Project reference: *2015-1-LU01-KA202-001353*

Project acronym: BIM4VET

Project title: Standardized Vocational Education and Training for BIM in EU

KA2- Cooperation for Innovation and the exchange of good practices strategic partnerships for vocation education and training

IO6. ASSESSMENT REPORT OF THE TANGIBLE DEVICE EXPERIMENTATION

Dissemination level	Public
Activity	6 – Report of the tangible tabletop device experimentation
WP Leader	LIST
Contributor(s)	Cardiff University, CEA
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Status (F: final, D: draft)	F

Erasmus+

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History

Version	Description	Lead author	Date
1.1	First version of the protocol	Valérie Maquil, Annie Guerriero	11/02/2018
1.2	Second version of the protocol	Valérie Maquil, Annie Guerriero	29/03/2018
1.3.	First version of the results	Valérie Maquil	03/04/2018
1.4.	Complete version of the report	Valérie Maquil	16/04/2018
1.5.	Review and corrections	Annie Guerriero	18/04/2018
1.6	Final version	Valérie Maquil	20/04/2018

Diffusion

Version	Sent to	Date
1.1	All consortium partners	11/02/2018
1.2	All consortium partners	29/03/2018
1.3.	All consortium partners	03/04/2018
1.4.	All consortium partners	16/04/2018
1.5.	All consortium partners	18/04/2018
1.6.	All consortium partners	20/04/2018

Acknowledgements

BIM4VET has received funding from the Erasmus+ programme (*Key Action: Cooperation for innovation and the exchange of good practices, Action Type: Strategic Partnerships for vocational education and training).*

The partners of the project are LIST, Cardiff University, and Commissariat à l'Energie Atomique et aux Energies Alternatives.

Acronym

BIM	Building Information Modeling
TAM	Technology Acceptance Model
TUI	Tangible User Interface

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1. Context of the user study

To evaluate the BIM4VET application developed as IO5, we conducted three experiments in parallel at the three locations: Luxembourg, Cardiff and Paris.
For each of the locations, we used the same BIM4VET application as well as the same protocol.

2. Method

2.1. Participants

At each of the locations, we invited two groups of 3 persons. Participants were either professionals from the construction sector or researchers that got an introduction on BIM.

2.2. Materials

To prepare the **BIM4VET application,** we created a new construction project in the database and defined requirements. In addition, we created three different user profiles on the BIM4VET web portal (see IO3 report for more details) with different maturity levels with regard to their BIM responsibilities. The user profiles correspond to three different BIM roles, previously identified in the project: BIM coordinator, BIM manager, BIM author.

At each of the three locations, we setup an experiment room.

The BIM4VET application was deployed on a MultiTaction MT555UTB installed at the center of the room. The objects were placed on the border of the table embedding the tangible tabletop.

An **additional screen** was setup in front of the table to provide a series of tasks to the participants.

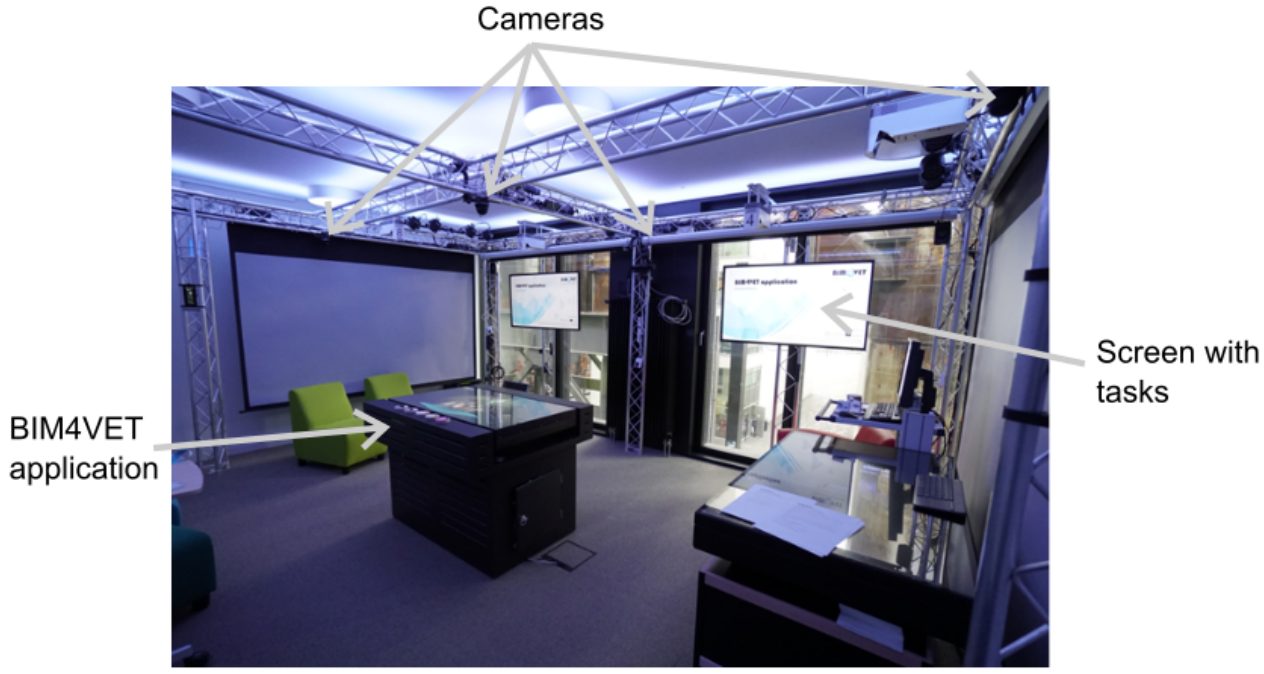

Figure 1: Setup of the experiment room in Luxembourg

We installed up to 5 **cameras** distributed across the room:

- On top of the table (all locations),
- In front of the table (only in Luxembourg),
- At the back of the table (only in Luxembourg),
- At the right of the table (only in Luxembourg),
- At the left of the table (only in Luxembourg).

In one of the locations (Luxembourg) we further life streamed the video data to a computer outside the experiment room. This way, two researchers could observe the activity from the outside, avoiding direct observations of the participants as well as intermediate questions. Sound was transmitted through an additional microphone and headphones.

Figure 2: Two researchers observed the activity through a life stream of the cameras and sound.

We prepared three different **persona cards** according to the profiles defined in the database. Each of the cards contains the name of the persona, sociodemographic information, as well as information on the professional experience, personality, objectives and general BIM maturity.

Figure 3: One of the three personas created for the experiment.

We printed the cards and inserted them in plastic covers attached to a lanyard to allow participants to hang them around their neck. Through this, we wanted the participants to have the cards always ready at hand, but to avoid having the table cluttered with additional material.

Figure 4: The 3 persona cards inserted into plastic covers attached to a lanyard

We defined a scenario, and specified a series of **tasks** around the scenario. Aim of the tasks was to integrate the different interaction possibilities related to the BIM4VET application in a meaningful context. While some tasks only had one correct answer, some were open-ended allowing participants to discuss and take a decision taking into account their role.

Scenario: *"You are a group collaborating on an upcoming BIM project: the future planetarium of Belval, called "Millenium". For this project, certain BIM responsibilities are needed. The client has already encoded them in the system. You are all rather new to BIM and want to participate to BIM trainings to ensure you have all the required skills in your group. Before the meeting, you have already encoded your profile to the database"*

Task Number	**Instruction**
0	Familiarize yourselves with your profile For each team member: Where do you live? What is your BIM profile?
1	View your current BIM responsibilities For each team member: for which responsibilities do you have at least the level "competent"?
2	View the project dashboard How many BIM responsibilities are not sufficiently elaborated in your group?
3	Select your expected BIM responsibilities Modify the expected maturity level of your BIM responsibilities to cover the project needs: • Decide in your group who focusses on which skill gap
4	Configure the filter criteria Configure your filter criteria: • @Luke: choose local trainings costing ~ 500 – 1500 € • @Leia: choose local trainings costing ~ 100 – 1200 € • @Han: choose local and abroad trainings costing ~ 100 – 750 €
5	View recommended training courses How many training courses are recommended to your group? In which countries are they located? For each team member: Choose one of the training course which is most recommended: What is its title? How much does it cost?
6	Select the training courses For each team member, subscribe to this training course.
7	View the expected maturity level of the group Are now all BIM responsibilities covered for your project? If not, which ones are still missing?

As with the persona cards, we decided against printing the tasks on a sheet of paper. On one hand, this was to limit the amount of additional artefacts participants need to manipulate during the experiment. On the other hand, we wanted to avoid that one of the participants takes over the role of "reading tasks" aloud, which might have an impact on the collaboration experience around the table.

Due to these reasons, we decided to create slides and show them on the separate screen. On each slide only one task was presented. That way, all participants can easily read and track the current instructions and they do not need to worry about organising their artefacts on the tabletop.

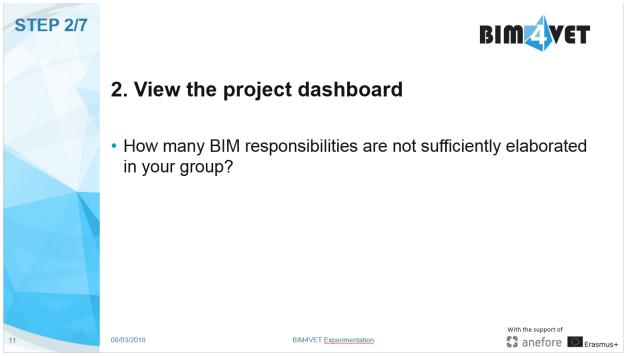

Figure 5: Example of a task presented on a slide.

Furthermore, we prepared a questionnaire based on the TAM3 (Venkatesh 2008) questionnaire. TAM3 is an extension of the technology acceptance model which was developed and introduced by Fred D. Davis (1989) and uses Perceived Ease of Use (PEU), Perceived Usefulness (PU) und Intention to Use (IU) as main constructs impacting acceptance. TAM3 proposes 13 different determinants, out of which we chose 6 suitable for our context: Job relevance, Output Quality, Result demonstrability, Perceptions of external control, Perceived enjoyment, and Objective usability.
We prepared the questionnaire using google forms and setup three computers to allow participants to fill them out directly after the experiment. Each of the constructs (except Objective usability) were measured through 3-4 items, that participants had to rate on a 5-point likert scale (strongly disagree, disagree, undecided, agree, strongly agree).

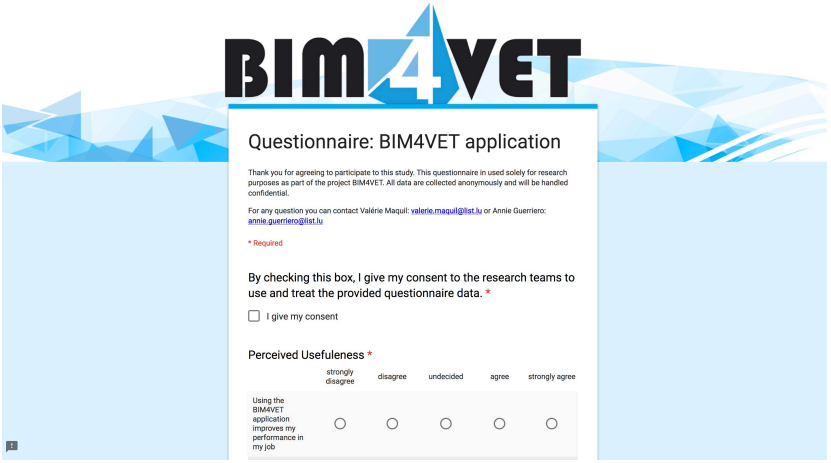

Figure 6: The questionnaire on BIM4VET application is provided online.

2.3. Procedure

Before starting with the experiment, we provided the participants an information sheet explaining the aim of the experiment, its context, what data is collected and how it is treated and stored. They were also informed about their rights to withdraw from the experiment at any time and ask for deletion of the data. After that they were asked to sign a consent form.

Then, participants were provided an introduction to BIM, an explanation on the background and purpose BIM4VET application, as well as an overview of the procedure of the experiment. In particular they were requested to familiarize themselves with their roles, then follow the tasks on the screen. Answers to the questions should be said out aloud. When finished with the task, they should

make a sign in the camera, and the research would put the next slide. This introduction took about 5 min. No information on how the table should be used was given.

Next followed the actual experiment. The participants took one of the persona cards, go progressively through the tasks, following the instructions, and then go to the next task.

The researchers switched on the camera(s) and observed to take notes with regard to:

- If the tasks could be successfully completed,
- If not, which errors have been made,
- The start and end time of each task,
- Observations with regard to how the tasks have been solved.

At the end of the experiment, participants were invited to fill in the questionnaire provided on the computer.

After the experiment, observations were completed and verified by means of the collected video data.

2.4. Measures

As part of the experiment, we focused on the following measures and indicators, collected through the questionnaire as well as observations and video analysis.

Measure	**Description**
Perceived usefulness	The degree to which a person believes that using the BIM4VET application would enhance his/her job performance (Davis, 1989). This measure is evaluated in a questionnaire provided at the end the experiment.
Job relevance	The degree to which an individual believes that the BIM4VET application is applicable to his or her job (Venkatesh & Davis, 2000). This measure is evaluated in a questionnaire provided at the end the experiment.
Output quality	The degree to which an individual believes that the BIM4VET application performs his or her jobs well (Venkatesh & Davis, 2000) This measure is evaluated in a questionnaire provided at the end the experiment.
Result demonstrability	The degree to which an individual believes that the results of the BIM4VET application are tangible, observable, and communicable (Moore & Benbasat, 1991). This measure is evaluated in a questionnaire provided at the end the experiment.
Perceived ease of use	The degree to which a person believes that using the BIM4VET application will be free of effort (Davis, 1989). This measure is evaluated in a questionnaire provided at the end the experiment.
Perceptions of external control	The degree to which an individual believes that organizational and technical resources exist to support the use of the BIM4VET application (Venkatesh et al. 2003). This measure is evaluated in a questionnaire provided at the end the experiment.
Perceived enjoyment	The extent to which the activity of using the BIM4VET application “is perceived to be enjoyable in its own right, aside from any performance consequences resulting from system use” (Venkatesh, 2000, p. 351). This measure is evaluated in a questionnaire provided at the end the experiment.

Objective usability	A “comparison of systems based on the actual level (rather than perceptions) of effort required to completing specific tasks” (Venkatesh, 2000). A usability score is calculated based on the success rate.
Behavioral intention to use	“The degree to which a person has formulated conscious plans to perform or not perform some specified future behavior” (Warshaw & Davis, 1985) related to the use the BIM4VET application.
Success rate	Percentage of the tasks that could be completed.
Task time	Total time to accomplish the tasks

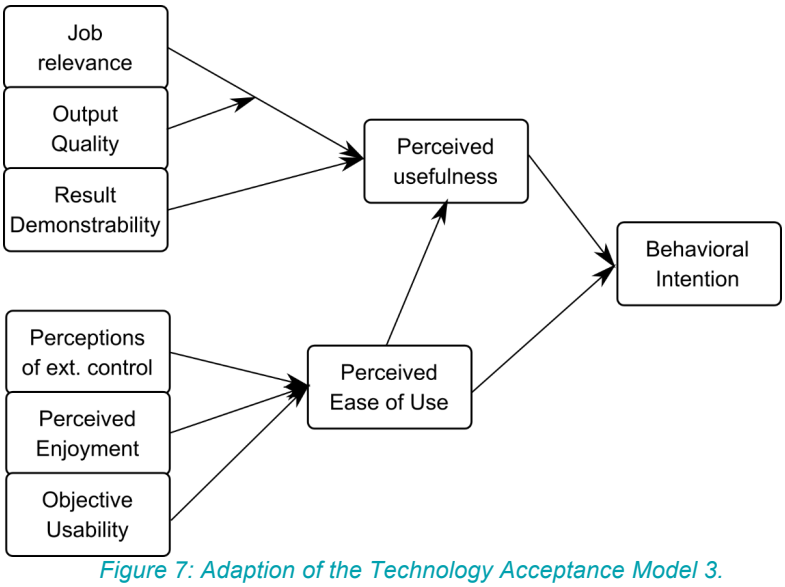

Figure 7: Adaption of the Technology Acceptance Model 3.

2.5. Pilot study

To test the protocol, we conducted a pilot study with one group of three participants in Luxembourg. The pilot study showed some minor problems with the task descriptions. For instance, we observed that the participants spend a lot of time reading their persona cards, trying to find the solution on the cards, without touching the table. After the study, the participants mentioned that it was not clear to them at what moment the actual activity on the tangible tabletop should begin. We adapted the task descriptions to clarify which tasks should be solved with which tools.

3. Results

In total, 7 groups of three participants took part of the study. The groups took between 13:14 minutes and 43:02 minutes to accomplish the tasks. For two groups (CEA), there were technical problems, and therefore not all tasks could be completed, which resulted in poor success rates.

Figure 8: Screenshot of the video recording made in Luxembourg (left) and Cardiff (right)

3.1. Participants' Background

Of the 21 participants, 1 indicated being <25 years, 11 between 25 and 34 years, 8 between 35 and 44, and 1 between 45 and 54 years. 4 participants were female and 17 male.

With regard to their position, 14 indicated being a researcher, 4 a BIM Manager, 3 an architect, 2 an engineer in construction, 1 a construction firm, 1 a software engineer, and 1 a modeler.

Furthermore, the experience in construction is rather equally distributed (2-7 in each category) and participants rating themselves as having no BIM expertise (6 participants) or being novice (5 participants) or advanced beginner (5 participants).

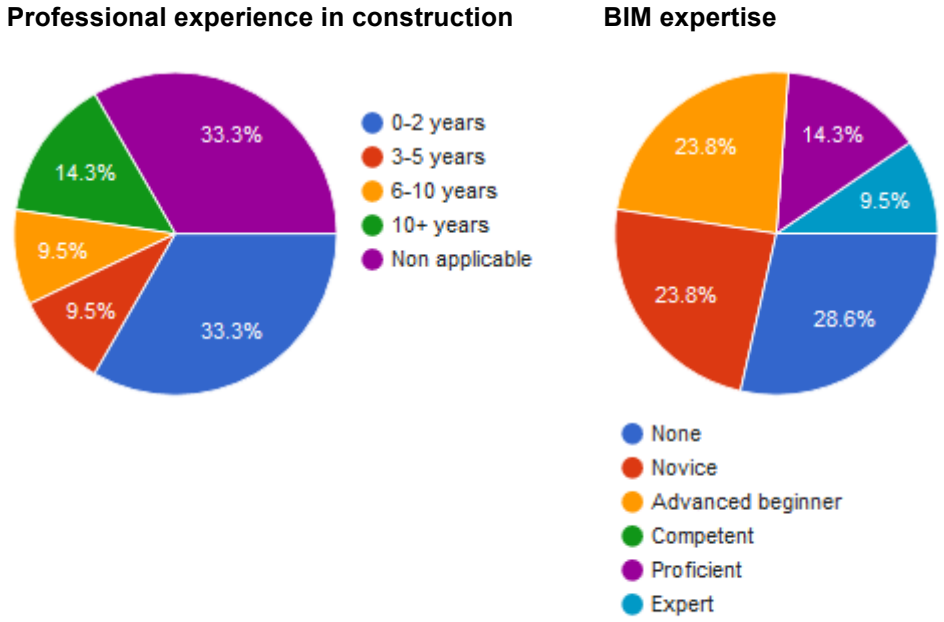

Figure 9: Professional experience in construction (left) and BIM expertise (right) by the participants

3.2. TAM 3 Questionnaire

The TAM 3 questionnaire returned an overall behavioral intention of 3.69 (SD: 1.20). Highest score received the perceived enjoyment (M: 4.14, SD: 0.88). Lowest was rated the output quality (M:

3.38, SD: 0.85) and the perceived usefulness (M: 3.38, SD: 1.20). Perceived ease of use was rated slightly higher (M: 3.55, SD: 0.81) as perceived usefulness (M: 3.38, SD: 1.20).

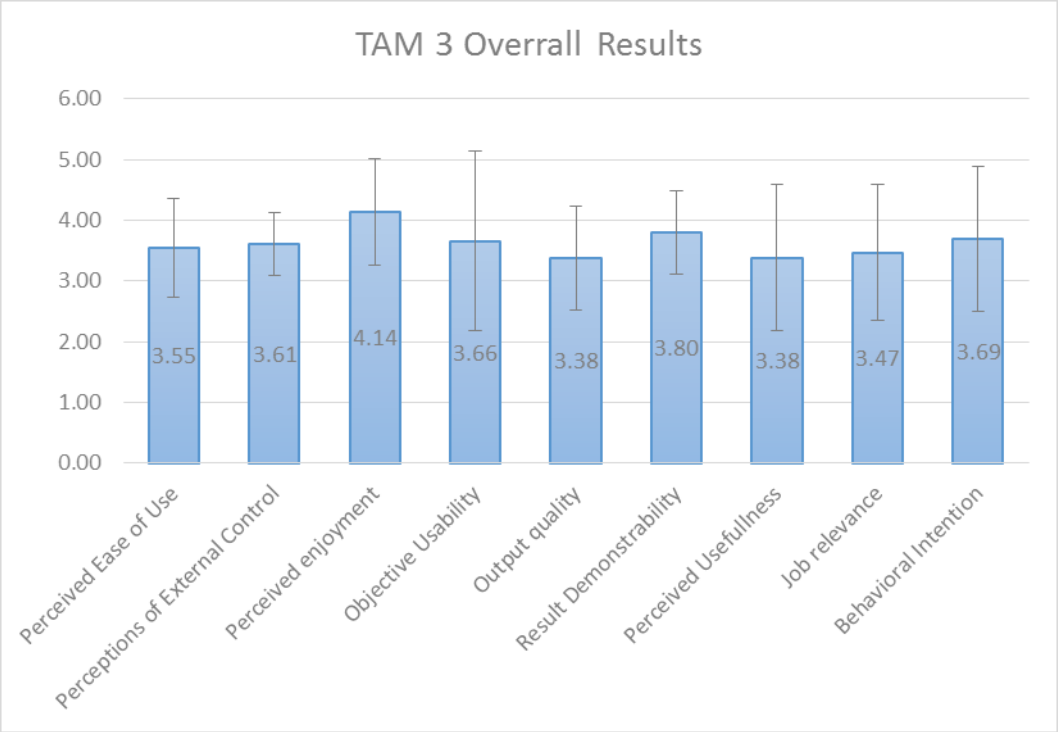

Figure 10: Results of the TAM3 Questionnaire

If considering the different locations of the studies (Luxembourg, Cardiff and Paris), we can see common differences. Except for job relevance, the system was rated on all categories best in Cardiff with scores between 3.78 (Job relevance) and 4.71 (Objective usability). In Luxembourg it obtained the second best scores between 3.37 (Output quality) and 4.41 (Objective usability). Lowest score was given in all categories in Paris, with ratings between 1.47 (Objective usability) and 3.56 (Perceived enjoyment). This low score in Paris can be explained through the technical problems (i.e. related to limitations of the internal IT infrastructure), due to which not all tasks could be completed.

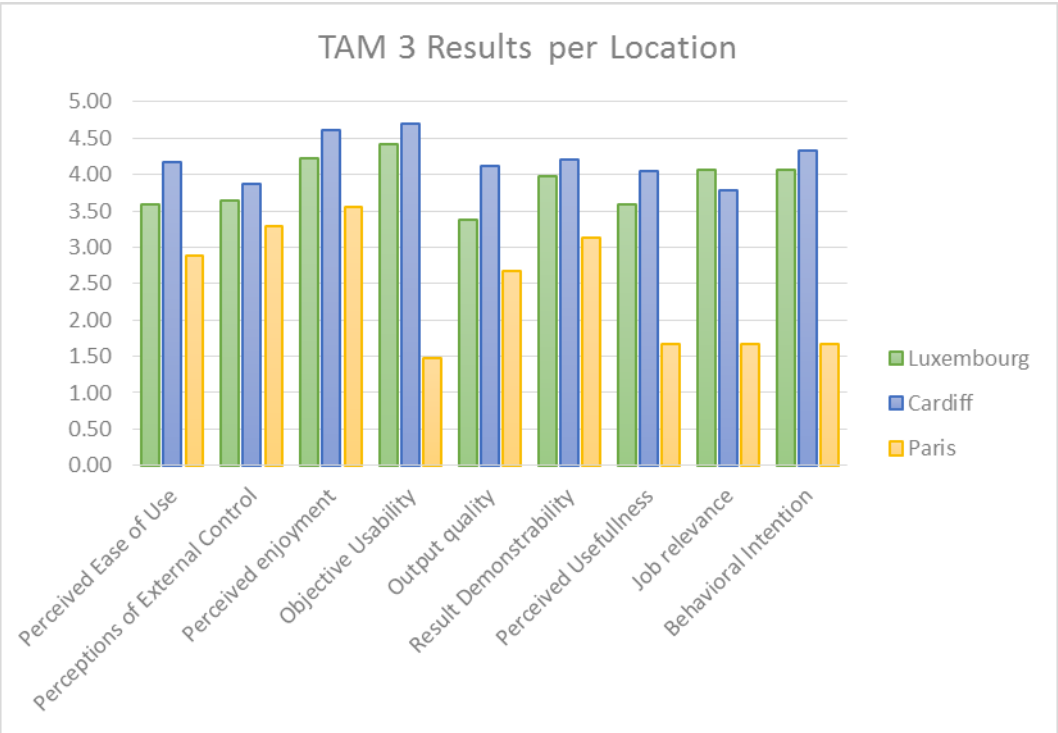

Figure 11: Results of the TAM3 questionnaire, grouped by location.

If omitting the data from Paris, we obtain much higher data scores. In this situation, the lowest score receives Output quality in Luxembourg (M: 3.37, SD: 0.65) and the highest objective usability in Cardiff (M: 4.71; SD: 0), followed by perceived enjoyment in Cardiff (M: 4.61; SD: 0.65).

4. Conclusion

In this report, we have presented a protocol for evaluating the BIM4VET application. The protocol is based on a series of tasks, which participants have to accomplish in a group of three. Each of the participants plays a role during the use of the application.
After using application, participants filled out a questionnaire based on the TAM3 questionnaire. The results show an above average rating for all categories, with a slightly higher rating for the perceived ease of use as compared to the perceived usefulness.
This first feedback is very encouraging, showing the acceptance of the BIM4VET application. In the meantime, some of the small problems detected during the experiments let place to minor improvements and a new version of the BIM4VET application.

5. Annex

Questionnaire: BIM4VET application

Thank you for agreeing to participate to this study. This questionnaire in used solely for research purposes as part of the project BIM4VET. All data are collected anonymously and will be handled confidential.

For any question you can contact:
For LIST: Valérie Maquil: valerie.maquil@list.lu or Annie Guerriero: annie.guerriero@list.lu For CEA LIST: Jean-Philippe Poli: jean-philippe.poli@cea.fr
For Cardiff University: Alex Bradley BradleyA@cardiff.ac.uk

* Required

1. **Age**
   Mark only one oval.

   - ◯ <25 years
   - ◯ 25-34 years
   - ◯ 35-44 years
   - ◯ 45-54 years
   - ◯ 55+ years
   - ◯ prefer not to say

2. **Gender**
   Mark only one oval.

   - ◯ Female
   - ◯ Male

3. **Position**
   Check all that apply.

   - ☐ Architect
   - ☐ Engineer in construction
   - ☐ Construction manager
   - ☐ Owner
   - ☐ Construction firm
   - ☐ Facility manager
   - ☐ BIM manager
   - ☐ Researcher
   - ☐ Other: _____

4. **Professional experience in construction**
   Mark only one oval.

   - ◯ 0-2 years
   - ◯ 3-5 years
   - ◯ 6-10 years
   - ◯ 10+ years
   - ◯ Non applicable

5. **BIM expertise**

Mark only one oval.

- None
- Novice
- Advanced beginner
- Competent
- Proficient
- Expert

6. **Perceived Ease of Use** *

Mark only one oval per row.

	strongly disagree	disagree	undecided	agree	strongly agree
My interaction with the BIM4VET application is clear and understandable.					
Interacting with the BIM4VET application does not require a lot of my mental effort.					
I find the BIM4VET application to be easy to use.					
I find it easy to get the BIM4VET application to do what I want it to do.					

7. **Perceptions of External Control** *

Mark only one oval per row.

	strongly disagree	disagree	undecided	agree	strongly agree
I have control over using the BIM4VET application					
I have the resources necessary to use the BIM4VET application.					
Given the resources, opportunities and knowledge it takes to use the BIM4VET application, it would be easy for me to use the BIM4VET application.					
The BIM4VET application is not compatible with other applications I use.					

8. **Perceived enjoyment** *

Mark only one oval per row.

	strongly disagree	disagree	undecided	agree	strongly agree
I find using the BIM4VET application to be enjoyable.					
The actual process of using the BIM4VET application is pleasant.					
I have fun using the BIM4VET application.					

9. **Output quality** *

Mark only one oval per row.

	strongly disagree	disagree	undecided	agree	strongly agree
The quality of the output I get from the BIM4VET application is high.	⬭	⬭	⬭	⬭	⬭
I have no problem with the quality of the BIM4VET application's output.	⬭	⬭	⬭	⬭	⬭
I rate the results from the BIM4VET application to be excellent.	⬭	⬭	⬭	⬭	⬭

10. **Result Demonstrability** *

Mark only one oval per row.

	strongly disagree	disagree	undecided	agree	strongly agree
I have no difficulty telling others about the results of using the BIM4VET application.	⬭	⬭	⬭	⬭	⬭
I believe I could communicate to others the consequences of using the BIM4VET application.	⬭	⬭	⬭	⬭	⬭
The results of using the BIM4VET application are apparent to me.	⬭	⬭	⬭	⬭	⬭
I would have difficulty explaining why using the BIM4VET application may or may not be beneficial.	⬭	⬭	⬭	⬭	⬭

11. **Perceived Usefullness**

To be filled in only if you are or were working in construction.

Mark only one oval per row.

	strongly disagree	disagree	undecided	agree	strongly agree
Using the BIM4VET application improves my performance in my job	⬭	⬭	⬭	⬭	⬭
Using the BIM4VET application in my job increases my productivity	⬭	⬭	⬭	⬭	⬭
Using the BIM4VET application enhances my effectiveness in my job	⬭	⬭	⬭	⬭	⬭
I find the BIM4VET application to be useful in my job.	⬭	⬭	⬭	⬭	⬭

12. **Job relevance**

To be filled in only if you are or were working in construction.

Mark only one oval per row.

	strongly disagree	disagree	undecided	agree	strongly agree
In my job, usage of the BIM4VET application is important.	⬭	⬭	⬭	⬭	⬭
In my job, usage of the BIM4VET application is relevant. The	⬭	⬭	⬭	⬭	⬭
use of the BIM4VET application is pertinent to my various job-related tasks.	⬭	⬭	⬭	⬭	⬭

13. **Behavioral Intention**

To be filled in only if you are or were working in construction.
Mark only one oval per row.

	strongly disagree	disagree	undecided	agree	strongly agree
Assuming I had access to the BIM4VET application, I intend to use it.					
Given that I had access to the BIM4VET application, I predict that I would use it.					
As soon as the BIM4VET application is available, I plan to use it in the next 6 months					

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BIM4VET Partners

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