Teaching Building Performance Simulations to students with a diverse background by using a Control Method

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Abstract

Performing advanced and reliable Building Performance Simulations (BPS) in order to study, for example, the energy use of future buildings is an important ability to gain as a future energy specialist. Learning and understanding BPS software and results may be arduous, notably for groups with disparate knowledge. Frustration may arise among students, making learning even more difficult. In this paper, we use questionnaires to evaluate the introduction of a so-called “control method” in the first BPS teaching module of a Master Programme attended by students with diverse backgrounds. The control method verifies – or *controls* - the results of a basic energy simulation of a traditional shoebox model with those obtained via an Excel sheet based on building code. Through a smoother and guided introduction of BPS to novices, the method aims to increase the level of confidence in BPS tools and more independence in the work. The questionnaires’ answers suggest that the method fulfils its goals to a reasonable extent.

Introduction

One fundamental ability for energy specialists is the competence in Building Performance Simulations (BPS). Teaching BPS and critically analysing the results may be challenging, especially in courses with students of diverse backgrounds (Tojo and Kiss, 2015).

Lund University provides a two-year Master Programme in Energy-efficient and Environmental Building Design, yearly attended by about 25 students. They have background in engineering and architecture, from different countries. BPS is introduced early in the programme. The adopted software are widespread among Swedish and international practitioners, and they include: a 3D modelling interface, a visual programming environment, and the actual energy simulation engine. The aim is to generate a tight link between education and practice, which is in line with IBPSA's view (Clarke, 2015) and the expectations of students themselves (Göçer and Dervishi, 2015).

BPS tools are introduced by using collaborative learning (Cohen, 1994) in groups of three-four students. Literature on group cognition seems to support learning in small groups, particularly for computer technology (Lou, Abrami and D'Apollonia, 2001), while diversity in the group is both an opportunity and a barrier. For example, Curşeu and Pluut (2013) have clearly demonstrated that

gender and nationality diversity have potential to increase the collective knowledge of the group, but diversity in the team's expertise negatively affects the quality of teamwork.

Based on anecdotal observations, we argue that also diversity in previous knowledge is a barrier to group development. In the past years, we observed that teams with different areas of expertise tended to share their workload based on individual strengths, which led to an unsought shift from collaborative learning to cooperative learning (Dillenbourg et al., 1995). Individual strengths can be software skills (i.e. how to practically handle the software) or theoretical skills (i.e. how to set-up the input and scrutinize the results of a BPS). If the groups tend to use cooperative learning, the Master programme objectives cannot be reached, as the student will tend to simply reinforce the existing individual strengths.

We also argue that the lack of trust in newly introduced software enhances cooperative learning. Namely, if the student faces difficulties in understanding functioning, input or output of one of the software, then the student will contribute to the group report only in the areas or software where she/he has already competences.

Therefore, cooperative learning may be reduced by enhancing trust in software. This is supposed to also boost student's self-confidence and reduce a sense of frustration. In order to do so, we introduced a so-called ‘control method’.

The control method verifies – or *controls* - the results of a basic energy simulation of a traditional shoebox model performed with a BPS tool with those obtained via an Excel sheet based on building code.

The control method is thought for introducing BPS to classes with significantly different educational background and where time in class to teach BPS is limited. The pedagogical purpose is to improve trust and understanding of the newly introduced software, hence prompting the student to use BPS independently during the individual study time.

The control method does not aim to teach BPS faster or at very advanced level, but it simply tries to bring the entire class to a level of knowledge to which each student feels capable to run and interpret a simple BPS in an independent way.

This paper reports the evaluation of the control method by exploring students' satisfaction, understanding of

software, and reduction of cooperative learning. To achieve this, two classes were compared, before and after the introduction of the method. We surveyed these students via anonymous online questionnaires with mainly open-ended questions.

Need for a customized teaching method

In our programme, we teach BPS using Archsim and EnergyPlus (E+) via the Grasshopper (GH) interface (Solemma LLC, 2019). In this course, the GH environment is chosen because the students will work extensively with this environment in the following courses and a gradual exposure to GH was expected to give the best learning experience for students. One difficulty is that, in this course, three different type of tools are introduced for the first time: (i) a 3D CAD modelling software (Rhinoceros 3D), (ii) a visual programming language (GH), and (iii) an energy simulation software (E+). On top of mastering these three different tools, students should also understand relations between building parameters and its energy performance.

Students in the programme have different prior knowledge; some are new to energy simulations, some never modelled in 3D, most of them are completely new to visual programming language, and few of them have experience with all the tools but they may have previously used other software (e.g. Dynamo instead of GH).

In summary, the students face the following challenges:

- They have to learn three different tools at the same time. We noticed that the steepest learning curve has been the introduction of GH and gaining an understanding of energy simulations.
- They have to understand the relationship between the energy performance of a building and the geometry and characteristics of the building. Students should have prior knowledge about building physics, but it may have been taught in a different way and maybe never applied to a project.

Helping the students throughout these two challenges is a difficult task for the involved teachers. We investigated existing pedagogical papers on the topic before conceiving a method *ex-novo*.

For example, Reinhart et al. (2012) introduced a game-based method to improve students' understanding of different design solutions. The game proposes a range of design choices that, combined, offer about 400 000 solutions with different energy use intensity (EUI) and costs; students group achieving the lowest EUI and acceptable costs are awarded with extra credits in their examination. The method is extremely interesting, but it focuses on how to inform design, while we needed a method that, at the same time, was developing basic BPS skills.

Zweifel (2017) presented an interesting competition-based method to introduce novices to BPS. In this method, the trainer provides a full-modelled building in IDA-ICE. A number of building parameters in the provided model are not optimized; the students are required to identify and optimize such parameters in a two-step process. As the

first step, the students define and optimise areas of intervention (e.g. building envelope). As second step, the students are free to choose any combination of measures leading to energy performance optimization. This second step is proposed as a competition. As the author mention, a potential risk is that students use several measures together in step two, which may create some difficulties in understanding the impact of each measure. The method proposed by Zweifel (2017) seems to be very effective for learning the impact of a number of building parameters, but the students are provided with a complex and fully functional model from the beginning. One of the scope of our course, instead, is to introduce the student to the modelling part in parallel to the simulation part.

Rabenseifer (2015) highlighted three obstacles in learning BPS for novices: (i) complexity of quality software, (ii) time for modelling, and (iii) existence of many different standards to describe identical building physics issues. The author illustrated a method based on a simple generic simulation model controlled via external interface aiming at overcoming such obstacles. Our control method is, to some extent, similar to what Rabenseifer (2015) proposed, since it provides a ready-made model to start with, and it reduces the degrees of freedom in the model in order for the students to deal more easily with complex software. Differently from Rabenseifer (2015), the control method does not use a simple interface and it is based on the existing interfaces of the adopted tools (Rhinoceros 3D and Grasshopper); on the contrary, it compares the results with these from a very basic and familiar tool, like Excel.

Beausoleil-Morrison and Hopfe (2015) formalized a pedagogical framework to teach BPS based on the Experiential Learning Theory (ELT) by Kolb (2014). The framework is based on a continuous cycle in which the student recursively face theoretical learning, application of BPS, analysis of BPS results, and reflections linking learning experience to theory. The framework was applied successfully to students with no previous experience on BPS, which were able to handle two BPS tools in just three weeks of training (Beausoleil-Morrison, 2019).

One issue highlighted by Beausoleil-Morrison (2019) is that the ELT-based framework does not assure that students could make reliable predictions. The issue of making reliable predictions is commonly highlighted in literature (Beausoleil-Morrison and Hopfe, 2015; Berkeley, Haves and Kolderup, 2015) and most of BPS trainers have probably experienced that in their careers.

Therefore, Beausoleil-Morrison (2019) further developed the ELT-based framework and extended it to a so-called BPS learning spiral. In the generalization of this model, several of the continuous cycle "theoretical learning > application of BPS > analysis of BPS results > and reflections linking learning experience to theory" are interconnected; together, they built a learning spiral aiming at a full understanding of BPS, from underlying theory to the actual handling of software. For the specific case, Beausoleil-Morrison (2019) identified and

implemented 15 cycles in the spiral: one for the introduction to BPS, five to handle “indoor environment” related aspects, six for “exterior environment”, and three for the “building envelope”. A final cycle, a “culminating trial” integrates all the learnings together (Beausoleil-Morrison, 2019, p. 312). By providing specific examples from teaching experience, the author demonstrated that the method allows students to make predictions, that are more reliable, and they gain confidence and understanding in the simulations. The full implementation of this method would require an entire semester, but the method is modular to some extent. For shorter courses – as for our case – a trainer may simply use less cycles and leave the remaining cycles for follow up sessions.

Although this method would fit the purpose of this work, it could not be tested since the control method was designed and implemented before this publication appeared in literature.

Methodology

BPS tools are introduced during the course ‘Energy use and thermal comfort in buildings’ (7.5 ECTS). The course includes a theoretical introduction to topics which are later scrutinized in the Master programme (basics of thermodynamics, thermal comfort, air quality, heat balances, heating and cooling strategies, moisture safety, thermal bridges, thermal performance of windows and frames), and a practical part, where BPS are introduced for the first time in the Master programme.

The course content is introduced as in Figure 1. After the theoretical part, the lecturer provides an Excel sheet for calculating the annual energy intensity of a simple shoebox, which is based on the Swedish Building Code BBR (Boverket, 2018). The static calculations consider transmissions losses through the building envelope, ventilation and infiltration losses, the thermal mass, and a template value to consider the internal loads and solar gains.

Figure 1: Overall course structure

Then, students get some theoretical lectures on BPS and start working with the modelling in Rhinoceros 3D, and with the BPS part in Archsim/E+ in GH environment. In previous years, as assignment, the students were required to model a shoebox identical to the one calculated in Excel and try to match the resulting annual energy use intensity by forcing the dynamic simulation to be “static”, for example by creating a weather file with constant outdoor

temperature. Because of the students’ experience and the large number of settings and inputs in the BPS, the difference in results generated ambiguity; namely, the student was not sure if the difference was linked to physical factors, some inputs that were overlooked, or her/his own errors.

In 2018, the control method was introduced in the course structure.

The control method

The control method goes through different steps, where the complexity of the energy calculation and simulation is steadily increased. The control method is looking at the same simple shoebox, initially without windows, and then with a window (Figure 2). The output are the annual energy use intensity and the energy peak load.

Figure 2: the shoebox model used in the course

The steps of the control method are: 1) room with no windows, no internal loads, no ventilation, no infiltration, no solar gains and a constant ambient temperature, 2) add infiltration, 3) add intentional ventilation, 4) add heat exchanger, 5) add window to the model, and 6) add internal loads. The final step is to add irradiation and a varying ambient temperature, but in this case, Excel is not able to calculate that. In Table 1, the differences for the annual energy use intensity between the different methods are shown.

Table 1. Example of difference in results for the annual energy use intensity / (kWh/m²y).

	Excel	Archsim/E+	Diff
I = windowless	12.59	12.82	1.83%
II = I + infiltration	13.74	14.07	2.40%
III = II + ventilation	22.14	22.57	1.94%
IV = III + heat exchanger	15.84	16.19	2.21%
V = IV + window	17.04	17.15	0.65%
VI = V + internal loads	14.04	14.2	1.14%

Each simulation step is run with the teacher. This has two important advantages:

1. If the student gets a different result, she/he is immediately aware of some errors at that step in her/his simulation; hence, the student can check in detail where the error was made.

To support students in that, we produced video tutorials on Vimeo explaining how to redo the control method at home.

2. On the contrary, if results match, the student knows that the difference in results does depend on underlying equations and approximations and not on her/his own mistake; hence, the student may autonomously scrutinize the theoretical reasons of such difference.

To support the students in that, the teachers relied mostly on the documentation of Archsim and the E+ and incited students to perform further research.

It was considered relevant to show students that dynamic simulation programs will give slightly different results than handmade, static, calculations (considering the same conditions) because of the nature of both methods. In both methods, assumptions and simplifications are made to approach complex physical real-world situations, resulting in different outcomes with different accuracy.

In a pedagogical perspective, the control method follows the framework of the Structure of Observed Learning Outcome (SOLO) taxonomy proposed by Biggs and Collis (1982). The control method intervenes at a *unistructural* level of understanding, and it guides the student towards a *relational* level (Figure 3), i.e. understanding why and how different parameters of the energy simulation affects each other. From that point, the student has confidence and ability to produce autonomously new building designs, to propose solutions to improve building efficiency, and to predict the simulation outcomes. In other words, the student is capable to reach independently an *extended abstract* level of competence (Figure 3).

Figure 3: the SOLO taxonomy (Biggs and Collis, 1982) applied to the here presented control method

In respect to the learning spiral proposed by Beausoleil-Morrison (2019), the control method follows a linear theoretical framework. The fundamental prestructural knowledge is progressively enriched with relational capacities, in a single “block”. The learning spiral, instead, utilizes several “blocks” to build knowledge and reach the extended abstract of knowledge.

Beausoleil-Morrison (2019) suggests that “We need to teach important theoretical concepts, and I argue [...]”

that this is best accomplished by allowing students to explore and experiment with BPS tools in a guided manner” (Beausoleil-Morrison, 2019, p. 310). Despite the differences in theoretical frameworks, this is, after all, the ground from which both the learning spiral and the here presented control method were conceived.

Evaluation of the control method

The evaluation follows a between-groups study design. Two anonymous questionnaires were submitted to the classes attending the ‘Energy use and thermal comfort in buildings’ course in 2017 (before the introduction of the control method) and in 2018 (after). The questionnaires were:

- the standardized CEQ questionnaire (Ramsden, 1991). This is a standard course evaluation method for the majority of courses held at Swedish universities. The CEQ evaluation forms provide an overall evaluation of the course where BPS are introduced. The CEQ questionnaire is automatically submitted to students when the course ends.
- a custom-made online questionnaire with open ended questions addressing specifically teaching and learning of BPS within the course (Table 2). The custom made questionnaire was handed in to both classes at the end of the 2018 course. This means that the 2017 class answered one year later, which is a limitation of the survey.

Because of the between-groups design, the CEQ questionnaire was mainly used to identify biases linked to different appreciation of the overall course, namely a class largely unsatisfied with the course may provide partial evaluation even for the BPS part. The custom-made online questionnaire, instead, first identifies the groups’ differences by addressing students’ previous knowledge in the field of BPS, by means of closed-ended questions (Table 2). Secondly, and most importantly, it explores students’ satisfaction, understanding of software, and reduction of cooperative learning in regards to the BPS part only. Within this overarching goal, the questionnaire aims at identifying strength, weaknesses, and room for improvement for the control method. Provided also that the statistical population in the analysis is relatively small, a survey with open-ended questions was judged a more suitable tactic of enquiry (Robson, 2011).

In order to keep evaluations as objective as possible, none of the students were aware that a new method for introducing BPS was used in the 2018 edition of the course. For the same reason, the custom-made questionnaire does not address the method itself, rather it asks general feedback on teaching and learning, assuming that positive feedback are triggered by an effective teaching method (Table 2).

The subsequent analysis of qualitative data adopted a thematic coding approach (Robson, 2011, p. 467) and, in general, the analysis was conducted by following best practice.

Results

First, based on the custom-made questionnaire, the students' background is reported. Then, results of the two questionnaires are discussed.

Students' background and previous knowledge

Seven students of the 2017 class (34% response rate) and 17 students of the 2018 class (81% response rate) answered to the questionnaire. Statistical significance tests are not reported due to the small effect size.

The background of the two groups differs only in terms of students' countries of provenience, the control method group being formed by a majority of students from outside Europe. Roughly, 70% architects and 30% engineers form both groups (Figure 4). A 2018 student declared a background in "other", specified owing a bachelor in "architecture, sustainability" and was hence included in the architects group.

Previous knowledge of 3D CAD software is much more common among students with background in architecture (88%) than engineering (56%), independently from provenience and year of the course. The majority of engineers had only experience of 2D CAD. However, most of the students having previous 2D or 3D CAD knowledge commented that this was superficial (e.g. "Very brief sketches in CAD. Very basic knowledge").

Figure 4: Background information of the students. Inner doughnut shows 2017 students (previous teaching method); outer doughnut shows 2018 students (control method)

Independently from groups and students' background, previous knowledge in energy simulations and visual programming is limited. In this case, engineers are more prone to be familiar with energy simulations (44%) than architects (12%), while 12% of engineers and 25% of the architects had some kind of experience with visual programming. Interestingly, on visual programming, one student claiming experience, commented as follow:

"To be honest, my answer here should only account as half a yes, since the Software I used was LEGO Mindstorms. However, it was a great basic experience, as

it was a fun time to make a robot do something according to your script [...]"

We claim that the comment has the same tacit pedagogical grounds of the BPS learning method by playing proposed by Reinhart et al. (2012), and it deserves consideration for future studies.

CEQ questionnaire

The CEQ questionnaires were handed in by 16 students in 2017 (76% response rate) and 15 students in 2018 (71% response rate). The CEQ evaluation of the course was different from 2017 to 2018. In the CEQ questionnaires, the general evaluation of the course, is provided on a scale going from -100 (very bad) and +100 (very good), with 0 being neutrality. The general evaluation consists of the following elements: 1) good teaching (in 2017, the CEQ score for this element was +31, in 2018 the number was +37), 2) Clear Goals and standards (2017: +15, 2018: +39), 3) Appropriate assessment (2017: +28, 2018: +22), 4) Appropriate workload (2017: +18, 2018: +25) and 5) generic skills (2017: +21, 2018: +47). This shows that in general, the 2018 students evaluated the course much better than the 2017 students did.

Students were also allowed to give free-text answers. In that section, we looked for software-related answers. In 2017, students answered amongst others that they had a Good experience with Excel sheet, students wanted more time to understand "Grasshopper" (which could mean GH or BPS connected to GH), students complaining about the amount of different software that had to be learned.

In 2018, students experienced it as positive to learn multiple programs, students experience the comparison between Excel and Arcsim/E+ "interesting", but students also stated that they needed more time.

The CEQ clearly showed that the whole course was evaluated more positively, but it was less specific about the BPS part.

Custom-made questionnaire

The totality of students from 2017 recalled difficulties in learning the logic behind GH. The comments were generally negative and they completely ignored the modelling and simulation parts, as if the entire course would have been based on GH:

- "[...] I had super hard time understanding why we connected where [...]"
- "[...] the base script that was provided was working and we could get a result. However, at that point I had great difficulties with understanding what each single part of the script did [...]"

This suggests that the visual programming part was absorbing all the students' energy, and the BPS learning was not really a concern. One student confirmed that quite clearly:

- "[...] even if we were highly motivated, we run out of time, and I did not consider the results to be used in the assignment".

When evaluating what they liked and disliked most in the course, the students' had contradictory feelings. On the

one hand, they recognized the usefulness of parametric BPS and the power of GH in that field; on the other hand, learning difficulties raised a sense of frustration.

- “[...] I really liked the fact that we used grasshopper”
- “[...] Like: learning new useful things which will be huge asset on market”
- “I would say, that we were introduced to the right software for the scope of the masters [...]”
- “[GH] plugins have been very useful to me later but I remember that my beginnings were difficult and I had to look for help in different tutorials available on the internet, which I do not think is wrong either”.

According to the students, improvements in the way in which BPS should be introduced (last question in Table 2), are still almost entirely concerning GH.

- “More lectures focusing on basic functions, more explanations of components.”
- “Individual assignments, using GH tutorials to get a better understanding of the software.”
- “[...] we should focus more on the initial handling of Grasshopper.”

Finally, on cooperative learning, some comments seem to confirm the worry that students’ split work based on their expertise:

- “[...] In the end of the day I have to admit, that for the assignment I was not working with E+ [...], we divided the simulations for the assignments into three parts, one each [...]”.
- “Not everybody participated in learning the software. This is now a “problem” in the public building course (the following course, an), there are only 3 out of 7 groups using the Grasshopper interface to make energy simulations”.
- “I highly recommend individual assignments, where students have to use E+ [...] themselves and individual, so everybody is forced to spend some time in the very beginning”.

After introducing the control method in 2018, the students’ evaluation was different. The students were generally more positive about the way in which BPS are taught and most importantly, students provided feedback – both positive and negative - on all the three tools that were introduced (Rhinoceros 3D for modelling, GH, and Archsim/E+ for energy simulations). For example:

- On the modelling, “The modelling in Rhino was a bit tricky since I was only used to 2D modelling.”
- On GH, “It was difficult to write a script independently.”
- On the energy simulation, “[...] you guys did a great job and try your best to teach us the programs and give us the theoretical knowledge in thermal energy.”

The Grasshopper environment seems to be less hostile to the 2018 students, most probably because the control method allows more systematic guidance on how the GH environment works and how to use GH, combined with Archsim (“Because we did the scripts all together in the

class and it was a short script, it was easy to follow and understand.”).

Students felt less lost (“It was glad to see that the simulation exercise started from a very basic level.”) and they had time to dig into the results, rather than only focusing on making things working (“[I liked] The fact that I got the time to go by myself into the program. Most likely it was thanks to the assignment since we need to compare the program, which was really nice.”, but also “The idea to be able to simulate an environment is in itself exciting. Seeing results change by varying different design parameters is also exciting.”).

The students found that the three tools are powerful, but they could recognize a steep learning curve in order to master them properly:

- “I like the complexity of the software and it seems you can do pretty much anything with it. On the other hand, the complexity also makes the software very time consuming to master which I know will be a struggle in the future.”
- “I find the simulations very useful, once understanding better the software [...]”

Thus, the control method students do not perceive the BPS learning as an insuperable obstacle, and they seem to feel less frustration in comparison to the other group.

Although the control method attempts to meet the needs of all the class independently from the background knowledge, some students still found the method either too complex or too easy. For example:

- an engineer, with experience in 2D CAD: “The big amount of parameters in the simulations made it harder to control what was being changed and led to some wrong results”;
- another engineer, with experience in 2D CAD: “I would propose from the beginning simpler exercises to get to know the software.”;
- a third engineer, with experience in energy simulation: “It would be better if we could learn much more details and basics about the simulation programme not that only settings for some tabs”.

One student suggested that a risk of the control method is that students tend not to leave from their comfort zone: “[...] we were introduced so many things and there are different ways to do one thing, in order to be on the safe side, we didn't try other methods but kept with the given script”.

The control method seems to favourite collaborative learning in respect to cooperative learning. In fact, differently from the 2017 class, one comment was explicitly mentioning “[I liked] teamwork”, while only one student out of 17 commented on teammates who shared work based on their expertise:

- “[...] if you are not the one doing the simulations and doing another part of the project you don't get to learn and the other members of the group don't share what they have done”.

This is in sharp contrast with the 2017 class, where three out of seven students reported the issue.

Conclusion

This paper has shown the results of an intervention in an energy course with the goal to increase students' individual learning of building performance simulation software. A control method was introduced, where students systematically compared the energy balance of a simple shoebox with Excel and by simulating it with Archsim/E+. The introduction of the control method was evaluated via a standard course questionnaire and a custom-made questionnaire for the BPS part. In the standard course evaluation, students evaluated the whole course more positively for the course after introducing the control method. The open comments showed that the control method students were more aware of the potential of the software that were introduced to them, rather than commenting their lack of understanding GH. They were also more confident with the newly introduced software, and some comments suggest that they may be keener on trying additional exercises on their spare time.

Probably in consequence of increased confidence, free comments on group dynamics indicates that the control method may also support collaborative learning.

In conclusion, the control method seems to offer a smooth way to introduce BPS in classes with diverse background knowledge. Although the comments make difficult to judge whether the control method was actually beneficial to understanding and interpreting results of BPS, the fact the students had desire and allowed time to dig into results is certainly a positive sign in this direction.

The student mentioning programming games as good learning occasion for visual programming in BPS suggested ideas for follow-up work. For example, future courses may merge - in some ways - the pedagogical principles of "learning by playing" with the need for a smooth and systematic introduction to BPS as done by the control method.

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Table 2: Content of the custom made questionnaire.

Question	Options and other info
1. I come from (one choice)	'Europe'/'Outside Europe'/'I prefer not to answer'
2. Previous education (one choice)	'Engineering'/'Architecture'/'Other'
3. Independently from your previous selection, please specify the type of education	Open-ended
4. Did you ever use CAD software before joining our Master course? (one choice)	('Yes'/'Yes, but only 2D'/'No')
5. I would like to add more about my previous experience with CAD software	Open-ended
6. Did you ever run energy simulation before joining our Master course? (one choice)	('Yes'/'No')
7. I would like to add more about my previous experience with energy simulations	Open-ended
8. Did you have any previous experience with visual programming languages (e.g. Grasshopper or similar)? (one choice)	('Yes, Grasshopper'/'Yes, but not Grasshopper'/'No')
9. I would like to add more about my previous experience with visual programming languages	Open-ended
10. Please add all the relevant 3D modelling, energy simulation and visual programming languages that you may have used in the past and that are not included in our list. (multiple choice)	('Rhino 3D'/'AutoCAD'/'SketchUp'/'3ds Max'/'IDA-ICE'/'EnergyPlus'/'IES-VE'/'Design Builder'/'Revit'/'Grasshopper'/'Autodesk Dynamo')
11. Add other software and comments	Open-ended
Now a difficult exercise... Please try to recall your feelings when you were attending the "AEBF10 Energy use and thermal comfort in buildings". For what possible, try not being biased by your current knowledge in simulation software.	
12. At that time, which difficulties did you face for the simulations part?	Open-ended
13. What did you like the most and the least about the simulations part in that course?	Open-ended
14. Today you are several steps ahead with energy simulations. Considering your current knowledge, do you think that simulations could have be introduced differently in that course?	Open-ended, submitted to the 2017 class only