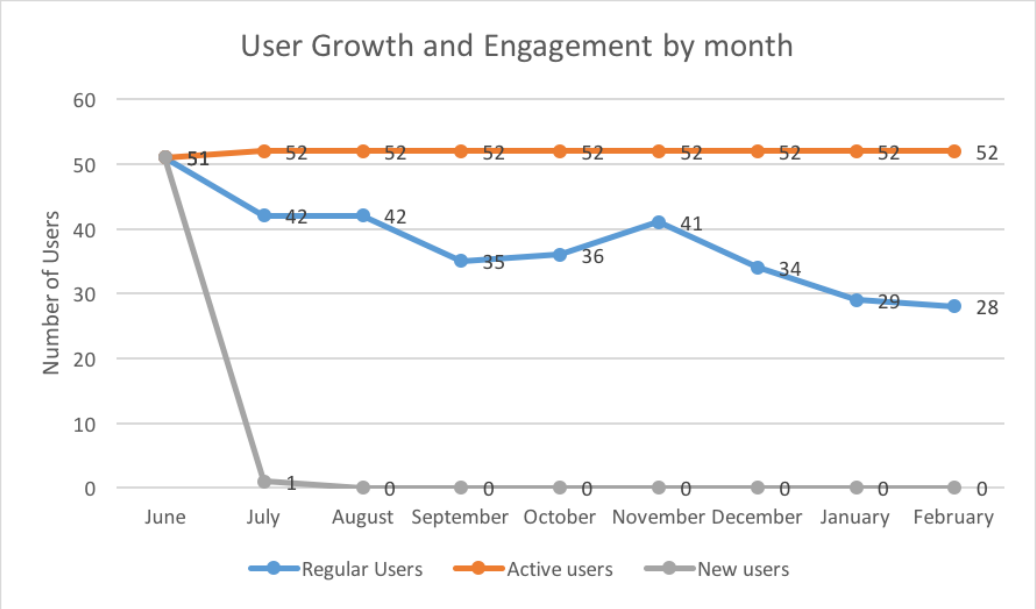


Figure 29: User Growth and Engagement by month in the Swiss pilot

Next, we wanted to see how frequently the users interacted with the main visualizations and screens of the awareness application described in Section 3.1**.** We calculated the monthly average frequency of interaction per user per month of awareness app membership[12]. The average interactions with the main pages can be seen in Figure 30. As we can see from the figure, in this pilot, the users interacted most frequently with Savings & Goals visualization, followed by Comfort page and then the Tips page[13]. This result shows that Swiss users are most interested in the "Savings and Goal visualization" page which allows them to monitor the achievement of the energy saving goal as described in Section 2.1. Users accessed this visualization on average over 14 times a month which is a very good result. Then Swiss users found Comfort to be the second most important page with an average of over 10 access per month. Interestingly, the Tips page is only on the third place, although it considers the multiple tips that can be read by the users. The Impact and Comfort Feedback pages have been accessed less, but this can be expected as accessing these pages requires more clicks since they follow after the higher-level visualization pages, thus it is also an expected finding that they would be used less than the higher-level pages of the app.

[12] The frequency was computed by dividing for each user the total frequency by the number of days between sign-up and the 28.2.19, multiplied by the average number of days in the months in the pilot.

[13] The tips page contains multiple tips that can be read by the user by swiping through them. Therefore, the number for this metric is calculated by adding the number of times a user has read the tips and the number of tips that were read by the user.

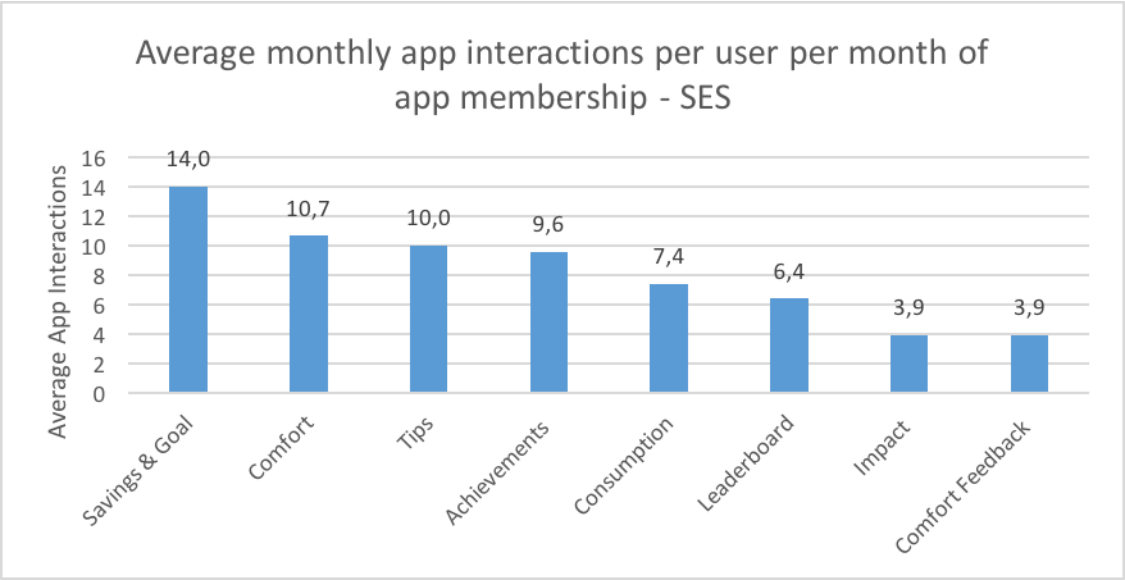


Figure 30: Average monthly interactions with the main pages of the Awareness Application of the household users in the Swiss pilot (ordered by frequency)

To shed more light on the interaction with the impact visualizations as described in Section 2.2, we first show the distribution of the motivation for energy saving across the users in the pilot. The motivations of the household users for energy savings are shown in Figure 31. We see from the figure that almost all users (88%) have the environment as their main motivation, and the rest is evenly split between the monetary and hedonic motivation. This is an interesting result in the Swiss pilot, which differs from the German pilot where also a significant number of users had a monetary motivation. As described previously, the motivation that the users indicated determined the default impact visualization that the user would see in the awareness application.

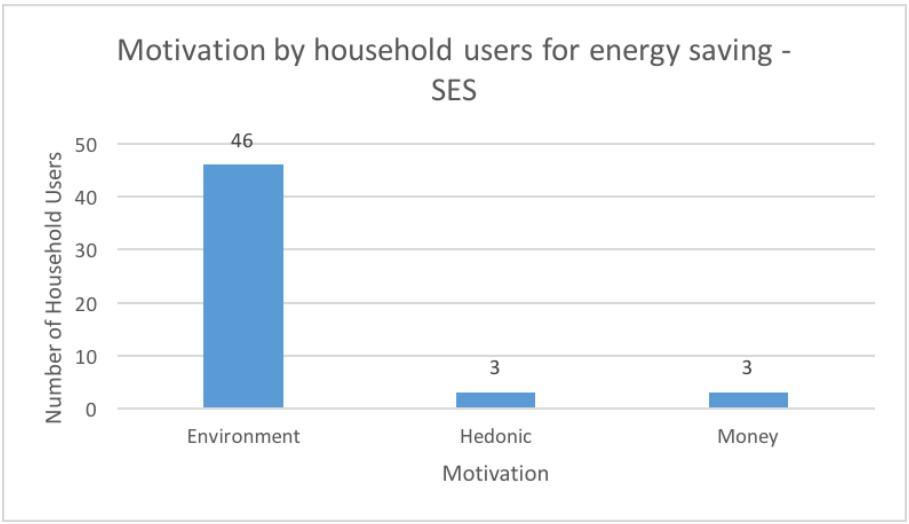


Figure 31: Motivation by household users in the Swiss pilot.

Next, in Figure 32 we show how many of these users accessed the default impact visualizations in the awareness application based on their stated motivation to save energy and how many of them have changed the default impact visualization to another one. The logic of this graph is the same as described in Section 5.1.1. We can see from the Figure 32, that most of the users who indicated their preference to save energy also accessed the impact visualization reflecting that preference at least once: e.g. 46 users stated environment as their preferred motivation as shown in Figure 31, and 44 users accessed the environmental

visualization as shown in Figure 32. At the same time, some users who had environmental visualization as default changed their default visualization to a different one, specifically: 50% changed to monetary and 55% changed to hedonic at least once. This shows that although most people are motivated rather by the default visualizations matching their primary motivation, some are also interested in other impact visualizations.

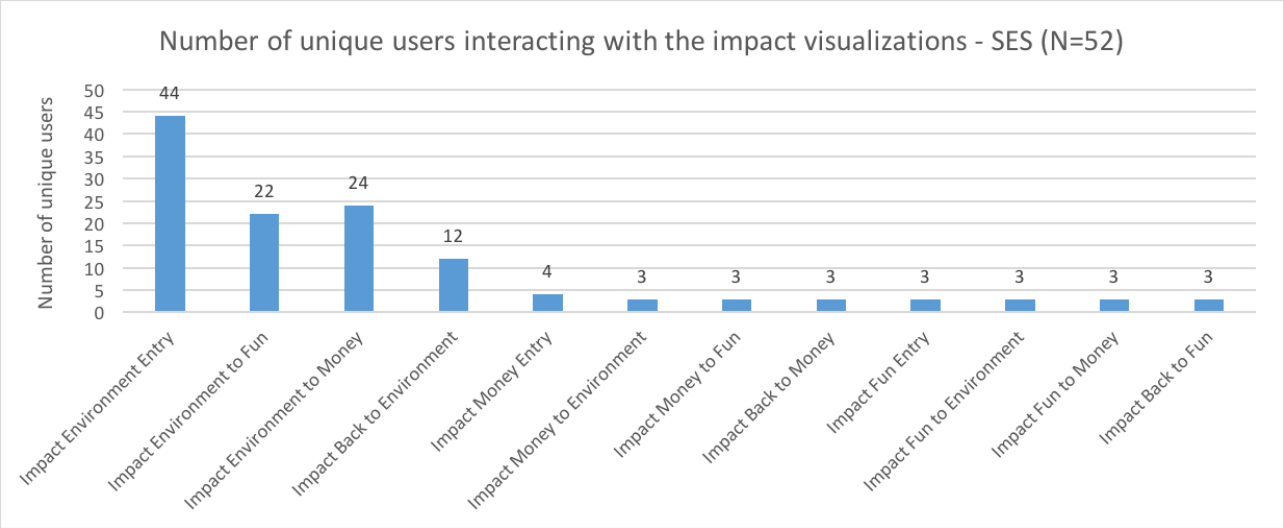


Figure 32 Number of unique users interacting with the impact visualization in the Swiss pilot

Users collect points for different actions that they perform in the application. Based on the number of points, users receive badges in three categories described in Section 3.1. Each user can receive up to 14 badges, in Figure 33 the histogram of the % of badges obtained by users is presented. From the figure, we can see that most users are actively receiving badges for their interactions with the App: 21% of users already obtained more than 50% badges, and another 44% have obtained more than 30% of available badges.

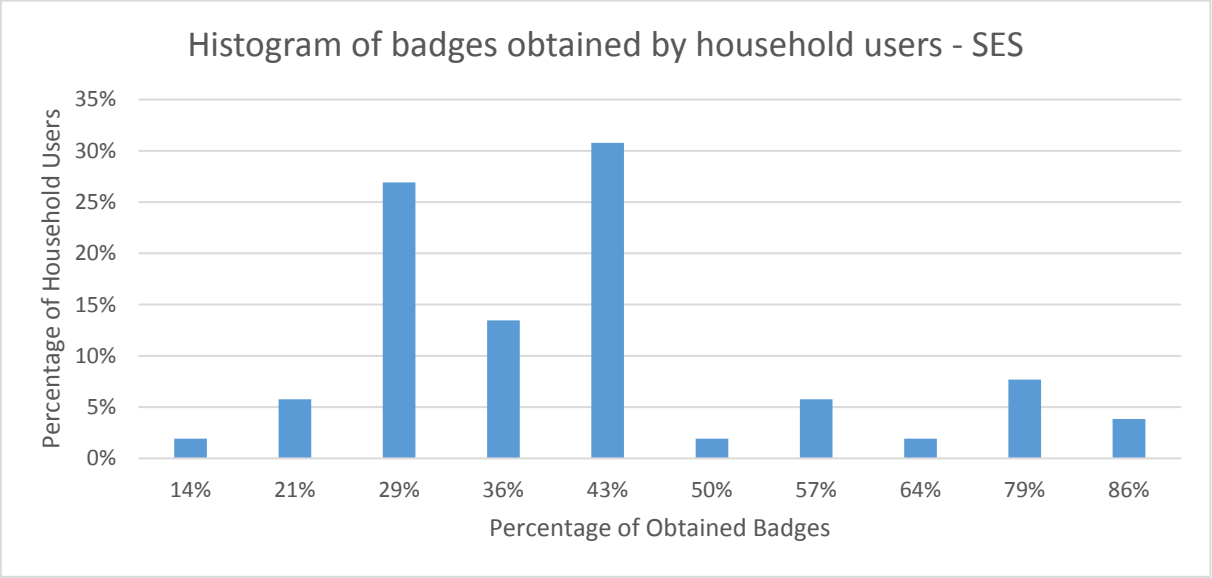


Figure 33:Histogram of number of badges obtained by household users in the Swiss pilot.

Next, we would like to see which badges are obtained by the users. The 14 badges that the users can receive are classified into three categories: Learning, Saving Energy and Profiling. In each category the user can receive up to 4 or 5 badges. Badges of different categories can be obtained in parallel, while badges of

the same category can only be obtained sequentially. In Figure 34 is shown which types of badges were obtained by the users. From this figure we see that most of the users have received the first badges in all of the categories: 96% the learning category, 100% in the energy saving category and 94% in the profiling category. Over half of the users have also obtained the second badge in each category, with almost 98% of users also having the second energy saving badge which is a good result. Overall, the distribution of obtained badges across the user population shows a good impact of this element on supporting engagement, with the stratification common in such cases.

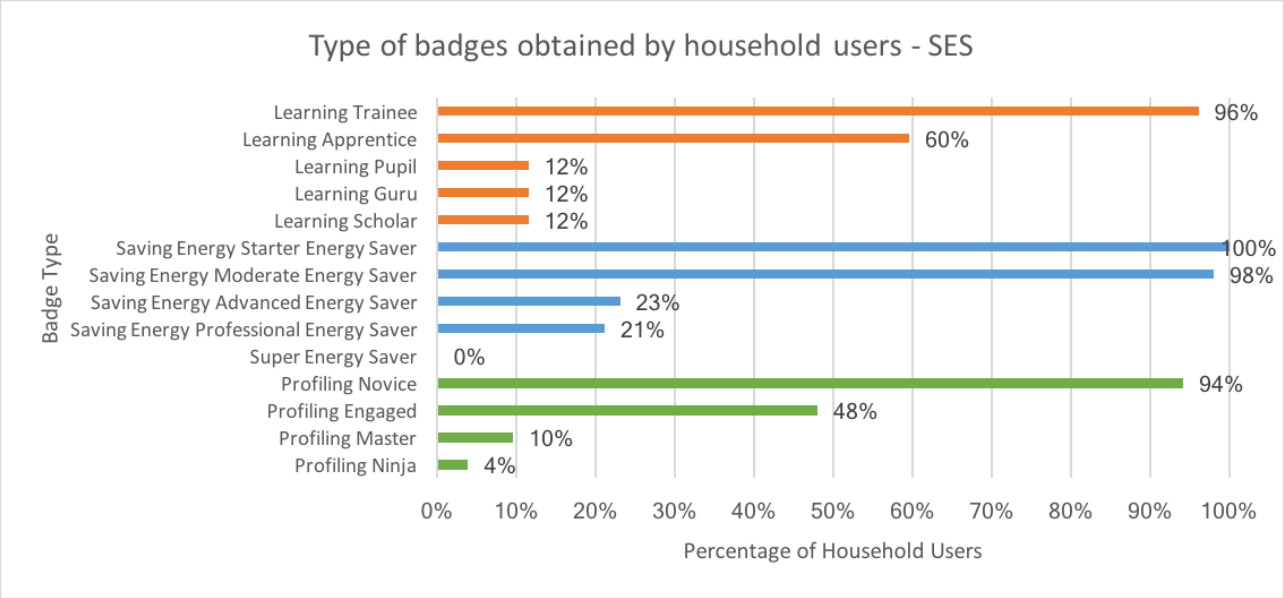


Figure 34: Type of badges received by household users in the Swiss pilot

5.1.3 Greek Pilot – Household Users

In Greece, 83 household users have signed-up to the Awareness App; 44 of those users have logged in only once to the Awareness App since they signed up, thus we are only considering 39 active users who logged in more than once. Please note that due to reasons reported in *D7.3 First validation report and data set* the pilot in Greece started in October 2018, therefore there are only 5 months of data that are analyzed in this deliverable. For this reason, we cannot make direct comparisons of this data with the Greek and German pilots which have been running since June 2018.

Figure 35 shows the frequency of new sign-ups per month, the number of active users each month (those who logged in more than once over the course of the pilot) and the regular users – those who logged in at least once in that month. From the figure we see that a few users signed up in October and stayed active in the awareness application, however most users signed-up in February. We can also see that in November and February the larger part of the active users were regular users of the awareness application, however in December and January only a few users regularly logged in the awareness application. The analysis of possible causes of the observed behaviour quite different from the other two pilots is subject of WP7. Given the later start of this pilot and compared to the observed dynamics of the other two pilots, this is likely to significantly increase in the next months.

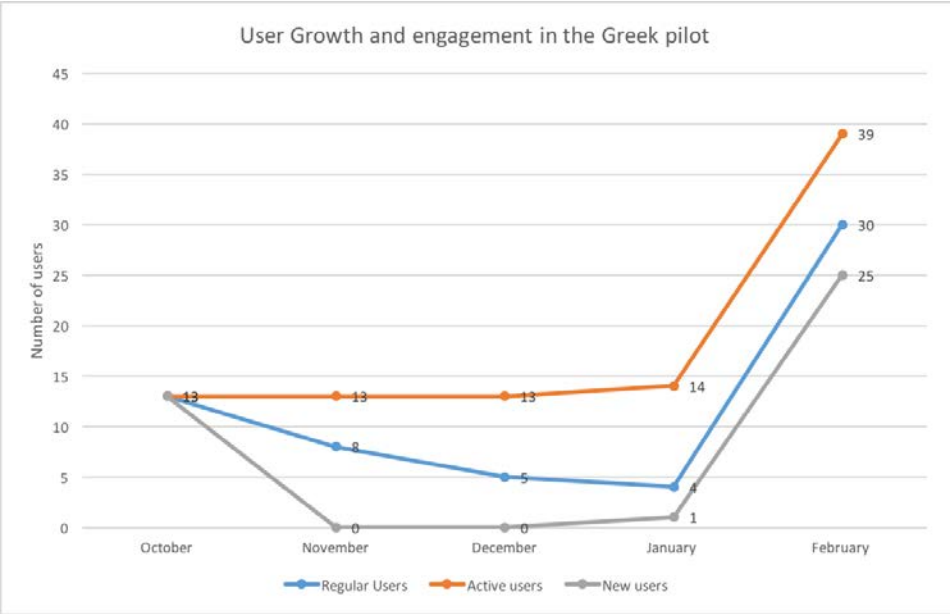


Figure 35: User Growth and engagement of household users in the Greek pilot.

Next, we wanted to see how frequently the users interacted with the main visualizations and screens of the awareness application described in Section 3.1. We calculated the monthly average frequency of interaction per user per month of awareness app membership[14]. The average interactions with the main pages can be seen in Figure 36. As we can see from the figure, the users in the Greek pilot interacted most frequently with the Tips page, followed by Comfort page and finally "Savings & Goals visualization" page. This can be expected as the tips page contained multiple tips that could be viewed at a time and Greek users read over 19 tips on average[15]. Additionally, the Comfort visualization and the "Savings and goals visualization" were accessed on average over 14 and 13 times, respectively. From the Figure 36 we see that the few users are very actively using the Awareness application which we can consider a promising result. Interestingly, the Leaderboard and Impact pages are accessed the least number of times by Greek users, but this can be expected as accessing these pages requires more clicks since they follow after the higher-level pages, thus it is also an expected finding that they would be used less than the higher-level pages of the app.

[14] The frequency was computed by dividing for each user the total frequency by the number of days between sign-up and the 28.2.19, multiplied by the average number of days in the months in the pilot.

[15] The tips page contains multiple tips that can be read by the user by swiping through them. Therefore, the number for this metric is calculated by adding the number of times a user has read the tips and the number of tips that were read by the user.

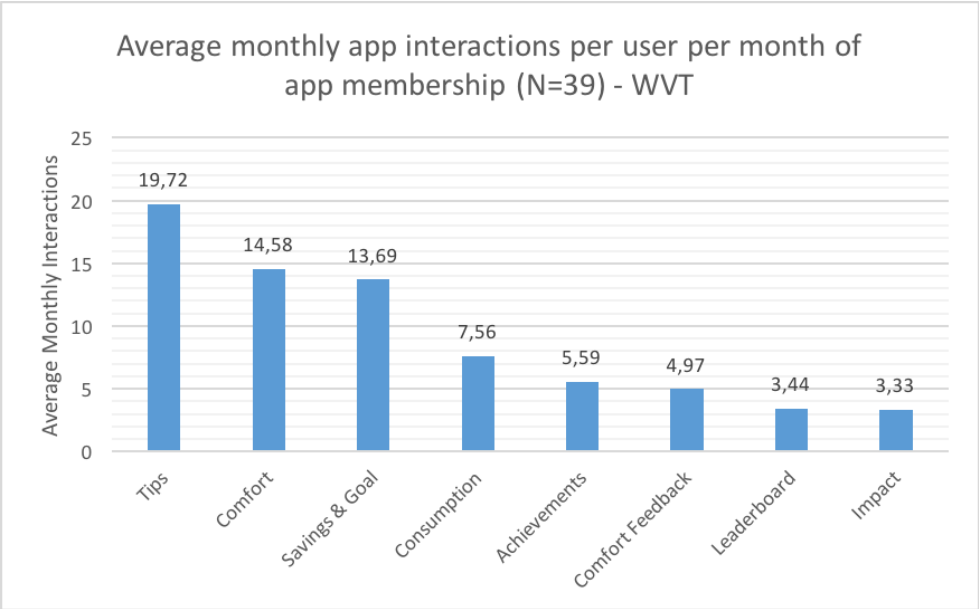


Figure 36: Average monthly interactions with the main pages of the Awareness Application of the household users in the Greek pilot (ordered by frequency)

To shed more light on the interaction with the impact visualizations as described in Section 2.2, we first show the distribution of the motivation for energy saving across the users in the pilot. The motivation of the household users for energy savings are shown in Figure 37. We see from the figure that the majority of users have the environment as their main motivation, followed by monetary and lastly hedonic motivation. This can be expected as people participating in the pilot most likely took part in it due to environmental or monetary reasons, however we also see that a few took part just for fun and as such we can confirm the need for inclusion of this type of motivation, as suggested by the goal-framing theory. As described previously, the motivation that the users indicated determined the default impact visualization that the user would see in the awareness application.

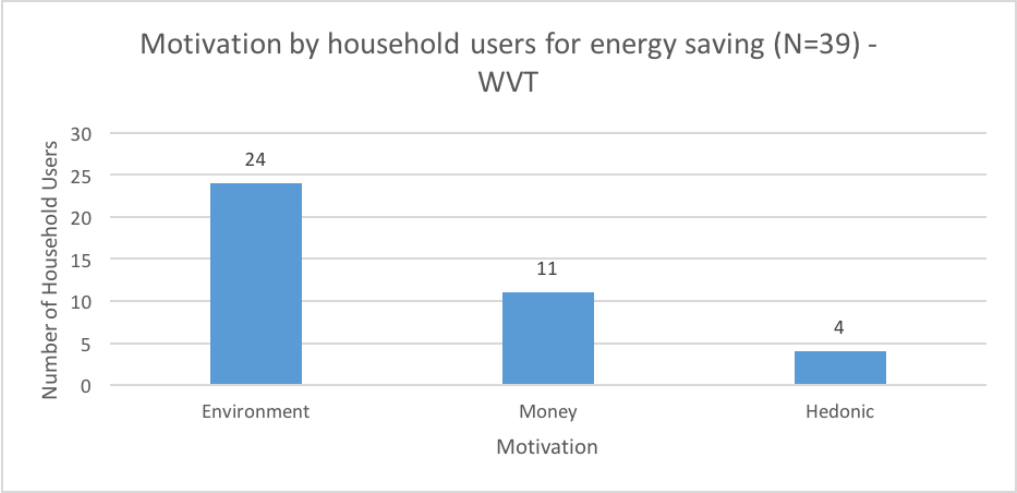


Figure 37: Motivation for energy savings of household users in the Greek pilot.

Next, in Figure 38 we show how many of these users accessed the default impact visualizations based on their stated motivation to save energy and how many of them have changed the default impact visualization to another one. The logic of this graph is the same as described in Section 5.1.1. We can see from the Figure 38, that most of the users who indicated their preference to save energy also accessed the impact visualization reflecting that preference at least once: e.g. out of 24 users stated environment as

their preferred motivation as shown in Figure 37, 19 users accessed the environmental visualization as shown in Figure 38. At the same time, as Figure 38 shows, only about 36% of users who had environmental visualization as default changed their default visualization to a different one (monetary or hedonic); and 40% of the users who had monetary visualization as default changed their default to a different visualization (environmental or hedonic). These numbers are similar to the other two pilots and show that although most people are motivated rather by the initial visualizations provided to them, others are also interested in other impact visualizations.

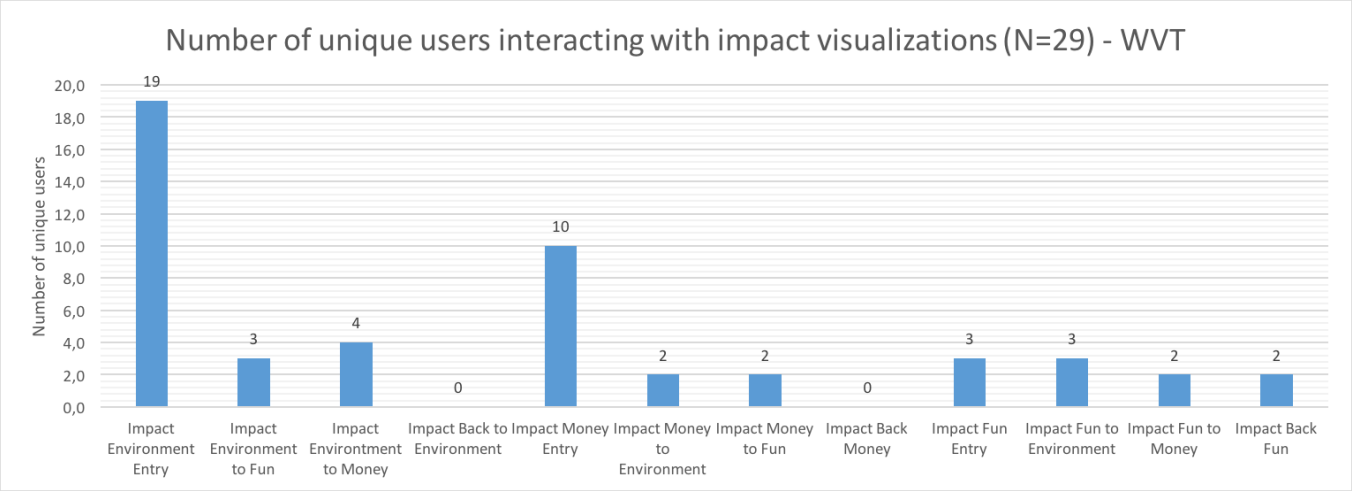


Figure 38: Number of unique users interacting with the impact visualizations in the Greek pilot.

Users collect points for different actions that they perform in the application. Based on the number of points, users receive badges in three categories described in Section 3.1. Each can receive up to 14 badges, in Figure 39 the histogram of the % of badges obtained by users is presented. From the figure, we can see that users are beginning to receive badges for their interactions with the App: over 50% of users already obtained more than 14% of possible badges, and another almost 20% have obtained more than 20% of available badges. Given the later start of this pilot and compared to the observed dynamics of the other two pilots, this is likely to significantly increase in the next months.

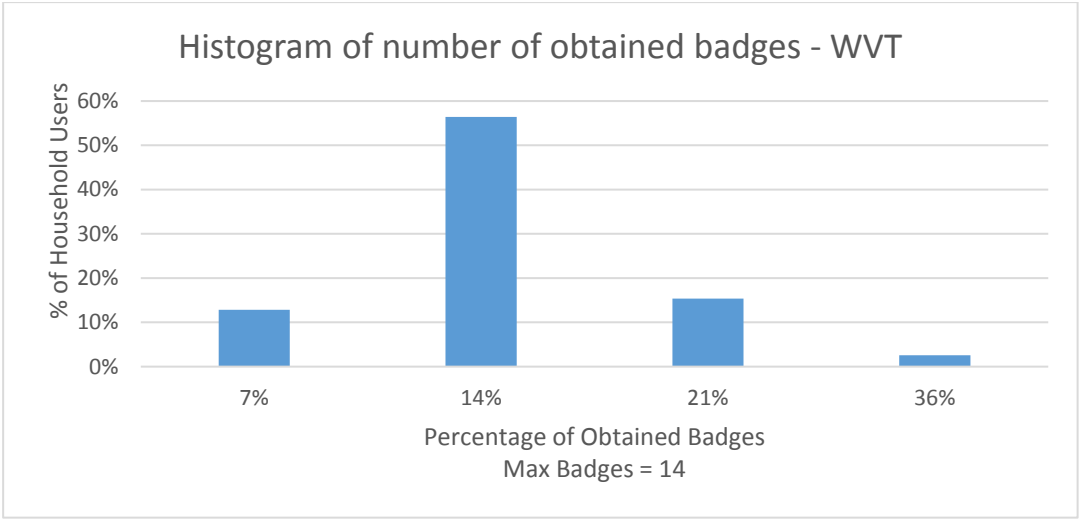


Figure 39: Histogram of number of badges obtained by household users in the Greek pilot.

Next, we would like to see which badges are obtained by the users. The 14 badges that the users can receive are classified into three categories: Learning, Saving Energy and Profiling. In each category, the user can receive up to 4 or 5 badges. Badges of different categories can be obtained in parallel, while badges of

the same category can only be obtained sequentially. In Figure 40 is shown which types of badges were obtained by the users in the Greek pilot. From this figure, we see that few badges were obtained by the users: most users obtained the trainee level (89%) in learning, and over 85% obtained novice level in profiling. This is currently quite different from the results achieved in the German and Swiss pilot, although given the later start of this pilot it might still change significantly.

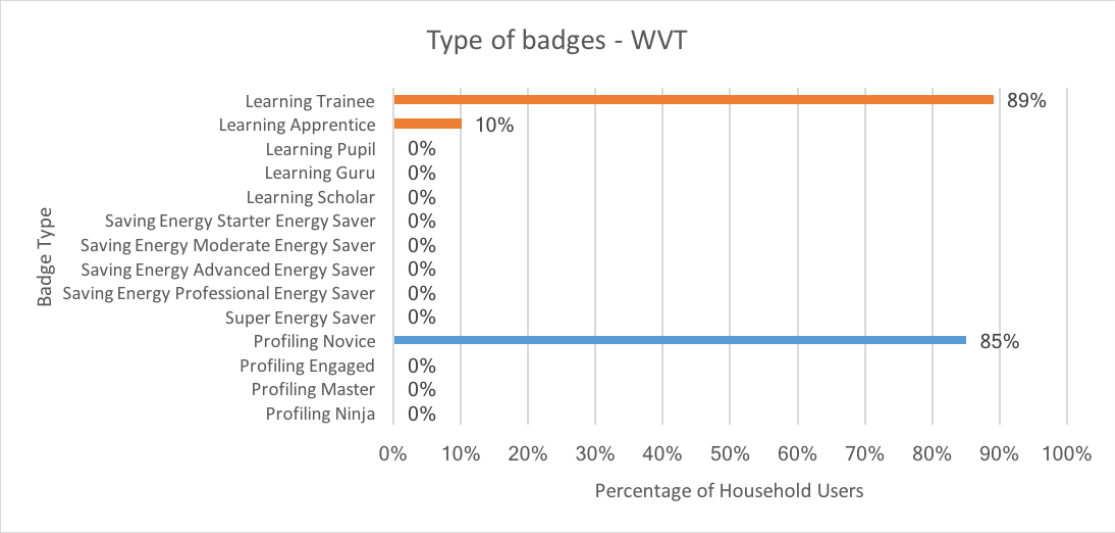


Figure 40: Type of badges received by household users in the Swiss pilot

5.2 Awareness Application Usage in Schools

In this section, we show the main usage statistics for the visualizations and the Awareness application screens for the school users as defined in 3.2. As the Awareness application for the schools differs from the household app and has fewer pages, here we present fewer graphs than the ones reported about households in 5.1.1. The data available for the school pilot ranges from the time the pilot started there (various dates, see sections below) until 28.2.2019. As opposed to the households, here the usage of the application occurs in teams (one classroom = one team) as defined in *D2.2 Final requirements*.

5.2.1 German Pilot – School

In the German pilot 20 classes are taking part in the pilot in the two primary schools. The pilot in the school in Germany started in November 2018, as reported in *D7.3 First validation report and data set*. All the users started using the awareness application in the same month, so in Figure 41 we show the % of regular users accessing the awareness application in the months since the start of the pilot. From the figure, we can see that since December 2018 the classes are actively using the awareness application with 80% of users accessing the application regularly. This is a very good result, considering also the large number of users in this pilot. This coincides with continuous feedback we receive from the German schools that is very positive: the children are engaged, are learning new things and using the application on a regular basis.

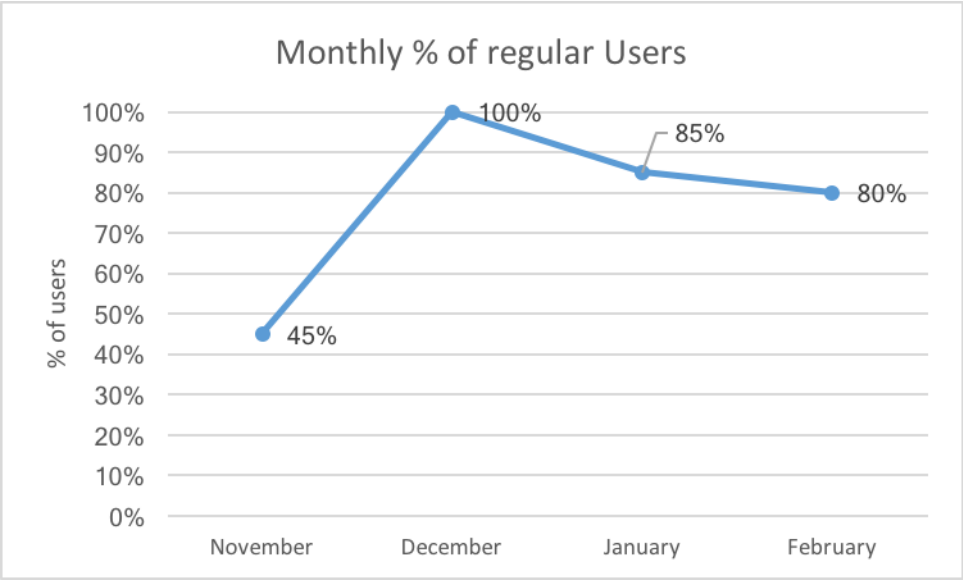


Figure 41: % of regular school users in the German pilot

Next, we wanted to see how frequently the school users interacted with the main screens of the awareness application described in Section 3.2. In Figure 42 we show the average monthly app interactions which reveal that the school users have interacted most frequently with the Comfort page, followed by the Tips page and the "Savings and Goal visualization" pages. We see that the average values are much higher than in the household pilot, but this of course is also explained by the fact that the awareness application in the school is used by many children who belong to the same classroom. We see, however, that the students are mostly interested to see their savings in relation to comfort with over 51 average visits per month, as well as that they are interested to learn how to save energy with over 34 tips[16] read over the course of the month. Overall, this can be considered a very good sign of user engagement in the schools.

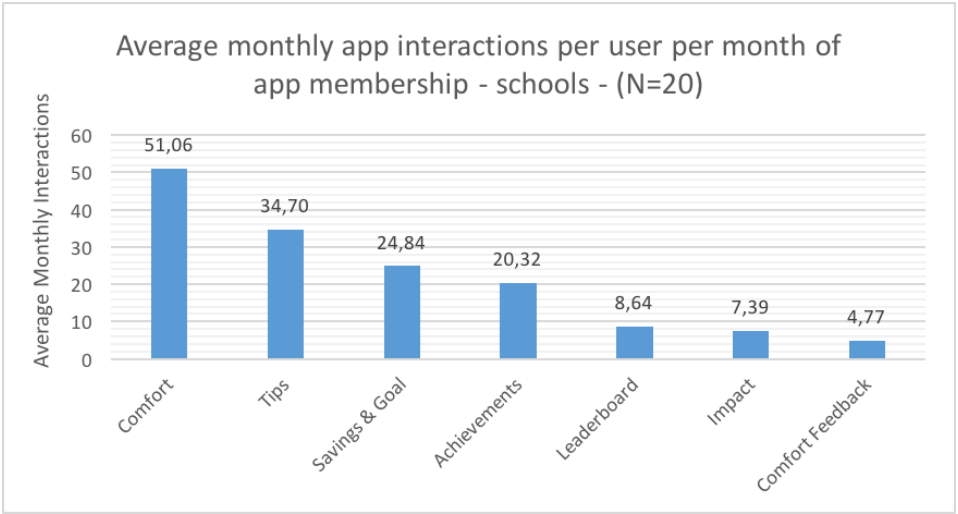


Figure 42: Average monthly interactions with the main pages of the Awareness application by school users in the German pilot (ordered by frequency)

Users collect points for different actions that they perform in the application. Based on the number of points, users receive badges in three categories. Each can receive up to 14 badges for the various achievements – learning, saving energy and profiling. Figure 43 shows the badges obtained by school users

[16] The tips page contains multiple tips that can be read by the user by swiping through them. Therefore, the number for this metric is calculated by adding the number of times a user has read the tips and the number of tips that were read by the user.

in Germany. We see that what concerns learning, most users have obtained the trainee badge and 40% have obtained the apprentice badge; whereas what concerns energy saving, all users have obtained the starter badge and 40% have obtained the moderate energy saving badge[17].

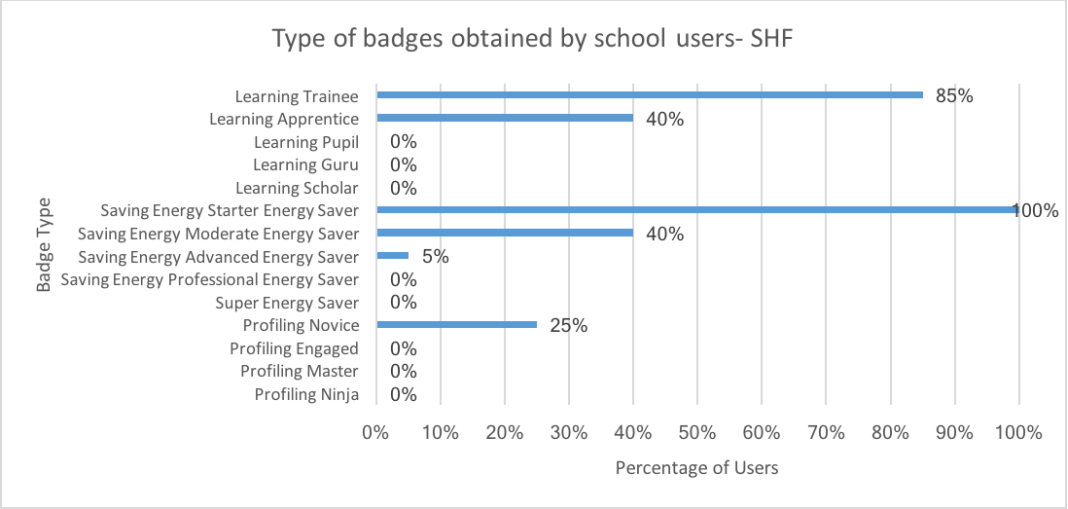


Figure 43 Badges obtained by school users in the German pilot

5.2.2 Swiss Pilot – School

In the Swiss school pilot, there are 5 classrooms involved in the Awareness app usage from one primary school. The pilot in the school in Switzerland started in September 2018 with the start of the school year. All the users started using the awareness application in the same month, so in Figure 44 we show the % of regular users accessing the awareness application in the months since the start of the pilot. From the figure, we can see that the engagement is quite variable through the course of the pilot: there are some months in which almost all classes used the awareness application, whereas in December and February the engagement has been low. Usage pattern shows periods of intense usage and those of low activity repeatedly following each other. This is an interesting observation and if it persists throughout the pilot could be an interesting finding, since it could suggest that continuous usage throughout the pilot is not always necessary for maintaining user engagement. It can be the case that in the German pilot the schools are a bit more motivated as there are two schools competing with a total of 20 classes and this might be more interesting, whereas in Switzerland there are only 5 classes competing with each other.

[17] Energy saving badge is the same for the whole school, as the children are saving energy not only in the classroom, but in the whole school. As there are two schools in the pilot, they are competing against in each other in this category.

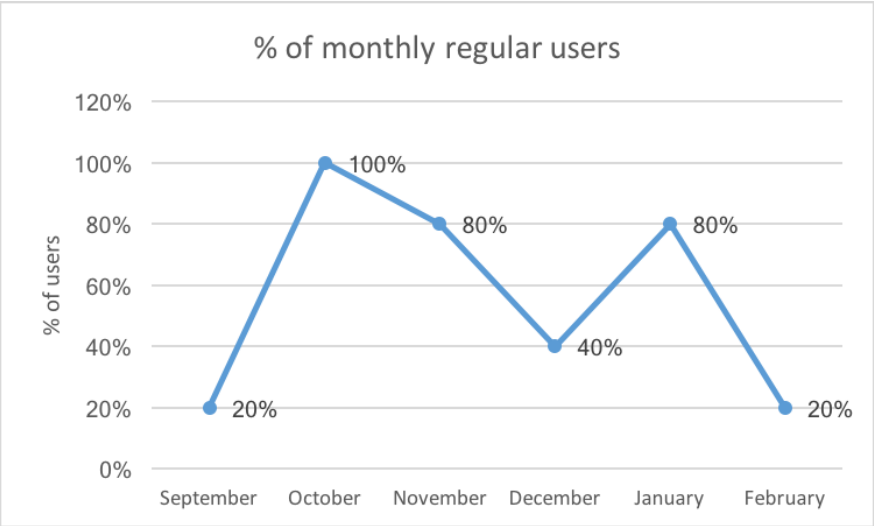


Figure 44: % of regular school users in the Swiss pilot

Next, we wanted to see how frequently the users interacted with the main screens of the awareness application described in Section 3.2. In Figure 45 we show the average monthly app interactions which reveal that the school users have interacted very frequently with the Consumption page, followed by the Achievements page and finally the Tips pages. We see that the average values are lower than in the German pilot, with slightly over 6 average monthly interactions for consumption, over 4 for achievement and 3 for tips. This can be expected as there are fewer users in the Swiss pilot.

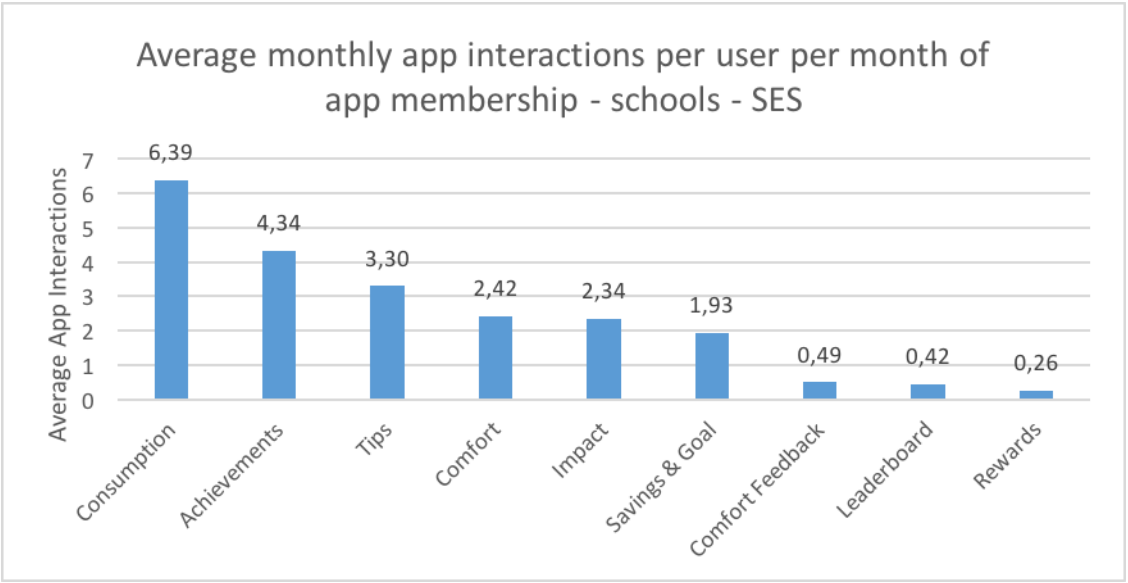


Figure 45: Average monthly interactions with the main pages of the awareness App in the school pilot in Switzerland (ordered by frequency)

Users collect points for different actions that they perform in the application. Based on the number of points, users receive badges in three categories. Each can receive up to 14 badges for the various achievements – learning, saving energy and profiling. School users in the Swiss pilot obtained so far few badges: 80% obtained the Learning trainee and 20% obtained the profiling novice. In contrast to the school in the German pilot, here the school has not yet obtained any energy saving badges which might also be due to possible differences of energy saving potential between the two school buildings.

5.2.3 Greek Pilot – School

In the Greek school pilot, there are 7 classrooms involved in the Awareness app usage from one vocational school. The pilot in the school in Greece started in December 2018 due to reasons reported in *D7.3 First validation report and data set*. All the users started using the awareness application in the same month, so in Figure 46 we show the % of regular users accessing the awareness application in the months since the start of the pilot. From the figure, we can see that although all users logged in to the application in December and almost all in February, none of the users have done so in January. This might be explained by the start of the pilot right before the holiday season.

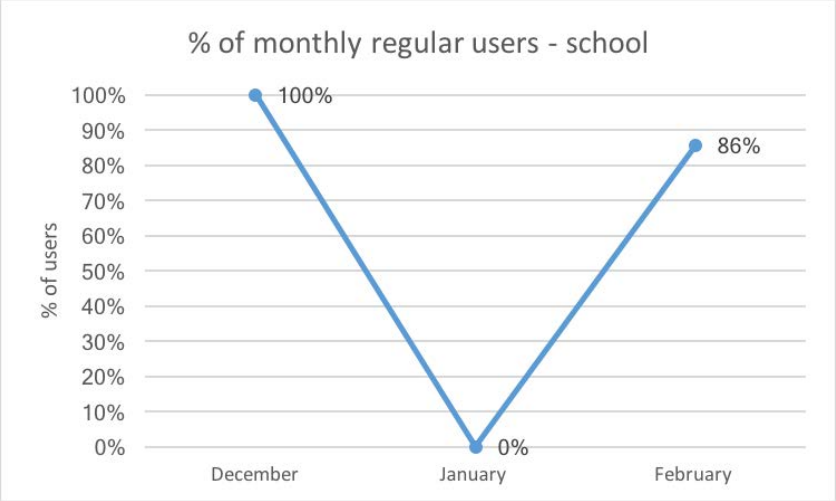


Figure 46: % of regular school users in the Greek pilot

Next, we wanted to see how frequently the users interacted with the main screens of the awareness application described in Section 3.2. In Figure 47 we show the average monthly app interactions which reveal that the school users have interacted most frequently with the "Savings and Goal visualization" page, followed by the Tips page and the Comfort page. We see that the average values are quite low overall, but the pilot has been going on just for three months and as previously seen the users were not active in January, so these values cannot be reliably analysed at this stage of this pilot.

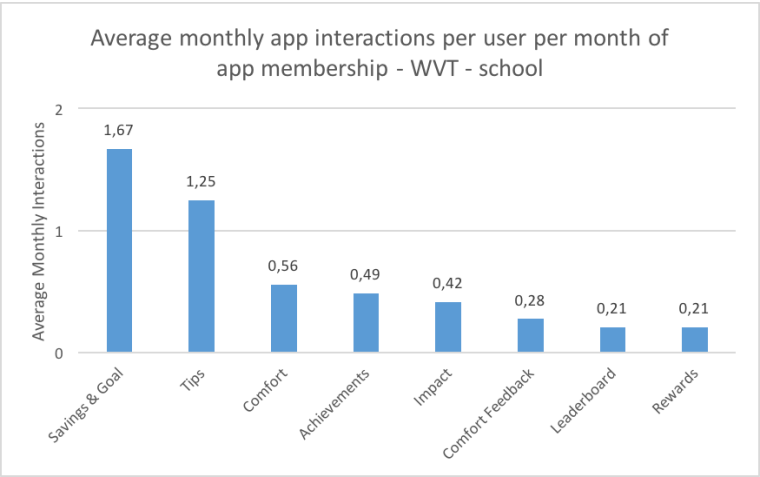


Figure 47: Average monthly interactions with the main pages of the awareness App in the school pilot in Greece (ordered by frequency)

Users collect points for different actions that they perform in the application. Based on the number of points, users receive badges in three categories. Each can receive up to 14 badges for the various

achievements – learning, saving energy and profiling. School users in the Greek pilot obtained so far very few badges: 2 out of 7 obtained the Learning trainee and all of the users obtained energy saver starter[18]. This again is likely due to the pilot having been running only a short period of time so far with users not being active in one out of three months.

5.3 Awareness Application Usage in Public Buildings

In this section, we show the main usage statistics for the usage of the visualization and Awareness application by the public building users as defined in Section 3.3. As the version of the Awareness application for the public buildings contains a different set of pages, here we present the usage results in an adjusted manner as compared to the ones reported about households in 5.1.1. The data available for the public buildings pilot ranges from the time the pilot started there (June in Germany and Switzerland and October in Greece) until 28.2.2019. As opposed to the households, here the usage of the application occurs in teams as defined in *D2.2 Final requirements*.

5.3.1 German Pilot – Public Building

In the German pilot, there are 3 teams in public buildings involved in the Awareness app usage. The pilot in the public building in Germany started in June 2018. All the users started using the awareness application in the same month, so in Figure 48 we show the % of regular users accessing the awareness application in the months since the start of the pilot. From the figure, we can see that the engagement is quite variable through the course of the pilot: in most months of the pilot all teams used the awareness application, whereas in September and January the engagement was a bit lower. This can be expected as the employees need to carry out their daily tasks and cannot consistently pay attention to the application which is likely to be influenced by the varying office workload.

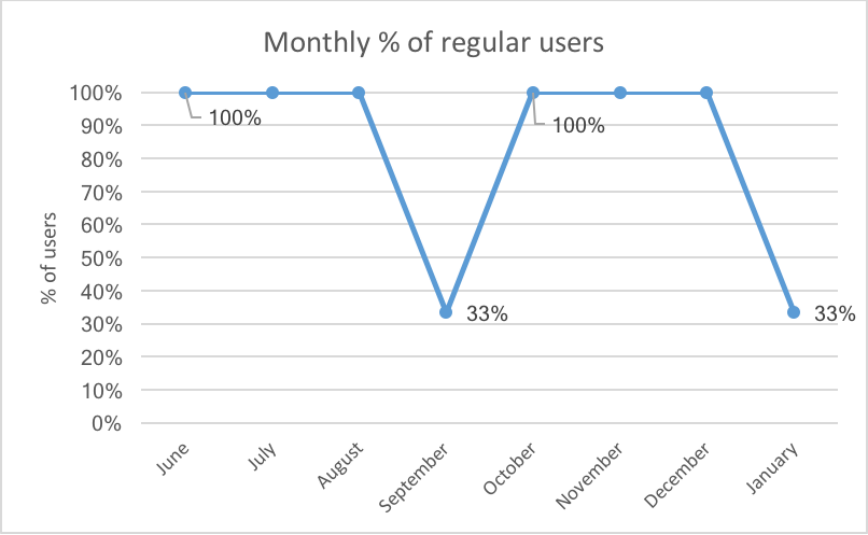


Figure 48: % of regular public building users in the German pilot

Next, we wanted to see how frequently the users interacted with the main screens of the awareness application described in Section 3.3. In Figure 49 we show the average monthly app interactions which reveal that the public building users have interacted most frequently with the Tips page, followed by the Comfort page and then "Savings and Goal visualization" page. They accessed these pages on average somewhat more than once a month, which is not a high number in absolute terms, but it may be a realistic result for the workplace setting where employees have work duties to perform. Overall, the usage so far

[18] Energy saving badge is the same for the whole school, as the students are saving energy not only in the classroom, but in the whole school.

shows a moderate engagement with the application which if it persists throughout the pilot could be considered a good result. One limiting factor may be the fact that there are only 3 teams competing with each other in this pilot, which might not be as challenging for the users as in a larger setting (similarly to what we observed in the difference between the larger and smaller school pilots).

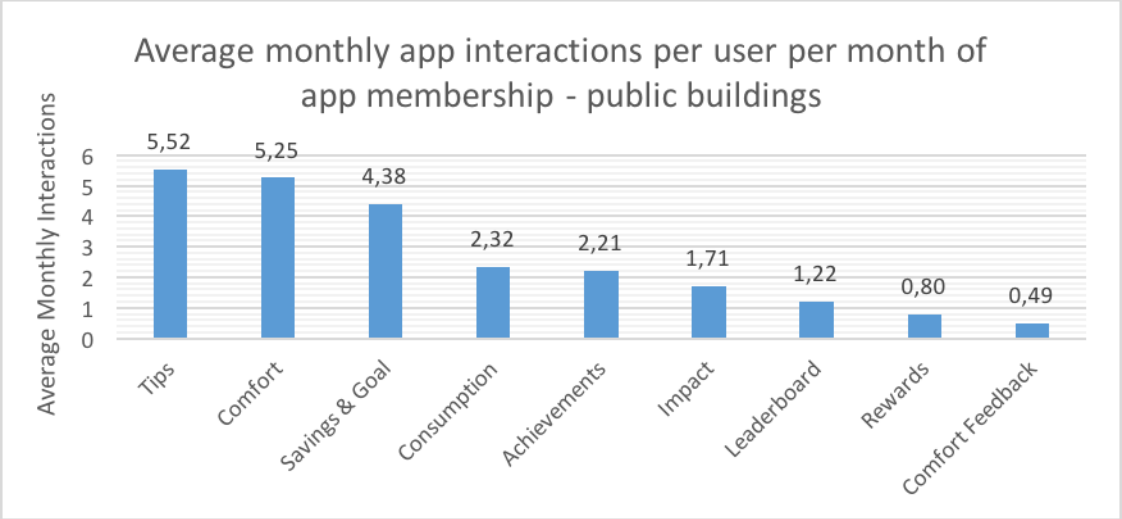


Figure 49: Average monthly interactions of public building users with the main pages of the Awareness Application in the German pilot (ordered by frequency)

Users collect points for different actions that they perform in the application. Based on the number of points, users receive badges in three categories. Each can receive up to 14 badges for the various achievements – learning, saving energy and profiling. Figure 50 reveals which badges users in the German pilot in public buildings obtained: we see that all obtained a learning trainee and 33% learning apprentice. Interestingly, they have received starter and moderate energy saver[19], which shows that they are capable of saving energy as a result of using the awareness application.

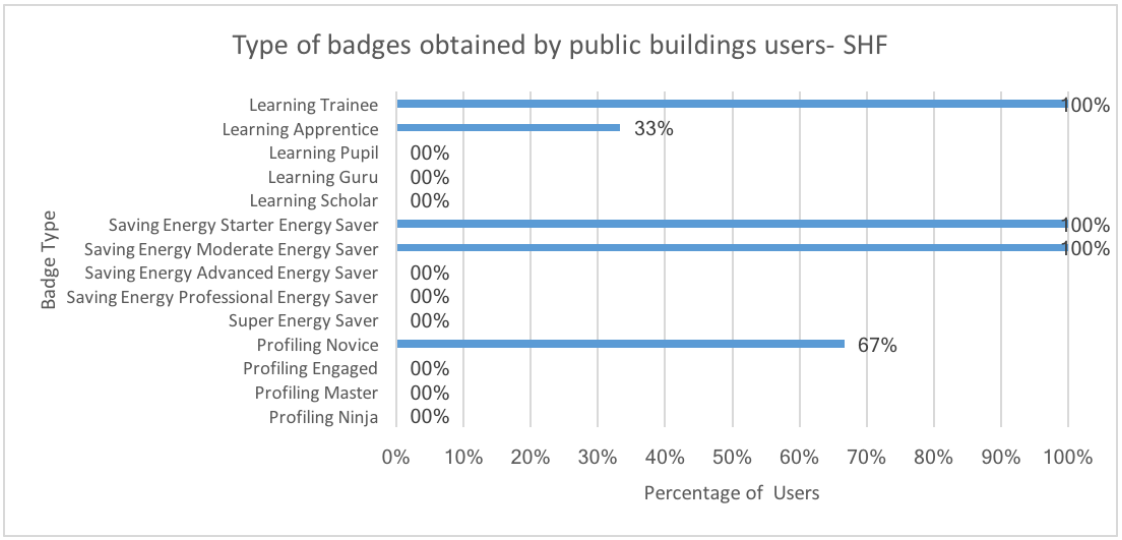


Figure 50: Types of badges received by public building users in the German pilot

[19] Energy saving badge is the same for the whole buildings, the employees are not only saving energy in their office, but in the whole building.

5.3.2 Swiss Pilot – Public Building

In the Swiss pilot, there are 5 teams in public buildings involved in the Awareness app usage. The pilot in the public building in Switzerland started in June 2018. All the users started using the awareness application in the same month, so in Figure 51 we show the % of regular users accessing the awareness application in the months since the start of the pilot. From the figure, we can see that the engagement is a bit declining in this pilot: in the beginning the users seemed motivated to use the Awareness application, whereas in January and February only 40% regularly accessed the application. Though this can be expected, as the employees have work related duties to perform and they might forget to use the awareness application in their working routine, this is different to the observed usage pattern in the German pilot.

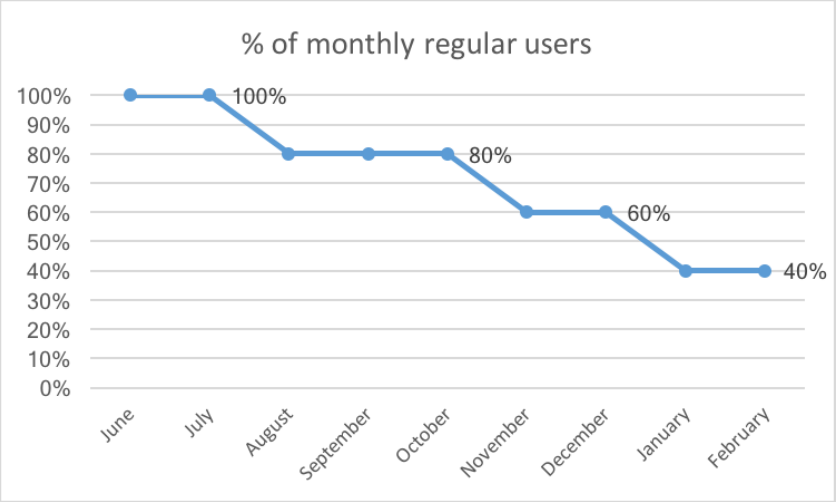


Figure 51: % of regular public building users in the Swiss pilot

Next, we wanted to see how frequently the users interacted with the main screens of the awareness application described in Section 3.3. In Figure 52 we show the average monthly app interactions which reveal that the public building users have interacted most frequently with the Comfort page, "Savings and Goal visualization" page and Achievements page. The number of times the users accessed these pages is very high which shows that the users have been very active in accessing these pages – on average 23 times the comfort page and 19.5 times the savings and goal page which can be considered a very good result. This is an interesting observation as it suggests a possible difference in patterns of usage intensity and continuity: while in the German case there was a lower level of usage intensity but a higher level of continuity, here we see a much higher level of usage intensity with declining continuity. If this pattern persists in the final evaluation, this could be an interesting finding informing future design approaches for addressing such different patterns of usage.

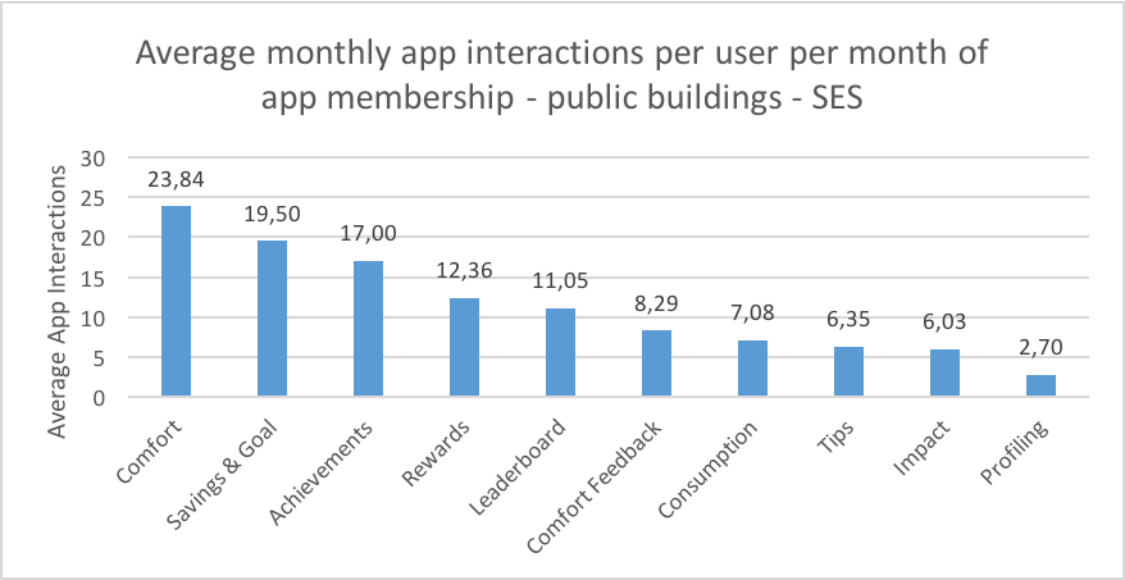


Figure 52: Average monthly app interactions by public users in the Swiss pilot (ordered by frequency)

Users collect points for different actions that they perform in the application. Based on the number of points, users receive badges in three categories. Each can receive up to 14 badges for the various achievements – learning, saving energy and profiling. Figure 53 reveals that the users in the public building in Switzerland have obtained learning trainee (100%) and learning apprentice badges (80%), as well as profiling novice (100%) and profiling engaged (40%), however they have not yet obtained any energy saving badges yet.

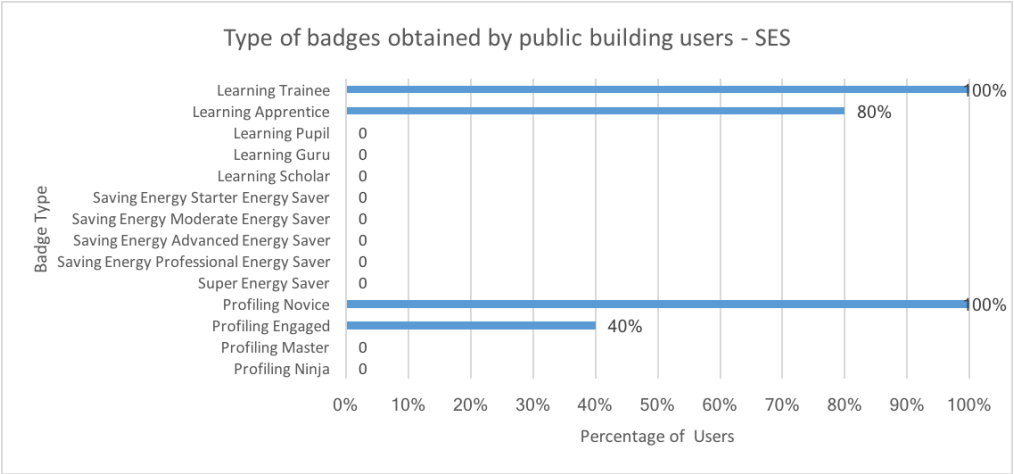


Figure 53: Types of badges obtained by public building users in the Swiss pilot

5.3.3 Greek Pilot – Public Building

In the Greek pilot, there are 8 teams in three public buildings involved in the Awareness app usage. Due to the reasons reported in *D7.3 First validation report and data set* the pilot in the public buildings in Greece started in October 2018. All the users started using the awareness application in the same month, so in Figure 54 we show the % of regular users accessing the awareness application in the months since the start of the pilot. From the figure, we can see that the engagement in this pilot is overall high with 63-75% of users engaged in each month, with the exception of January where only 25% of users accessed the application. This might be due to the shift in the festivity season in Greece (orthodox festivities going well into January) as well as to the variability in the intensity of the workload.

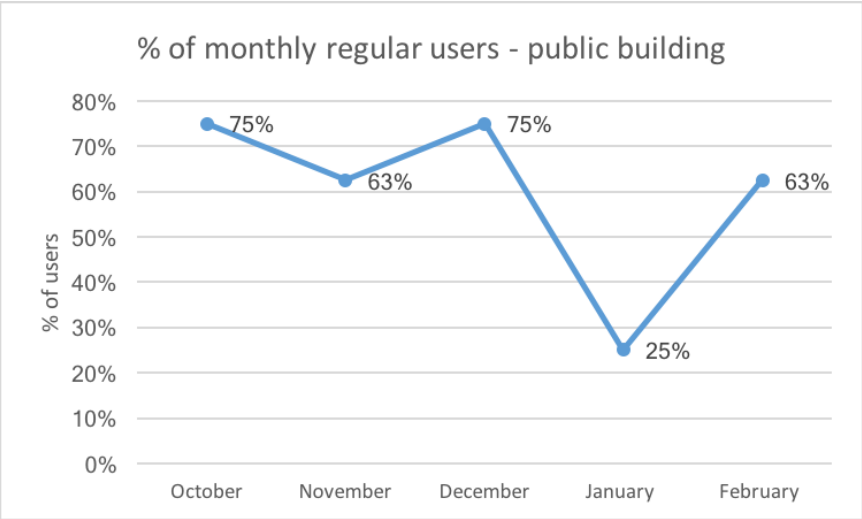


Figure 54: % of regular public building users in the Greek pilot

Next, we wanted to see how frequently the users interacted with the main visualizations and pages of the awareness application described in Section 3.3. In Figure 55 we show the average monthly app interactions which reveal that the public building users have interacted most frequently with the Tips page, followed by the Comfort page and then the "Savings and goal visualization" page. Here we see that the users accessed these pages on average somewhat over once a month, which is not a high number in absolute terms, but it may be a realistic result for the workplace setting where employees have work duties to perform. Overall, the usage so far shows a moderate engagement with the application which if it persists throughout the pilot could be considered a good result.

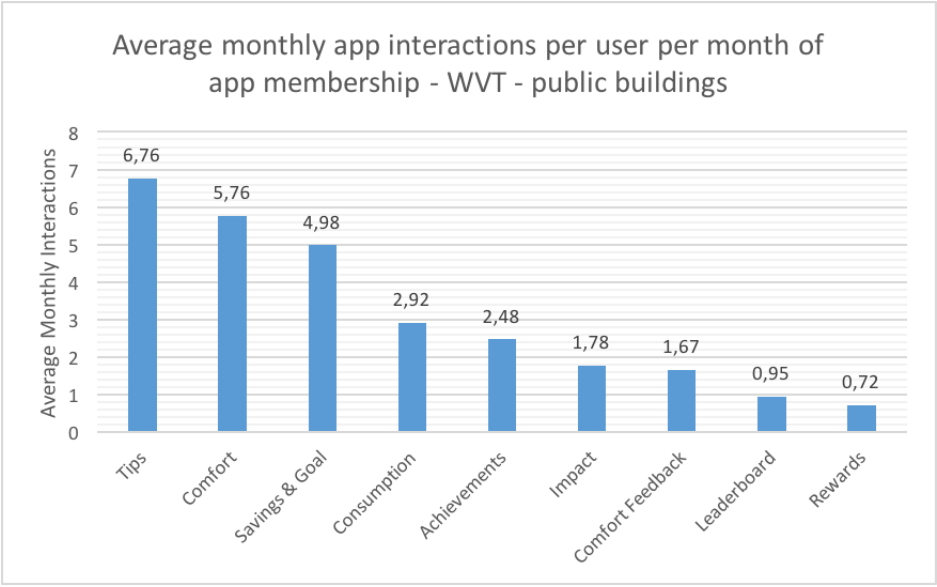


Figure 55: Average monthly app interactions of the public building users in the Greek pilot (ordered by frequency)

Users collect points for different actions that they perform in the application. Based on the number of points, users receive badges in three categories. Each can receive up to 14 badges for the various achievements – learning, saving energy and profiling. Figure 56 reveals that the users in the public building in Greece have received learning trainee badge (75%), energy saver badge (13%) and profiling novice badge (38%). Overall, users have not received many badges yet. This is different from the German and Swiss public building pilots and if it persists till the end of the pilot it could point to possible differences between the three settings.

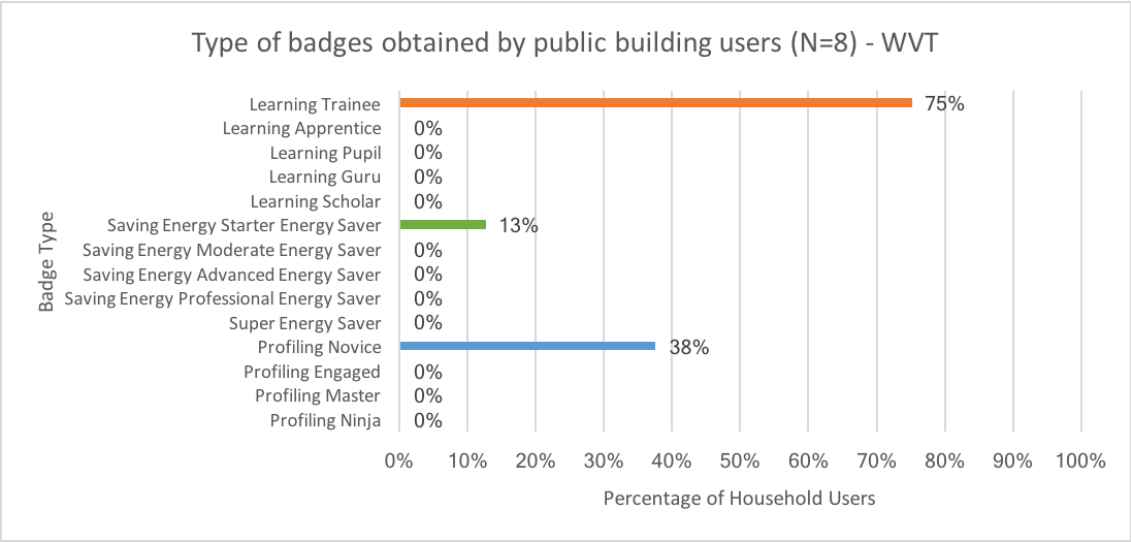


Figure 56: Types of badges received by public building users in the Greek pilot

6 CONCLUSIONS

Overall, the final visualizations and feedback interfaces have been successfully developed in a user-centered design process: they have been adapted several times to make them more understandable and engaging for the users. The feedback collected from the users during the crowd tests reported in *D5.3 First visualization and feedback interfaces and behavioural game concept* was taken into account for the development of the final versions. The observed preliminary usage results show the suitability of the developed and deployed final versions of the visualizations and the integrated enCOMPASS awareness app.

The implementation of the awareness application has been adapted both for the Android and the iOS versions, as well as translated into three languages: German, Greek and Italian. The application and the visualizations have also been adapted for use in the schools and the public buildings. Specific materials have been developed for the integration of the usage of the awareness application in the classrooms (for the school pilot).

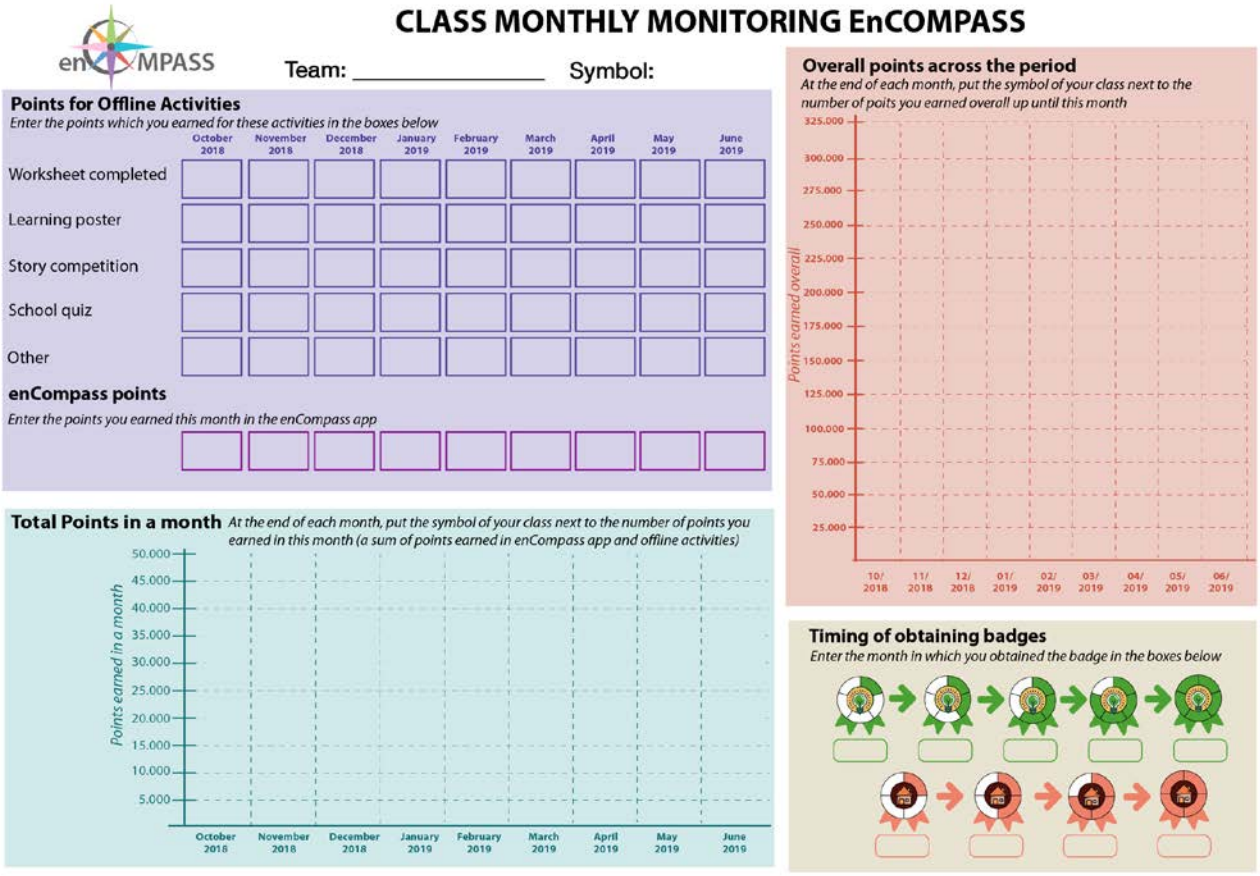
The usage statistics of the awareness application reveal that a range of 60-78% users across all pilot locations are regularly (at least once every month) logging in to the Awareness application, which is a good result considering that the application needs to be integrated with their daily life (households), learning (schools) and work settings (public buildings). At the same time, the pages the users interact most frequently are: Tips page where they can read energy saving tips, “Savings and Goal visualization” page where they can set and monitor their energy savings goal and Comfort page where they can view their comfort in relation to the achieved savings. Our analysis shows that the users are accessing these pages in a range of 9-20 times a month depending on the pilot. The school users are quite variable with a range of 2-50 times a month, and public building users are in a range of 4-24 times a month. Overall, we can consider this a very good result, showing that the visualizations that have been developed and deployed in the enCOMPASS awareness application are effective in engaging the users.

In all pilots, the users are mainly motivated by the environmental considerations to save energy, with only a few in the German and the Greek pilot are motivated by monetary and hedonic motivations, which is also reflected in their use of the corresponding impact visualizations. Most of the users preferred the visualizations that depicted their motivations (e.g. users who are motivated by environmental concerns also accessed more frequently the visualization that depicts environmental impact), although some users also switched between the visualizations.

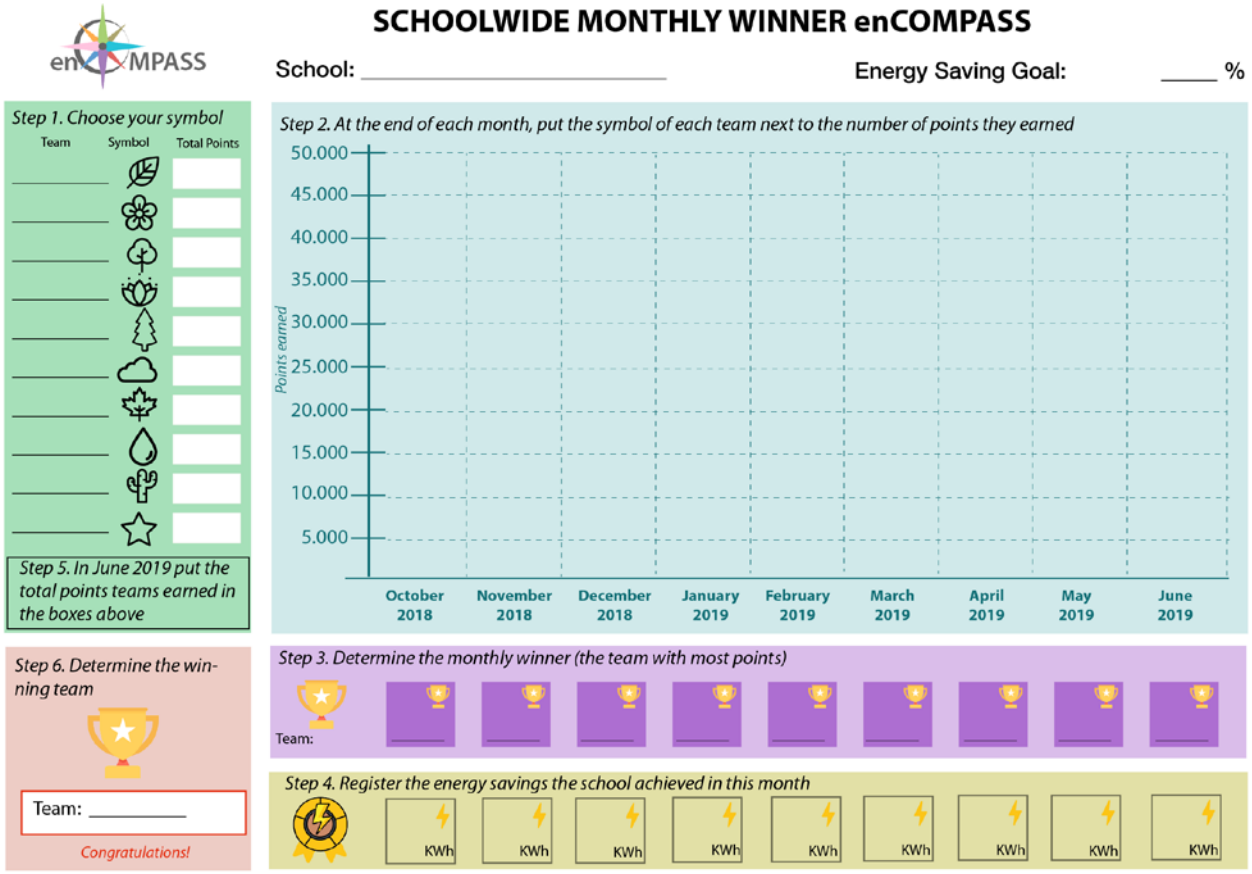
Overall, the activity of the household users is roughly comparable across pilots, whereas in the school and public building pilots there are some differences: users seem to be more active in the school pilot in Germany and in the public building pilot in Switzerland. There also seem to be some differences in the usage patterns, which if they persist till the end of the pilots could provide interesting research findings for informing future design of such systems. Overall the reported preliminary observations of usage of the awareness app show that the users are indeed using the developed visualizations to monitor their consumption and save energy, i.e. that these are considered useful (a detailed analysis and evaluation including the comparison of the achieved energy savings is subject of D7.4 *Final overall validation and feedback report*).

7 APPENDIX

Appendix 1 Poster for the school users to monitor their progress in the classroom



Appendix 2 Poster for the school users to monitor the competition in the school.



Appendix 3 Quiz used to determine student's energy related knowledge

NAME: _____ **enCOMPASS QUIZ**
Class:

Please answer the questions below:

Mark the answers that you think are correct with a cross.

1. How important is it to save energy in school and at home?

◯ It's not so important because energy does not cost a lot.
◯ It's important because the production of energy pollutes the environment.
◯ I don't know why it is important.
◯ It's not important because saving energy means losing comfort. _____/1 point

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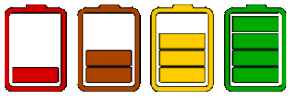
2. What happens if you turn the tablet off after you use it?



◯ The battery will last longer.
◯ The battery will run out faster.
◯ It doesn't make a difference.
◯ I don't know. _____/1 point

---

3. What is the difference between a battery and an accumulator?

◯ Both are the same.
◯ An accumulator is a re-chargeable battery, a normal battery is one-use only.
◯ Both store electric energy but the battery is more environmentally friendly.
◯ I don't know. _____/1 point

---

4. What does no-load loss mean?

◯ It's the time you lose when you forogt to charge your phone the night before and you are now waiting for it to recharge.
◯ It's the energy you lose when keeping a charger plugged in without charging anything.
◯ I don't know. _____/2 points

5. It is hot in summer and you want to take a shower.
But you also want to save energy.
What is the best thing to do?

◯ I take a hot shower.
◯ I take a cold shower.

NAME: _____ enCOMPASS
Class: QUIZ

◯ I don't know. _____/2 points

6. Look at the three pictures underneath. You see a tablet, a fridge and a laptop.

Compare the three items.

In one day: which one uses the most, some and the least energy?

Give each one a number:

1 = This item uses the most energy.

2 = This item uses some energy.

3= This item uses the least energy. _____/2 points

1,2 or 3? ☐ **The tablet**

1,2 or 3? ☐ **The fridge**

1,2 or 3? ☐ **The laptop**

---

7. You are hungry and you go to the fridge. *What do you do?*

◯ **FIRST: I open the fridge and look at the food. THEN: I decide what I want to eat and take it out.**

◯ **FIRST: I decide what I want to eat. THEN: I open the fridge and take it out.**

◯ I don't know.

_____/2 points

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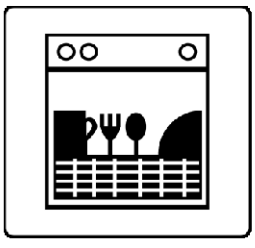
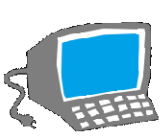
8. What should you avoid when using the dishwasher?



◯ **Filling it up as much as possible before running it.**
◯ **Running it half-empty.**
◯ **Stopping the dishwasher before the drying programme and letting the air dry the dishes.**
◯ I don't know.

_____/2 points

NAME: _____ **enCOMPASS**
Class: **QUIZ**




9. Your friend wants an electric toy for his/her birthday. Which statement is correct?

◯ Electronic toys are more fun than normal toys. It's good to buy them.
◯ Electronic toys use batteries, wires and plastic, which can be harmful for the environment. It would be better to avoid buying them.
◯ Since electronic toys only use very little energy, they don't do much harm to the environment. It's ok to buy them.
◯ I don't know.

_____/2 points

---

10. It is winter. What is the bettter solution for your heating system if you want to keep every room at its right temperature?

◯ Keeping the doors of the rooms closed means the warm rooms stay warm and the cool rooms stay cool withouth the heater having to work so hard.
◯ Keeping all the doors open so the warm air can travel freely through the flat, heating every room equally.
◯ I don't know.

_____/2 points

---

11. How can we as students help our school to save energy?

◯ Saving energy at school is something us students can't influence.
◯ Only if the principal of the school says so, we can reduce the energy consumption of the school.
◯ We can do small things every day that add up over time, thus making an important change to the school's energy consumption.
◯ I don't know.

_____/2 points

12. Class is finished and everyone is leaving the classroom. You are the last person still in the room. Who is responsible to turn off the lights in your classroom?

◯ My teacher. ◯ Me. ◯ No one. ◯ I don't know.

_____/1 point