ENhance **VI**rtual learning **S**paces using **A**pplied **G**aming in **E**ducation

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D5.3 - Implementation of the educational scenarios and evaluation report (second phase)

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Abstract

The aim of this document is to present the results of the implementation of the educational scenarios, conducted through a series of pilots from M14 until M22. The educational scenarios served as a testbed for the evaluation of the three ENIVISAGE components. Like the first phase, the second phase also focused on evaluating: 1) the authoring tools as a means for building virtual labs, 2) the analytics and visualizations tool for supporting the process of improving virtual labs and 3) the developed virtual labs as a means for successfully improving the learning process for teachers and students. For the second phase pilots, extra recourses have been accolated to user testing the virtual labs (Wind and Chemistry lab) as this was not possible during the first phase. However, between two and

three pilots were run for the authoring tool and the analytics tool, respectively, and, thus, all components of ENVISAGE are therefore adequately and successfully tested.
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Executive Summary

The current document aims to present the applied educational scenarios and to report on the results of the second phase of evaluation of the delivered components within ENVISAGE. The evaluation process investigates the three ENVISAGE components as e means of: 1) the authoring tool for building virtual labs 2) the analytics and visualizations tool for supporting the process of improving virtual labs and 3) the developed virtual labs as a means for successfully improving the learning process for teachers and students. The deliverable reports on the results obtained during the execution of a range of pilots and works towards addressing if the requirements identified has been meet by the tools. Succeeding to address the educational scenarios and requirements will reinforce the quality of the learning process for both students and teachers.

Most pilots were conducted and facilitated at Ellinogermaniki Agogi school and with support and test material (e.g. surveys) provided by AAU. However, some pilots also took place at conferences and workshop with a target group appropriate for ENVISAGE. These were pilots were facilitated by CERTH, EA and UoM. Afterwards, the data were analysed by AAU and results disseminated to the project partners for redesign and adjustments for the tools.

In total nine pilots were conducted between M16-22 evaluating the Authoring Process, Analytics and Visualizations and the Virtual Labs. The authoring tool had four: The Panhellenic workshop, the formal evaluation in EA, the EA's Summer School and the Teachers Training week in Malta. The Analytics and Visualizations two: The formal evaluation in EA and the Summer School. And the Virtual Labs had six: The Panhellenic workshop, eCrisis workshop, Test A – Wind Energy Lab, Test B - Wind Energy Lab, Test A – Chemistry Lab and Test B – Chemistry.

Result from the authoring process evaluation mainly turned up usability issues during the first pilot. They probably occurred, as the authoring tool were not completed as this point. Also the past user guide based on the step-by-step explanation of usage scenarios was very long and it was difficult for the users to read it. The video tutorial and the guided tour walkthroughs help educators to understand the system-authoring process more. After improving scenarios and finish the tool, usability issues were not showing up as often in the following pilots. Instead, error messages and recovery issues were the most pressing topics for the remaining pilots. The participants in the formal evaluation at EA are generally positive about the authoring tool and the only issue to report is therefore error messages and recovery issues. This is also true for the other pilots like e.g. the summer school pilot. Results from the Analytics and Visualizations evaluation shows that most educators understood the functionality of the analytics but needed more practical examples and instructions to be able to apply it on their own. The results for the virtual labs shows that the student expects the labs to be less fun than what they actually experienced. They also expected to learn more from the labs than what they did but were also extremely positive about their learning outcomes even before the play sessions. In addition, they generally find the labs easy to use and even more so for Test B than for Test A. After playing the labs, the students were asked to answer if they would play the lab again after the test (Q7) and for Test A 68,26% of the students (114) would either definitely or quite likely try the lab. This number decreases to 60,93% (92) for Test B. All participants were generally positive about the ENVISAGE assets and the issues found were only minor.

Abbreviations and Acronyms

MOS	Months
PM	Project Month

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1. Introduction

The overall concept of ENVISAGE is based on the process of improving virtual labs through iteratively employing the authoring process and the embedded analytics, to build, test and improve versions of the virtual lab templates. Templates are like a stencil for the virtual lab and are developed to make the authoring process a lot more intuitive and easy for the more novice end-user of the tool.

The development of the ENVISAGE components (authoring process, analytics and visualizations and virtual labs) is distributed across WP2-WP4. Throughout the project, all these three components will be evaluated through the activities in WP5. The process starts with the identification of the requirements and educational scenarios for the virtual learning spaces in WP1. Then, shallow game analytics are utilized for the aggregation of learner data and visualization in WP2. It continues, with predicting future and behavioural modelling, providing the appropriate learning content based on deep game analytics technologies in WP3. The cycle goes on with developing the authoring tool and virtual labs templates in WP4 and finishes with evaluating the degree to which the requirements gathered in WP1 have been fulfilled by the development conducted in WP1-4 (WP5).

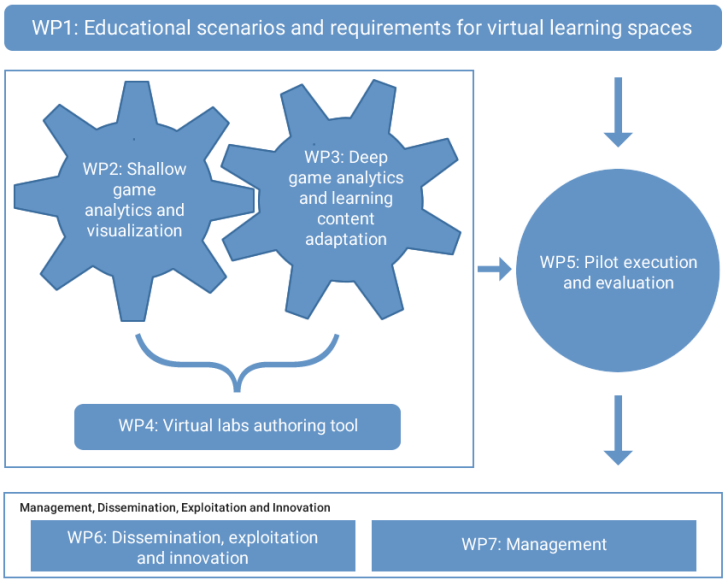

Figure 1: The role and internal relationships between the ENVISAGE work packages.

ENVISAGE is intended to focus on maximizing the benefit for schools using its components/assets and the benefit of these assets will be confirmed by evaluating them in WP5. Evaluation protocols, using both qualitative and quantitative measures, are utilized to ensure the ENVISAGE asset's quality and to estimate and present their effectiveness. Based on discussions among the partners of the consortium, applicable use cases for conducting pilots were carefully selected.

1.1 The objective of WP5

The objective of WP5 is to conduct a number of pilots towards addressing the scenarios identified in WP1. The work package will assess the quality of the developed components and help determine if they are meeting the requirements setup before the project. The evaluation conducted focuses on the effectiveness of the developed technologies for optimizing virtual lab design and functionality and evaluates their ability to benefit educational organizations using the finished solution. The evaluation process will target three separate conditions**:**

1) The process of using the ENVISAGE authoring tool as a means for building virtual labs;

2) The support offered by the analytics tools in the process of improving virtual labs; and

3) The delivered virtual labs and learning content with respect to their effectiveness to meet the goals and expectations of both teachers and students in the learning process [1]

Taking into account the outcomes from the first cycle of evaluations was a fundamental part of updating the designs of all three components of ENVISAGE. For the second cycle of pilots, the design and quality have been piloted more frequently, enabling the project to take a more agile approach for the development and ensuring higher quality of the components. This can e.g. be seen in chapter 2 in D4.4 - Final version of the "Virtual labs authoring tool" (Ververidis, 2018), where design updates for the authoring process has been presented, based on a pilots conducted. If the components are successful in addressing the requirements, the tool could improve the quality and engagement in the learning process for both students and teachers. More concretely, the evaluation will especially focus on estimating the below described criteria for each of the three components:

1.1.1 Authoring process evaluation:

This subtask will focus on evaluating the authoring tool as a means to easily and effectively build virtual labs. More specifically, a number of external evaluators (i.e. teachers) will utilize the authoring tool and evaluate several aspects of the tool like for instance its usability, its effectiveness, the friendliness of the interface, the ease of use and overall experience.

1.1.2 Analytics and visualization evaluation:

The focus of this subtask will be to demonstrate the effect of the analytics and visualization in the process of optimizing the design and the learning process of virtual labs. The benefit and support provided by the analytical techniques (both shallow and deep) in terms of their application in the practical life of a designer and teacher will also be assessed, together with the user friendliness.

1.1.3 Virtual lab evaluation:

This subtask will focus on the evaluating the usefulness and effectiveness of the delivered virtual labs and learning content towards fostering the engagement of the students with the lab. Both teachers and students will participate in the evaluation of the virtual lab in order to ensure that the real world scenario of using the labs in a classroom situation, and subsequently improving it, has been tested.

1.2 The scope and structure of D5.3

The document will start with a presentation of all pilots conducted for the second cycle. It will cover what ENVISAGE assets it was piloting, where the pilots were conducted, who participated and the methodological approach applied. This is done, as some pilots tested multiple assets and describing them multiple times during the report would thus be redundant. Afterwards, the analysis and results of the pilots will be presented. The chapter is structured with one section devoted to each of the asset (authoring process, analytics and visualization and the virtual labs). Lastly, the report will summaries and conclude on quality of each assets as well as the collective impact of the tools.

2. Educational Scenarios and Piloting

The first cycle of pilots was run between M11 and M13 and due to time constraints; it was pushed back one month. The second cycle of pilots has been conducted between M19 and M22 and has tested all the three assets of ENVISAGE. For the second cycle, we decided to add an additional month for evaluation as this would provide us with more feedback for perfecting the assets. In addition, June and July 2018 provided a good basis for conducting many of the pilots due to conferences and summer schools being held here.

In the table below, the two cycles of pilots can be seen. Light blue refers to a month where an activity was planned to be conducted but was postponed. Dark blue refers to a month where an activity was conducted as planned and Orange refers to activities conducted beyond the plan.

Table 1: Table showing the two phases of the project and the months dedicated for the pilots.

	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
Pilot/PM's	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Pilot 1																								
Pilot 2																								
Phase I																								
Phase II																								

2.1 eCrisis workshop

In M18, ENVISAGE had the opportunity to organize a workshop in the context of eCrisis Training Week. Here the 3rd version of the Wind Energy and the chemistry lab were played by 18 educators for 1-2 hours. They subsequently, answered a questionnaire with questions about both the educational quality of the labs, as well as the usability and usefulness. The educators were generally positive and interested in the labs. A number of bugs and useful suggestions for improvements were also communicated throughout the workshop.

In addition, they also had the opportunity to experiment a bit with the authoring tool. However, this has not been included in the evaluation, as the participants did not have enough time to fully evaluate the authoring tool.

Table 2: ENVISAGE Assets evaluated during the eCrisis pilot.

eCrisis workshop				
ENVISAGE Asset	**Authoring process**	**Analytics and Visualization**	**Wind Energy Lab**	**Chemistry Lab**
Tested				

Figure 2: Educators trying out the chemistry lab at the eCrisis workshop.

2.2 Panhellenic conference workshop

In M18 ENVISAGE also had the opportunity to participate at the 17th Panhellenic Conference of Greek Union of Physicists, with a two-hour workshop named: Design your own Virtual Laboratory. The conference took place in Thessaloniki (Greece), on Saturday 17th of March 2018. Eighteen secondary education teachers were engaged in the workshop and both played the Chemistry Lab and Wind Energy Lab.

Moreover, the teachers also tried out the ENVISAGE authoring tool and collaboratively designed a chemistry lab. For evaluation purposes, all educators both answered a questionnaire about the authoring tool and the virtual labs. Finally, the workshop additionally offered useful feedback and suggestions for improvements communicated by the participants.

Table 3: ENVISAGE assets evaluated during the 17th Panhellenic Conference pilot

Panhellenic Conference				
ENVISAGE Asset	**Authoring process**	**Analytics and Visualization**	**Wind Energy Lab**	**Chemistry Lab**
Tested				

Figure 3: Educators trying out the authoring tool durig the 17th Panhellenic Conference.

2.3 Test A - Wind Energy lab

In M16 ENVISAGE ran the first pilot using the Wind Energy Lab in a classroom setting. The pilot took place at EA, where seven teachers and 170 students of 6th grade participated. The participating teachers all took part in the pilot with their own everyday classes and the test is therefore identical to real-world educational use case. All seven teachers subsequently answered a questionnaire. The teacher's questionnaire attempts to disclose how the teachers would evaluate the Wind Energy Lab from their own view but also with respect to the experience of the students. The full questionnaire can be viewed in Appendix C.

Figure 4: Setup for the pilot.

One class at a time, the seven 6th grade classes participated in the pilots. They too were asked to answer a questionnaire. However, the student questionnaire was based on a one-group pre-test/post-test design, meaning that the students both answered questions before and after the test. This questionnaire design was chosen to uncover the student's expectation compared with their perceived experience of the Wind Energy Lab and could therefore only be investigated with pre- and post-test measures.

Table 4: ENVISAGE assets evaluated during Test A of the Wind Energy Lab

Test A

ENVISAGE Asset	Authoring process	Analytics and Visualization	Wind Energy Lab	Chemistry Lab
Tested				

Figure 5: Students playing the Wind Energy Lab during Test A.

2.4 Test B - Wind Energy Lab

During M20, ENVISAGE ran the second classroom pilot using the Wind Energy Lab. Again, the pilot took place at EA with the same participants: seven teachers and 170 students. The same questionnaires were also distributed among both teachers and students, which allowed a comparison to be made of the two versions. All seven teachers only answered their questionnaire after the session whereas the students had a pre-test/post-test questionnaire, meaning that the students both answered questions before and after the test. This questionnaire design was chosen to uncover the student's expectation compared with their perceived experience of the Wind Energy Lab and could therefore only be investigated with pre- and post-test measures. The full questionnaire for the students can be viewed in Appendix A and for the teachers in Appendix C.

Figure 6: Students playing the Wind Energy Lab during Test B.

Table 5: ENVISAGE assets evaluated during Test B of the Wind Energy Lab

Test B				
ENVISAGE Asset	**Authoring process**	**Analytics and Visualization**	**Wind Energy Lab**	**Chemistry Lab**
Tested				

2.5 Test A - Chemistry Lab

During M19 a pilot was conducted using version 1 of the Chemistry Lab. Participants for this pilot were 12 high school students, aged 16-18. An older group of students was chosen for this pilot as the content in the Chemistry Lab is more suited to a higher grade level than the Wind Energy Lab. As fewer students had chemistry on a level high enough to be capable of participating and since naming molecules is also a subject that requires background knowledge, a smaller group of students piloted the Chemistry Lab than the Wind Energy case.

The students answered a questionnaire both before and after the test. The questionnaire is based on a one-group pre-test/post-test design, meaning that the students both answered questions before and after the test. The students' questionnaires used for this pilot were the same as for Test A and Test B for the Wind Energy Lab. Full questionnaire can be viewed in Appendix C.

Web links for the chemistry lab version: **http://envisagelabs.iti.gr/games/chemistry/** and

http://160.40.51.48/games/chemistry/

Table 6: ENVISAGE assets evaluated during the Chemistry Lab Test A pilot.

Chemistry Lab Test A				
ENVISAGE Asset	**Authoring process**	**Analytics and Visualization**	**Wind Energy Lab**	**Chemistry Lab**
Tested				

2.6 Test B - Chemistry lab

In M21 the final pilot using the Chemistry Lab were conducted. This pilot used the version 2 Chemistry Lab. Again, the pilot took place at EA with the same participants as in Test A, 12 high school students, aged 16-18. This questionnaire is the same as for Test A and B Wind Energy Lab and Test A Chemistry Lab. Full questionnaire can be viewed in Appendix C. Web links for the chemistry lab version:

https://envisagelabs.iti.gr/games/ChemistryLab_v2.0/

Table 7: ENVISAGE assets evaluated during the Chemistry Lab Test B pilot.

Chemistry Lab Test B				
ENVISAGE Asset	**Authoring process**	**Analytics and Visualization**	**Wind Energy Lab**	**Chemistry Lab**
Tested				

2.7 Formal evaluation in EA (final version)

During M21, the formal evaluation of the Authoring Tool as conducted using the Chemistry Lab template as the Wind Energy was under the last cycle of development. The participants were teachers at the EA School. They received a pdf describing the scenario they had to perform using the authoring tool. The pilot was conducted from 23th to 27th of June 2018. Web link for the authoring tool tested:

https://envisagelabs.iti.gr/login/?redirect_to=https%3A%2F%2Fenvisagelabs.iti.gr%2Fwpunity-main%2F

As the authoring tool has two different logins with different access rights (for the novel teachers and for the systems administrator), three different scenarios were developed.

- Scenario 1 – Creating a virtual chemistry lab: testing the authoring process.
- Scenario 2 – Using the analytics front-end: testing the analytics and visualization.
- Scenario 3 – Administration user: being the advanced scenarios for the systems administrator testing, e.g., uploading of new assets.

Teachers 1-4 performed scenario 1 and scenario 2, while teacher 5 performed all three scenarios. The full scenarios can be view in Appendix E and F. The participants answered a questionnaire after finishing the scenarios, which assessed user satisfaction, ease of use and usefulness of the tool. The full questionnaire can be viewed in Appendix D.

Table 8: Demographics for the participants in the formal evaluation.

Test participants	
Name of test participant (anonymized)	MC, GMI, IA, TT and RM
Gender	M, M, M F and M
Age	Between 29-45 years old
Occupation	Teacher
If teacher **A) Which subjects?**	Physics, Astronomy, Science, Math, Informatics and Entrepreneurship

If teacher **B) Which age group**	Three teaches 10-12 year olds and two teaches 12-18 year olds
Where were the tests conducted?	All conducted their test on site at EA

All participants were teachers at EA and within subject related to the content in the lab used for the pilot. All tests were also conducted while the participants were in the school and the projects representative at EA Georgios Mavromanolakis could thus quickly answer to questions related to the pilot.

Table 9: ENVISAGE assets evaluated during the formal evaluation in EA.

Formal Evaluation				
ENVISAGE Asset	**Authoring process**	**Analytics and Visualization**	**Wind Energy Lab**	**Chemistry Lab**
Tested				

2.8 Additional summer school

In M22, ENVISAGE held a workshop during ”Play-Create-Learn Summer Academy 2018” in Pallini & Marathon, Greece, where, instructed by G. Mavromanolakis (EA), 15 educators engaged in in the workshop. First, participants were given a presentation providing them with an overview of ENVISAGE. Then, the educators were given the choice between using the Chemistry lab template (See scenario in Appendix F) or the Wind Energy Lab (See full scenario in Appendix E). Educator number 1- 7 chose the Chemistry Lab and 8-15 chose the Wind Energy Lab. They all followed scenarios 1 and 2 no matter what template they had chosen.

Web links: https://envisagelabs.iti.gr/login/ and https://bit.ly/2MH4iJm.

The participants answered a questionnaire after finishing the scenarios, which assessed user satisfaction, ease of use and usefulness of the tool. The questionnaire can be viewed in full in Appendix D

Table 10: ENVISAGE assets evaluated during the Summer school pilot.

Additional Summer School				
ENVISAGE Asset	**Authoring process**	**Analytics and Visualization**	**Wind Energy Lab**	**Chemistry Lab**
Tested				

Figure 7: Participants at the Play-Create-Learn Summer Academy 2018.

2.9 Teachers training week in Malta

In M22, the authoring tool was also piloted as part of a teachers training week in Malta. EVISAGE was contacted by an Education Officer from Malta, who after hearing about the project, wanted to use the tool as part of a Maltese schools training week. During the workshop, the participants used a set of scenarios, which can be viewed in full in Appendix E.1. The pilot was also a part of a larger schedule, where one hour had been allocated for it. Participants therefore only had time to try scenario 1 “Creating a virtual chemistry lab” and thus only tested the authoring process and not the analytics and visualization. The pilot had 20 participants who were all teachers at Maltese schools. The participants answered the same questionnaire, as for the Formal evaluation and Summer School, after finishing the scenarios. The questionnaire can be viewed in full in Appendix D.

Table 11: ENVISAGE assets evaluated during the teachers training weel pilot.

Teachers training				
ENVISAGE Asset	**Authoring process**	**Analytics and Visualization**	**Wind Energy Lab**	**Chemistry Lab**
Tested				

2.10 Pilot time schedule

This section will describe the pilot timeline of when and how the different assets of ENVISAGE were evaluated.

2.10.1 Authoring Process

The development of the authoring process was scheduled to run from M3 to M17 but due to the late start of the project, the development got pushed and therefore also included M18 and M19. However, adjustment has also been made in M20 to M22 to include the additional feedback from the later pilots. First, the Panhellenic Conference provided the development with the first insights for the improvement of the authoring tool. Then, the feedback from the formal evaluation (in M21) and the summer school (in M22) helped perfecting and finishing the tool.

Table 12: Light blue refers to a month where an activity was planned to be conducted but was postponed. Dark blue refers to a month where an activity was conducted as planned and Orange refers to activities conducted beyond the plan.

Authoring Tool Process	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
Pilots/PM's	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Development process																								
Panhellenic workshop																								
Formal evaluation in EA																								
Summer School																								
Teachers training week																								

2.10.2 Analytics and visualization

The development process for the Analytics and Visualization were, as for the authoring process, scheduled to start M3 but only run until M16. However, the process only got pushed one month. Evaluating the analytics without the authoring process being finished would not be meaningful as the context for the generation of the data would not be clear to the test participants. This would probably lead to confusion related to the test setup and not the tool and pilot results would thus be tainted by this. Instead, the analytic and visualization got piloted in M21 for the formal evaluation and again in an additionally planed pilot in M22.

Table 13 Light blue refers to a month where an activity was planned to be conducted but were postponed. Dark blue refers to a month where an activity was conducted as planned and Orange refers to activities conducted beyond the plan.

Analytics and	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S

Visualizations																								
Pilots/PM's	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Development process																								
Formal evaluation in EA																								
Summer school																								

2.10.3 Wind Energy Lab

The process of developing the 3D version of the Wind Energy Lab began and terminated according to the initial plan of the project. Three additional pilots were also arranged to ensure the lab meet the expectation and requirements for the entire group of stakeholders. During this cycle, the lab was also iteratively piloted and updated according to the feedback collected from teachers and students. The continued feedback and update loop took place between M16-M22.

Table 14: Light blue refers to a month where an activity were planned to be conducted but were postponed. Dark blue refers to a month where an activity was conducted as planned and Orange refers to activities conducted beyond the plan.

Wind energy lab	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
Pilots/PM's	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Development process																								
eCrisis workshop																								
Panhellenic workshop																								
Test A																								
Test B																								
Teacher training week Malta																								

2.10.4 Chemistry Lab

The development process of the Chemistry Lab were pushed three months and started in M7 instead of M4. It therefore also terminated in M20 and not in M18 as originally scheduled. One additional pilot was arranged for the chemistry lab in M19 during the eCrisis workshop to evaluate the quality and experience of the lab. In M18, the first formal evaluation for the lab took place with both teachers and students engaged in the pilot. After updated the lab according to the feedback, Test B was held in M21.

Table 15: Light blue refers to a month where an activity were planned to be conducted but were postponed. Dark blue refers to a month where an activity were conducted as planned and Orange refers to activities conducted beyond the plan.

Chemistry lab	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
Pilots/PM's	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Development process																								
eCrisis workshop																								
Panhellenic workshop																								
Test A																								
Test B																								

3. Results of the second round of pilots

3.1 Authoring process

3.1.1 Panhellenic workshop

The authoring process was first piloted during the first cycle in M12 (Reported in M13 in D5.2 (Mikkelsen, 2017)). During the second cycle of pilots, the Panhellenic conference workshop in Thessaloniki in March 2018 was the first pilot. Attended by 18 teachers used the authoring tool by following the scenario and instructions given during the workshop (see full scenario in Appendix E). Afterwards they answered the two questionnaires, about usefulness, ease of use and usability (see Appendix B).

The first questionnaire usefulness and ease of use is divided into three sections 1) about perceived usefulness; 2) about perceived ease of use and 3) about positive and negative aspects of the tool. Both usefulness and ease of use, consists of six questions answered using a 7-level Likert scale, whereas the positive and negative aspects are a prioritized textboxes.

Here we have collected only the responses of the teachers regarding the authoring tool that were below the average score (4 out of 7), with the intention to elicit the piece of information indicating the problems of the system. Questions with at least three responses below the score of four are taken into consideration. Overall, most of the comments are related to the user friendliness of the system that is the time needed to find the necessary information, to use easily the system, to interpret error messages, and to recover from mistakes.

1) Using the system would improve my job performance (Scores: 4, 4, 3, 4, 4)
   Response: This comment is related to how much the educators trust the system, which at that time was suffering from bugs and limited testing. User rights rules were implemented so that the users can only manages their game projects.

2) I would find the system useful for my job (Scores: 4, 3, 4)
   Response: The system was not complete in the first prototype so that it could persuade all educators about its usefulness. However, the remaining 12 educators rated the system with a high score.

3) Using the system would enhance my effectiveness on the job: (Scores: 4, 3, 4, 4, 4)
   Response: The system has to be integrated with an LMS (Learning Management System) that can relate the authoring of virtual labs with learning material for the learners. This is out of the scope of ENVISAGE as LMSs for WordPress are already available in the market by several companies (LearnPress[1], LearnDash[2], LifterLMS[3]). Also, although not a full LMS built on WordPress, the Edwiser Bridge[4] plugin enables the integration of the popular (and free/open source) LMS Moodle with a WordPress instance. It lets import and sync courses, users, and categories, and control students

[1] https://wordpress.org/plugins/learnpress/
[2] https://www.learndash.com/
[3] http://www.wpbeginner.com/refer/lifterlms/
[4] https://wordpress.org/plugins/edwiser-bridge/

enrolment in a Moodle course from within WordPress. In the future, we will seek collaboration with an LMS either commercial or open source.

4) Learning to operate the system would be easy for me (Scores: 4, 3, 2, 3, 2, 3, 4)
   Response: The instructive web pages are not as much prolonged as they used to be. Also, a tutorial video was made. In the next months (after this pilot), we used a guided tour walkthrough so that the authoring process is explained in-site for beginner authors. This will be done when all the graphic elements are finalized and implemented.

5) I would find it easy to get the system to do what I want to do (Scores: 3, 4, 1, 4, 2, 3, 4, 2, 4)
   Response: A reference guide was made in order help users find information about how each action can be made.

6) My interaction with the system would be clear and understandable (Scores: 4, 4, 4, 2, 3, 3, 3, 4, 4, 3)
   Response: The system has to be embedded in a learning management system in order to reveal its scope. This is discussed above in Comment 4.

7) I would find the system to be flexible to interact with (Scores: 4, 4, 1, 3, 4, 3, 4, 3)
   Response: This is related to the user friendliness that is discussed in Comments 1, 2, 4, and 5

8) It would be easy for me to become skilful using the system (Scores: 1, 3, 3, 4, 4)
   Response: The system is rather a prototype than a ready to be used tool. It needs to be enriched with more features as regards authoring in order to be a full training system for educators.

9) I would find the system easy to use (Scores: 4, 4, 2, 1, 4, 3, 4, 3, 3, 4, 3)
   Response: This is related to user friendliness already discussed in Comments 1, 2, 4, and 5.

10) I can effectively complete my work using the system (Scores: 3, 3)
    Response: This is related to user friendliness already discussed in Comments 1, 2, 4, and 5.

11) Overall, I am satisfied with how easy it is to use this system (Scores: 4, 3, 3)
12) It was simple to use this system (Scores: 4, 3, 3, 3)
13) I am able to complete my work using the system (Scores: 4, 1, 3, 4, 3)
14) It was easy to learn to use this system (Scores: 2, 4, 4)
    Response: All the above comments are related to user friendliness already discussed in Comments 1, 2, 4, and 5.

15) The system gives error messages that clearly tell me how to fix problems (Scores: 1, 1, 1)
    Response: An error showing mechanism alerts the user of the error occurred along with an error code to track in the reference guide.

16) Whenever I make a mistake with the system, I recover easily and quickly (Scores: 4, 2, 4, 4, 3)

Response: It is not easy to implement recover mechanisms in web pages. However, it is in our plans to make an undo mechanism in the 3D editor.

17) It is easy to find the information I needed (Scores: 3, 4, 4, 4)
Response: The new helping system with reference guide, and walkthrough guided tours allows one to find easily the information needed.

18) The information provided for the system is easy to understand (Scores: 3, 4, 4)
Response: The past user guide based on the step-by-step explanation of usage scenarios was very long and it was difficult for the users to read it. The video tutorial and the guided tour walkthroughs help educators to understand the system easily

3.1.2 Formal Evaluation in EA

The formal evaluation in EA took place during M21 and both tested the Chemistry Lab template. The participants were teachers at the EA School, who were send a pdf describing the scenario they had to perform using the authoring tool (see full scenario in Appendix F). Teacher 1-4 performed scenario 1 and scenario 2, while teacher 5 performed all three scenarios. The participants answered a questionnaire after finishing the scenarios, which assessed user satisfaction, ease of use and usefulness of the tool. The questionnaire used a 5-level Likert scale and all question were positive statements. Agreeing to them therefore meant a positive experience with the authoring tool. In addition, Q1-Q12 of the questionnaire will be used for this evaluation as Q13-Q15 are concerned with the visualizations and analytics and they will thus be covered in section 3.2 The questionnaire we be viewed in full in appendix D.

Disagree is 1 and agree is 5. This evaluation only the responses with three participants (or over) stating 1, 2 or 3 to the questions. This way, we can focus on areas where the authoring tool could be improved. Participant 1, answered 1 to all of the questions and must arguable not have found the experience with the authoring tool good. This might be due to some technical issues experienced during the session. P1 described it this way “Scenario1: Problem with compile lab on windows. System says zip file not found. It says Sorry but you are looking for something that is not here! Why? I followed all steps written in instructions. Tried again but the same error, frustrating”. This bug has been corrected and did not affect the rest of the test participants.

Error messages and recovery

Error messages and recovery generally receives the most negative response from the educators, with 1 disagreeing to the authoring tool providing clear messages on how to fix the problems and 2 somewhat disagreeing by saying 2 and 3. Q6, Recovering from mistakes when using the authoring tool, sees the same tendency in responses.

Table 16: Answer distribution for Q5 in the Formal Evalution.

Q5: The system gives error messages that clearly tell me how to fix problems					
	Disagree				Agree
Scale	1	2	3	4	5
Total	1	1	1	2	0

Table 17: Answer distribution for Q6 in the Formal Evalution.

Q6: Whenever I make a mistake using the system, I recover easily and quickly					
	Disagree				Agree
Scale	1	2	3	4	5
Total	1	1	1	2	0

In other of the pilot, the same tendency has been observed, indicating that error recovery and messages might be the weakest point for the authoring tool. However, only one participant disagreed to the statement and this participant disagreed to all the questions in the questionnaire. The issues related to error recovery might therefore not be as strong as first anticipated but improvements have still been made to improve this.

3.1.3 Summer School

In M22 ENVISAGE held a workshop during ”Play-Create-Learn Summer Academy 2018” in Pallini & Marathon, Greece. Instructed by G. Mavromanolakis (EA), 15 educators engaged in in the workshop. First, participants were given a presentation providing them with an overview of ENVISAGE. Then, the educators were given the choice between using the Chemistry lab template or the Wind energy. Educator number 1- 7 chose the Chemistry Lab and 8-15 chose the Wind Energy Lab. They all followed scenarios 1 and 2 no matter what template they had chosen. Web links: https://envisagelabs.iti.gr/login/ and https://bit.ly/2MH4iJm. The participants answered a questionnaire after finishing the scenarios, which assessed user satisfaction, ease of use and usefulness of the tool. The questionnaire can be viewed in full in Appendix D.

The questionnaire used a 5-level Likert scale and all question were positive statements. Agreeing to them therefore meant a positive experience with the authoring tool. Disagree is 1 and agree is 5. This evaluation only the responses with four participants (or over) stating 1 or 2. This way, we can focus on areas where the authoring tool could be improved.

Participant 12 and 13 have been removed from the sample as they only answered the first four questions. In addition, only Q1-Q12 of the questionnaire will be used for this evaluation as Q13-Q15 are concerned with the visualizations and analytics and they will thus be covered in section **Error! Reference source not found.** Overall, the participants agreed that they generally were satisfied with the system (Q10) and felt like the information provided by the system were clear (Q7 and Q8).

Confidence in using the Authoring Tool

None of the participants felt completely comfortable using the authoring tool for the first time, which is a tendency we also saw in other evaluations. This is probably due to the authoring tool performing quite complex tasks and understanding it can thus be hard, especially for novice users, who are not confident with their own computer literacy skills. However, most participants responded with 4, meaning that almost half of them a great deal of the participants felt somewhat comfortable using the system.

Table 18: Answer distribution for Q3 in the Summer School pilot.

Q3: I feel comfortable using the system

	Disagree				Agree
Scale	1	2	3	4	5
Total	3	2	2	6	0

Finding it easy to learn how to use the system, sees the same tendency as for Q3. Most participants say 4 or 5, agree to the statement, whereas four participants say 1 or 2. Yet, half of the participants still somewhat agreed to the statement.

Table 19: Answer distribution for Q4 in the Summer School pilot.

Q4: It was easy to learn to use this system					
	Disagree				Agree
Scale	1	2	3	4	5
Total	1	3	3	5	1

Error messages and recovery

For Q5 “the system gives error messages that clearly tell me how fix problems”, most participants responded with a neutral response. This could be because they did not experience error messages and had an instructor helping them with what steps to perform.

Table 20: Answer distribution for Q5 in the Summer School pilot.

Q5: The system gives error messages that clearly tell me how to fix problems					
	Disagree				Agree
Scale	1	2	3	4	5
Total	2	2	6	2	1

Mastering the authoring tool

With Q11, we again see a slightly disagreement and neutral response tendency. The largest amount of participants said 4, meaning that they somewhat disagree with the statement. The participant must thus have had issues getting the authoring tool to perform the task they were instructed to perform.

Table 21: Answer distribution for Q11 in the Summer School pilot.

Q11: I found it easy to get the system to do what I wanted					
	Disagree				Agree
Scale	1	2	3	4	5
Total	2	6	5	2	2

3.1.4 Teachers Training Week in Malta

In Malta during M22, 20 Maltese schoolteachers piloted the authoring tool. The participants answered the same questionnaire, as for the Formal evaluation and Summer School, after finishing the scenarios. However, the pilot was a part of a larger schedule, where one hour had been allocated for it. Participants therefore only had time to preform scenario 1 "Creating a virtual chemistry lab" and thus only tested testing the authoring process and not the analytics and visualization (See full scenario in appendix E.1). The questions (Q13-Q15) related to analytics and visualizations are therefore left out of this evaluation, as the participants did not have time to try it out. The questionnaire we be viewed in full in appendix D.

The questionnaire used a 5-level Likert scale and all questions were positive statements. Agreeing to them therefore meant a positive experience with the authoring tool. Disagree is 1 and agree is 5. For this evaluation, only the responses with four participants (or over) stating 1 or 2. This way, we can focus on areas where the authoring tool could be improved.

Generally, the participants agreed that they would easily become skilful at using the systems (Q12) and that it was easy to learn how the system worked (Q4). Q12 and Q4 are therefore not further described here. Participants 19 and 20 have also been excluded as they failed to answer most of the questionnaire.

Authoring tool Usability

Concerning the satisfaction of using the authoring tool, most participants said 3, which is a neutral answer to Q1. We see the same tendency for Q2 where most of the participants also responded with 3.

Table 22: Answer distribution for Q1 for the Teachers Training Week pilot.

Q1: Overall, I am satisfied with how easy it is to use this system					
	Disagree				Agree
Scale	1	2	3	4	5
Total	0	4	7	5	2

Table 23: Answer distribution for Q2 for the Teachers Training Week pilot.

Q2: It was simple to use this system					
	Disagree				Agree
Scale	1	2	3	4	5
Total	0	4	9	4	1

None of the participants disagreed with the any of the statements in Q1 and Q2, which is a good sign. The usability of the thus does not seem to be the biggest issue for the authoring tool, however improvements could still be made.

Confidence in using the Authoring Tool

None of the participants felt completely comfortable using the authoring tool for the first time, which is not a surprise when dealing with novice user in 3D editing. However, it is positive for a system performing as complex tasks as the authoring tool, to have the majority of the participants (13 participants out of 18) responding with a 3 or 4 for this question. We also have to point out that none of the ENVISAGE partners were physically present when the workshop ran (only over skype) making it even more complicated for first time users.

Table 24: Answer distribution for Q3 for the Teachers Training Week pilot.

Q3: I feel comfortable using the system					
	Disagree				Agree
Scale	1	2	3	4	5
Total	3	2	6	7	0

Error messages and recovery

Error messages and recovery generally gets a negative response from the educators, with 10 disagreeing to the authoring tool providing clear messages on how to fix the problems and 7 somewhat disagreeing to it being easy to recover from mistakes when using the authoring tool.

Table 25: Answer distribution for Q5 for the Teachers Training Week pilot.

Q5: The system gives error messages that clearly tell me how to fix problems					
	Disagree				Agree
Scale	1	2	3	4	5
Total	10	2	4	0	0

Table 26: Answer distribution for Q6 for the Teachers Training Week pilot.

Q6: Whenever I make a mistake using the system, I recover easily and quickly					
	Disagree				Agree
Scale	1	2	3	4	5
Total	0	7	4	2	2

Some participants made comments in their questionnaire and some pointed out that they did not make any mistakes because they followed the instructions but still scored it low. The issues may therefore not be as big as first anticipated when going through the scores.

Information and help text

Concerning help messages and the information in the authoring tool, the participants are generally quite neutral and centred around 2-4.

Table 27: Answer distribution for Q7 for the Teachers Training Week pilot

Q7: The information (such as online help, on-screen messages, and other

documentation) provided with this system is clear					
	Disagree				Agree
Scale	1	2	3	4	5
Total	0	6	7	4	0

Table 28: Answer distribution for Q8 for the Teachers Training Week pilot

Q8: The information provided for the system is easy to understand					
	Disagree				Agree
Scale	1	2	3	4	5
Total	0	5	6	6	1

When reading the comments made for Q8 and Q7, some participants point out that they have not seen any help messages or similar even though more tool tips and help buttons have been added after the first evaluation cycle discovered the same thing. It could therefore seem like the users do notice them. This could be because they are sticking to the instructions and scenarios they were given. Exploring the authoring tool would in that case be a less likely behavior. However, it could also be the design, color and shape that needs to be made more obvious to the end-users.

Overall satisfaction

With Q9 and Q11, we again see a neutral response tendency. The largest amount of participants said 3 for both Q9 and Q11, meaning that they are not completely contempt with the interface or getting the authoring tool to do what they wanted.

Table 29: Answer distribution for Q9 for the Teachers Training Week pilot

Q9: I like using the interface of this system					
	Disagree				Agree
Scale	1	2	3	4	5
Total	1	6	5	4	2

Table 30: Answer distribution for Q11 for the Teachers Training Week pilot

Q11: I found it easy to get the system to do what I wanted					
	Disagree				Agree
Scale	1	2	3	4	5
Total	2	6	5	2	2

The participants overall satisfaction with the authoring tool also received mostly neutral responses. The participants do not seem to be completely satisfied with the authoring tool but nor do they disagree with the statement.

Table 31: Answer distribution for Q10 for the Teachers Training Week pilot

Q10: Overall, I am satisfied with the system					
	Disagree				Agree
Scale	1	2	3	4	5
Total	0	5	8	4	0

The mostly neutral score for overall satisfaction aligns with the participant's confidence self-confidence in using the authoring tool and their view of the usability. However, the participants also believed that they would easily become skilful at using the authoring tool. Many participants also added that their scores were based on getting help from scenarios or instructor. This could mean that the participants would likely be more positive about the authoring tool, once they get more confident with using it.

3.1.5 Summary

The pilots for evaluating the Authoring Process were conducted during M18-M22. In total, four pilots were conducted evaluating the Authoring Process from an end-user perspective. Both the Wind Energy Lab and Chemistry Lab template have been subject for piloting during this cycle.

Panhellenic conference workshop

The Panhellenic conference workshop has 18 teachers attending the workshop. They used the authoring tool by following the scenarios as described in section 2.7 and instructions given during the workshop. Afterwards they answered two questionnaires, about usefulness, ease of use and usability (see Appendix A).

The responses from the Panhellenic workshop provided us with 18 places the authoring tool could be improved. "Using the system would improve my job performance" (Scores: 4, 4, 3, 4, 4), were resolved by implementing User rights rules were implemented so that the users can only manages their own game projects. Using the system would enhance my effectiveness on the job (Scores: 4, 3, 4, 4, 4) could be improved by integrating with an LMS (Learning Management System) that can relate the authoring of virtual labs with learning material for the learners. This is out of the scope of ENVISAGE as LMSes for WordPress are already available in the market by several companies. The full list can be viewed in section 3.1.1 Generally, most of them were related to usability issues, which probably occurred, as the authoring tool were not completed as this point. Also the past user guide based on the step-by-step explanation of usage scenarios was very long and it was difficult for the users to read it. The video tutorial and the guided tour walkthroughs help educators to understand the system easily.

Formal Evaluation in EA

The formal evaluation in EA took place during M21 and both tested the Chemistry Lab template. The participants were teachers at the EA School, who also used the scenarios, described section 2.7 The participants answered a questionnaire after finishing the scenarios, which assessed user satisfaction, ease of use and usefulness of the tool. The questionnaire used a 5-level Likert scale and all question were positive statements. Agreeing

to them therefore meant a positive experience with the authoring tool. In addition, Q1-Q12 of the questionnaire were used for this evaluation as Q13-Q15 are concerned with the visualizations and analytics and they will thus be covered in 3.2

The participants in the formal evaluation at EA are generally positive about the authoring tool and the only issue to report is therefore error messages and recovery issues. Only one participant disagreed to the statement and this participant disagreed to all the questions in the questionnaire. The issues related to error recovery might therefore not be as strong as first anticipated but improvements have still been made to improve this

Summer School

In M22, G. Mavromanolakis (EA) conducted the summer school pilot with 15 educators engaged in in the workshop. Both the Chemistry Lab and The Wind Energy Lab were used for this pilot. The participants answered a questionnaire after finishing the scenarios, which assessed user satisfaction, ease of use and usefulness of the tool. In addition, only Q1-Q12 of the questionnaire will be used for this evaluation as Q13-Q15 are concerned with the visualizations and analytics and they will thus be covered in section 3.2

In connection with the summer school, the biggest issue is that none of the participants felt completely comfortable using the authoring tool (Q3). This is probably due to the authoring tool performing quite complex tasks and understanding it can thus be hard, especially for novice users, who are not confident with their own computer literacy skills. Error messages and recovery, is again problem as most participants responded with a neutral response and four disagreed or somewhat disagreed to Q5 “the system gives error messages that clearly tell me how fix problems”. This could be because they did not experience error messages and had an instructor helping them with what steps to perform. With Q11 “I found it easy to get the system to do what I wanted”, we again see a slightly disagreement and neutral response tendency. The largest amount of participants said 4, meaning that they somewhat disagree with the statement. The participant must thus have had issues getting the authoring tool to perform the task they were instructed to perform.

Teachers Training Week

In connection with a teachers training week, 20 Maltese schoolteachers piloted the authoring tool in M22. The participants answered the same questionnaire, as for the Formal evaluation and Summer School, after finishing the scenarios. The questions (Q13-Q15) related to analytics and visualizations are also here left out of this evaluation.

In connection with the teachers training week in Malta, the participants generally agreed that they would easily become skilful at using the systems (Q12) and that it was easy to learn how the system worked (Q4). The participants were also quite neural on the question ns related to satisfaction of using the authoring tool. None of the participants disagreed with the any of the statements in Q1 and Q2, which is a good sign. The usability does therefore not seem to be the biggest issue for the authoring tool; however, improvements could still be made. None of the participants felt completely comfortable using the authoring tool for the first time, which is not a surprise when dealing with novice user in 3D editing. Error messages and recovery generally gets a negative response from the educators, with 10 disagreeing to the authoring tool providing clear messages on how to fix the problems and 7 somewhat disagreeing to it being easy to recover from mistakes when using the authoring tool. Some participants made comments in their questionnaire and some pointed out that

they did not make any mistakes because they followed the instructions but still scored it low. When reading the comments made for Q8 and Q7, some participants point out that they have not seen any help messages or similar even though more tool tips and help buttons have been added after the first evaluation cycle discovered the same thing. It could therefore seem like the users do notice them. This could be because they are sticking to the instructions and scenarios they were given. Exploring the authoring tool would in that case be a less likely behavior. However, it could also be the design, color and shape that needs to be made more obvious to the end-users. The participants overall satisfaction with the authoring tool also received mostly neutral responses (Q10). The participants do not seem to be completely satisfied with the authoring tool but nor do they disagree with the statement. The mostly neutral score for overall satisfaction aligns with the participant's confidence self-confidence in using the authoring tool and their view of the usability. However, the participants also believed that they would easily become skilful at using the authoring tool. Many participants also added that their scores were based on getting help from scenarios or instructor. This could mean that the participants would likely be more positive about the authoring tool, once they get more confident with using it.

3.2 Analytics and Visualization

3.2.1 Formal Evaluation in EA

The formal evaluation in EA took place during M21 and both tested the Chemistry Lab template. The participants were teachers at the EA School, who used the scenarios the scenarios fully described in section 2.7 The participants answered a questionnaire after finishing the scenarios, which assessed user satisfaction, ease of use and usefulness of the tool. The questionnaire used a 5-level Likert scale and all question were positive statements. Agreeing to them therefore meant a positive experience with the authoring tool. In addition, only Q13-Q15 of the questionnaire will be used for this evaluation as Q1-Q12 have already been covered in section 3.1.2 as they concerned the Authoring Tool. The questionnaire we be viewed in full in Appendix D.

Participant 1, answered 1 to all of the questions and must arguable not have found the experience with the authoring tool good. This might be due to some technical issues experienced during the session. P1 described it this way "Scenario1: Problem with compile lab on windows. System says zip file not found. It says Sorry but you are looking for something that is not here! Why? I followed all steps written in instructions. Tried again but the same error, frustrating". This bug has been corrected and did not affect the rest of the test participants.

Evaluation of the Analytics Dashboard

The analytics dashboard receives the most positive response from the participants with one tree neutral, one somewhat agreeing and one disagreeing (P1).

Table 32: Answer distribution for Q13 for the Formal Evalution pilot.

Q13: It was clear for me how I could use the information presented in the Analytics Dashboard					
	Disagree				Agree

Scale	1	2	3	4	5
Total	1	0	3	1	0

The participants asked for more examples or explanations for the analytics and visualizations as this might makes it more clear how and what they can be used for. Examples could be added in within the system, as e.g. tooltips or external links for in-depth tutorials on how to use it.

Evaluation of student-at-risk prediction

The usage of student-at-risk prediction is a bit more unclear to the participants as three gave a neutral response, one somewhat disagreed and one disagreed to Q14.

Table 33: Answer distribution for Q14 for the Formal Evalution pilot.

Q14: It was clear for me how I could use the student-at-risk prediction					
	Disagree				Agree
Scale	1	2	3	4	5
Total	1	1	3	0	0

Student-at-risk prediction can maybe seem overwhelming to the end-users as is shows a lot of information and data at once. The participants also expressed a need for more tables or graphs in this tab, which would help visualize and understand the functionality better.

Evaluation of Dynamic Difficulty Adjustment

The application of Dynamic Difficulty Adjustment received the most negative response from the participants as two disagrees and three are neutral.

Table 34: Answer distribution for Q15 for the Formal Evalution pilot.

Q15: It was clear for me how I could use the DDA					
	Disagree				Agree
Scale	1	2	3	4	5
Total	2	0	3	0	0

The concept of DDA might be hard for a none-data scientist to understand. However, the functionality is very valuable in keeping the students engaged and challenged throughout the lab. More examples and tutorials for this functionality would probably help as the participants are interested and can see the potential in using it.

Additional feedback

Here are a few field notes and comments made by the users during the pilot:

- P2: Scenario2 is ok I followed instructions. Need more examples of graphs or tables to understand what is there.
- P5: Scenario2 is ok no problem but more examples or explanations will be helpful

3.2.2 Summer School

In M22 ENVISAGE held a workshop during ”Play-Create-Learn Summer Academy 2018” in Pallini & Marathon, Greece. Instructed by G. Mavromanolakis (EA), 15 educators engaged in

in the workshop. First, participants were given a presentation providing them with an overview of ENVISAGE. Then, the educators were given the choice between using the Chemistry lab template or the Wind energy. Educator number 1- 7 chose the Chemistry Lab and 8-15 chose the Wind Energy Lab. They all followed scenarios 1 and 2 no matter what template they had chosen. Web links: https://envisagelabs.iti.gr/login/ and https://bit.ly/2MH4iJm. The participants answered a questionnaire after finishing the scenarios, which assessed user satisfaction, ease of use and usefulness of the tool. The questionnaire we be viewed in full in Appendix D. The questionnaire used a 5-level Likert scale and all question were positive statements. Agreeing to them therefore meant a positive experience with the authoring tool. Disagree is 1 and agree is 5. This evaluation only the responses with four participants (or over) stating 1 or 2. This way, we can focus on areas where the authoring tool could be improved.

Participant 12 and 13 have been removed from the sample as they only answered the first four questions. In addition, only Q13-Q15 of the questionnaire will be used for this evaluation as Q1-Q12 have already been covered in section **Error! Reference source not found.**as they concerned the Authoring Tool.

Evaluation of the Analytics Dashboard

The analytics dashboard gets the most positive response from the participants as the responses center around the middle, meaning a more neutral attitude towards the statements. An equal amount of participants (5) said 2 and 4. Half therefore somewhat disagrees, whereas the other half somewhat agrees with the statement.

Table 35: Answer distribution for Q13 for the Summer School pilot.

Q13: It was clear for me how I could use the information presented in the Analytics Dashboard					
	Disagree				Agree
Scale	1	2	3	4	5
Total	0	5	3	5	0

When reading the field notes made during the pilot, we can see that the educators generally understood the functionality but asked for more piratical examples of use. This could probably be solved by providing more information about the dashboard within the authoring tool but also in the scenarios and when using it during workshops.

Evaluation of student-at-risk prediction

Student-at-risk prediction has two participants disagreeing two the statement, three somewhat disagreeing and three neutral. Five students also somewhat agreed to the statement.

Table 36: Answer distribution for Q14 for the Summer School pilot.

Q14: It was clear for me how I could use the student-at-risk prediction					
	Disagree				Agree
Scale	1	2	3	4	5
Total	2	3	3	5	0

The student-at-risk prediction has a bit more complex to read than the dashboard as it do not have any visualization and also relies more on reading and understanding the numbers portrayed on the page. Again, looking at the field notes, we see that some teacher are more interested in analytics than others are. For example, the want to know if they can implement their own metrics and show it in graphs and tables.

Evaluation of Dynamic Difficulty Adjustment

The Dynamic Difficulty Adjustment get the lowest scores from the participants of the Summer School. This could be because this functionality is the most complex in the analytics and visualization tool. More indebt information about how this functionality works could maybe help increase the user's comprehension of it.

Table 37: Answer distribution for Q15 for the Summer School pilot.

Q15: It was clear for me how I could use the DDA					
	Disagree				Agree
Scale	1	2	3	4	5
Total	2	2	6	3	0

Additional Feedback

Below are a few field notes and comments made by the teacher during the pilot:

- Most teachers understood the functionality of analytics but asked for more practical examples
- Some teachers more interested in analytics asked how easy/possible is to implement their own metrics to show in graphs and tables

3.2.3 Summary

The pilots for Analytics and Visualizations were conducted during M21 to M22 and had 20 participants in total. The formal evaluation in EA took place during M21 and both tested the Chemistry Lab template. The participants were five teachers at the EA School, using scenarios described in section 2.7 In M22 ENVISAGE held a workshop during "Play-Create-Learn Summer Academy 2018" in Pallini & Marathon, Greece. Instructed by G. Mavromanolakis (EA), 15 educators engaged in in the workshop. Both group of participants answered a questionnaire that both cover the authoring process and the analytics and visualizations about both the educational quality, as well as usability and usefulness. The questionnaire used a 5-level Likert scale and all question were positive statements. Agreeing to them therefore meant a positive experience with the authoring tool. Only Q13-15 were used for this evaluation as Q1-Q12 concerned the Authoring Tool, and thus have been presented in section.

In both pilots, the analytics dashboard received the most positive response out of all the analytics and visualizations functionalities. Most respondents gave a neutral response meaning that they neither agreed nor disagreed to the statement. The purpose and usage of the analytics and visualizations could thus be made clearer for the users. This is also supported by feedback from the participants at both workshops, who expressed a need for more examples or explanations for the analytics and visualizations as this might makes it

more clear how and what they can be used for. Examples could be added within the system, as e.g. tooltips or external links for in-depth tutorials on how to use it. For the student-at-risk prediction and Dynamic Difficulty Adjustment, the responses were more negative than for the analytics dashboard. Student-at-risk prediction and Dynamic Difficulty Adjustment are more complex to read and understand than the dashboard as it do not have any visualization and also relies more on reading and understanding the numbers portrayed on the page. Here, the participants also expressed a need for more tables or graphs, which would help them visualize and understand the functionalities better.

In general, most educators understood the functionality of the analytics but needed more practical examples and instructions to be able to apply it on their own. Additional information could be added within the system, as e.g. tooltips or external links for in-depth tutorials on how to use it.

3.3 Virtual Labs

The eCrises and Panhellenic workshops both evaluated the Wind Energy and the Chemistry Lab. The results have therefore been merged together here in order to avoid too many repetitions of the same information.

3.3.1 eCrisis workshop

The eCrisis Training Week tested the 3rd version of the Wind Energy and the Chemistry Lab. The workshop had 18 participants, who played it for 1-3 hours. They subsequently, answered a questionnaire about both the educational quality of the labs, as well as usability and usefulness. The questionnaire used a 5-level Likert scale for assessing eighteen questions about the quality of the lab, implementation and what they believed the students would get out of playing it. Two participants failed to answer one question each, Q11 and Q15 about how the students would work with the virtual labs and if they believed the labs would stimulate curiosity and interest for the students in the subjects. The full questionnaire can be viewed in Appendix C. The participants also gave oral feedback during the workshop, which will also be covered during in this section.

Evaluation regarding virtual labs

Only questions with responses with negative feedback will be covered in this section as these are the areas were the labs could be improved. The range of scores are 1-5 but questions both contain positive statement and negative statements. Negative statements with scores between 1-2 and positive statements with scores between 4-5 will therefore be portrayed here. At least three people should rate 2 or below in order for the comment to be valuable. These comments are indicated below:

Q5: It is difficult to integrate the virtual lab into a learning context

Three out of the 18 participants agreed that it would be difficult to integrate the virtual lab a learning context.

Table 38: answer distribution among participants for Q5.

Q5: It is difficult to integrate the virtual lab into a learning context

	strongly agree	agree	neutral	disagree	strongly disagree
Scale	1	2	3	4	5
Total	0	3	3	6	6

Response: The educators who participated in this workshop might not teach their students about wind energy and integrating the wind energy lab for their classes might therefore seems tricky to them. Presenting educational scenarios where the labs could be integrated on the website and during workshops would probably help inspire the educators in terms of utilization. A lesson plan with learning material, books etc. would also make the adaptation of the labs easier for the educators.

Q10: I believe it will be hard for me to evaluate the students' performance in the virtual lab

Four out of the 18 participants either agreed or strongly agreed that it would be hard for them to evaluate the students' performance in the virtual labs.

Table 39: answer distribution among participants for Q10, for the eCrises workshop.

Q10: I believe it will be hard for me to evaluate the students' performance in the virtual lab					
	strongly agree	agree	Neutral	disagree	strongly disagree
Scale	1	2	3	4	5
Total	2	2	5	8	1

Response: This topic has been dealt already with the development of the analytics tools that allow the teachers to see the students' responses in the games. It therefore also emphasizes the need for the analytics as these educators did not use the analytics in connection with playing the labs. They were however shown the analytics when trying out the authoring tool. It seems that some teachers are not familiarized with the meaning of game analytics and it is difficult for them to use it. This is coped with the increased user friendliness in the second prototype as it.

3.3.2 Panhellenic workshop

The Panhellenic workshop took place during M18 at the 17th Panhellenic Conference of Greek Union of Physicists. The two-hour workshop was called "Design your own Virtual Laboratory", and eighteen secondary and higher education teachers participated. They both played the Chemistry Lab and Wind Energy Lab.

The participants were given a questionnaire after participating in the workshop. The questionnaire used a 5-level Likert scale for assessing eighteen questions about the quality of the lab, implementation and what they believed the students would get out of playing it. The full questionnaire can be viewed A. The participants also gave oral feedback during the workshop, which will also be covered during in this section.

Evaluation regarding virtual labs

In general, the comments for the Chemistry and Wind Energy virtual labs were positive indicating that the labs are on the right path. When it comes to the quality of the content and presentation of the subjects all participants either agreed or strongly agreed to the statements. Only questions with responses negative feedback will be covered in this section as these are the areas were the labs could be improved. The range of scores are 1-5 but questions both contain positive statement and negative statements. Negative statements with scores between 1-2 and positive statements with scores between 4-5 will therefore be portrayed here.

1) I believe it will be hard for me (the teacher) to evaluate the student's performance in the virtual lab: 3, 2, 3

   Response: This comment has been dealt already with the development of the analytics tools that allow the teachers to see the students' responses in the games. It seems that some teachers are not familiarized with the meaning of game analytics and it is difficult for them to use it. This is coped with the increased user friendliness in the second prototype as it.

2) Generally, the microscopes should be used as "gates" of constructing molecules from Atoms because no microscope can be used for such a process.

   Response: We have replaced the microscopes with laptops that were in generally accepted from the educators.

Additional feedback

For the Chemistry Lab the microscopes should be used as "gates" of constructing molecules from Atoms because no microscope can be used for such a process. As it is a virtual lab, staying true to the process of real world chemistry labs are important for the students learning process and immersion. We have therefore replaced the microscopes with laptops, which generally received positive feedback and acceptance from the educators. Comments from the project reviewers reported in the first review meeting were also considered. Safety signs were placed inside the chemistry labs, and the alcohol box was removed in order not to miss-conceive that methanol is a drinking liquid.

3.3.3 Test A

The following will cover the responses collected through the Test A pilot using the Wind Energy Lab. The two questionnaires targeted students and teachers. The student questionnaire sought to uncover the student's expectation compared with their perceived experience of the Wind Energy Lab, whereas the teacher's questionnaire attempts to disclose how the teachers would evaluate the Wind Energy Lab from their own view but also with respect to the experience of the students.

Teacher's questionnaire responses

The questionnaire was based on a one-group test design and used a 5-level Likert scale for the ten questions. The questionnaire was handed to the teachers after the pilots had been conducted.

Seven teachers in total participated in the test with each their own class of students. All seven teachers answered the questions in the questionnaire. Full questionnaire can be viewed in section A.

Content of the lab (Q1 and Q2)

In Q1: "The content presented in the virtual lab is correct and well balanced", five teachers stated that they strongly agree, one stated agreed and one state neutral. Most teachers either agreed or strongly agreed and the teacher stating neutral could either be because the teacher do not feel equipped to comment on the content of the lab, ad her or she is not an expert on the topic. Alternatively, the teacher do not find the content directly wrong or correct but thinks it could be improved.

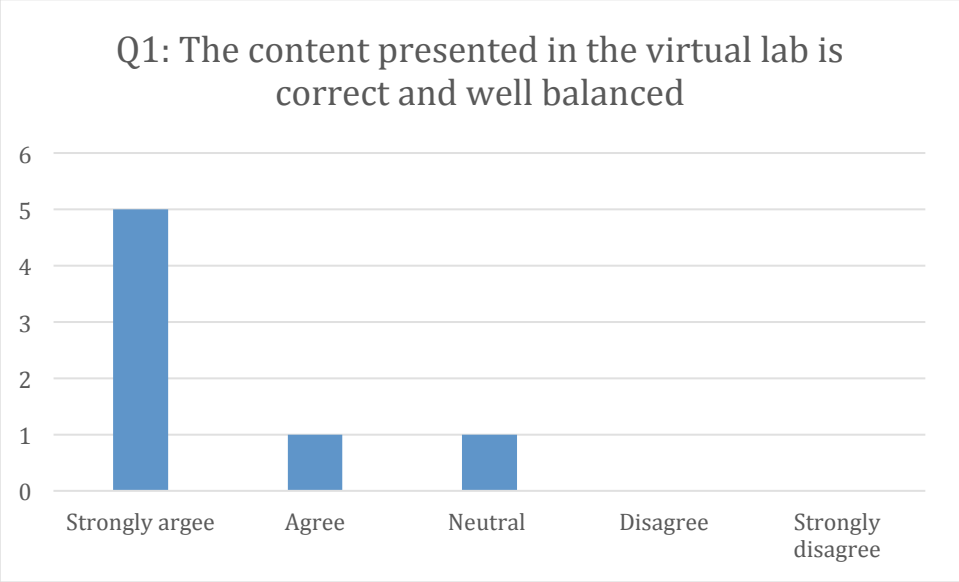

Figure 8: answer distribution among participants for Test A (Q10).

In Q2: "The virtual lab and the learning content did not meet my expectations" two teachers strongly disagreed, four disagreed and one was neutral. When compared with the responses for Q1, three teachers have moved from strongly agree to disagree and there is still one neutral. While the responses are not showing a negative attitude towards the lab content this could be one place where improvement could be focused.

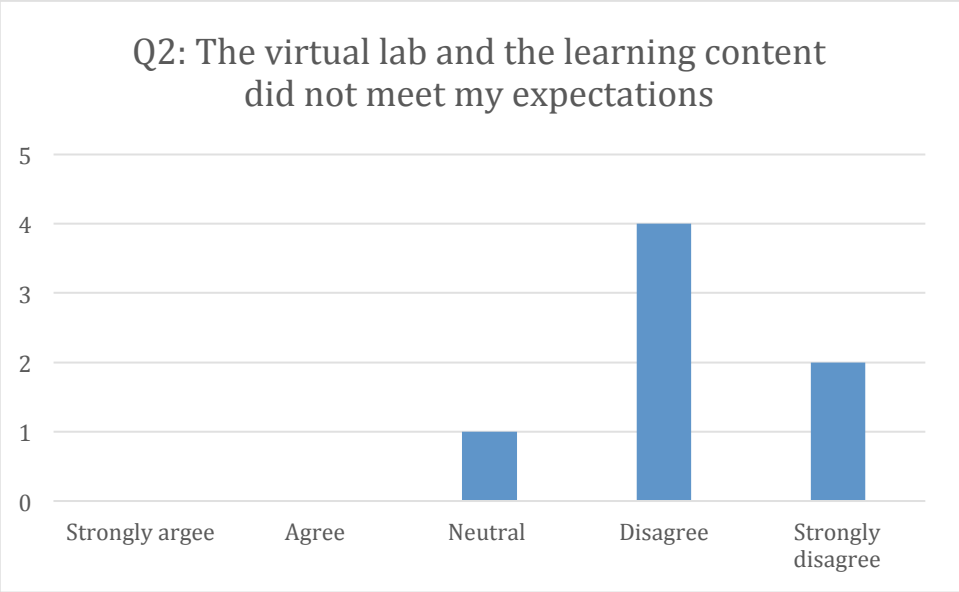

Figure 9: answer distribution among participants for Test A (Q2).

Structure and complexity fit for students (Q3)

For question Q3, three teachers stated that they strongly agree and four stated that they agreed with the statement made in the questionnaire. This question is a positive statement and respondents agreeing to it therefore means that they were satisfied with the Wind Energy Lab.

Q3: “The learning material is presented in a structure and complexity that suits the students' competencies”, a majority of respondents agreed with the statement, signifying that the learning content of the virtual lab is neither too complex, nor too easy for the students current educational level.

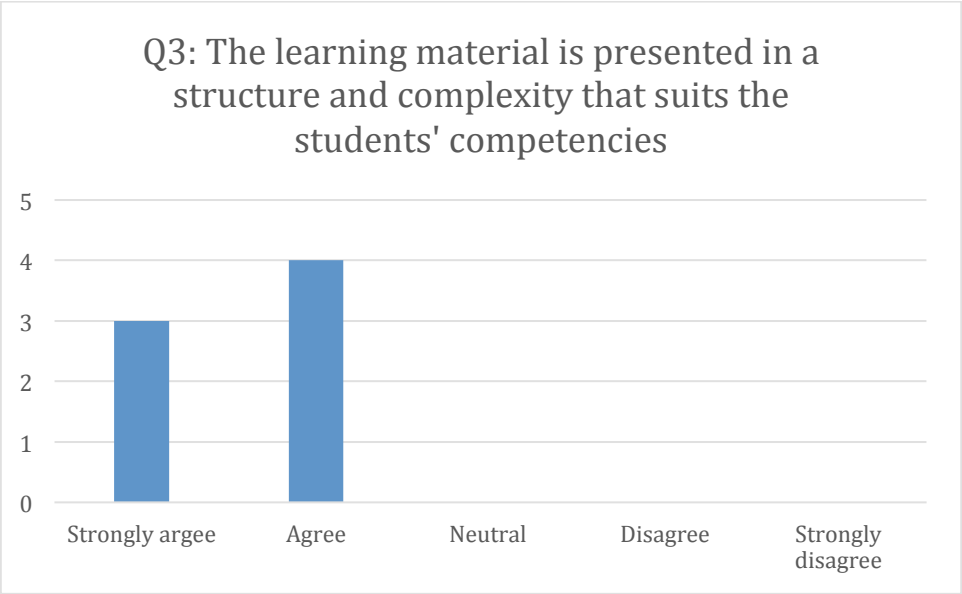

Figure 10: answer distribution among participants for Test A (Q3).

Teacher instructions (Q4)

For question Q4, three teachers stated that they strongly agree and four stated that they agreed with the statement made in the questionnaire. Q4: “I found that the instructions for the virtual lab were good”. As the question is a positive statement and a majority respondents agreeing to it could therefore indicate that the instructions provided within the lab, and leading up to the session, are informing and preparing the teachers for using it in a classroom setting.

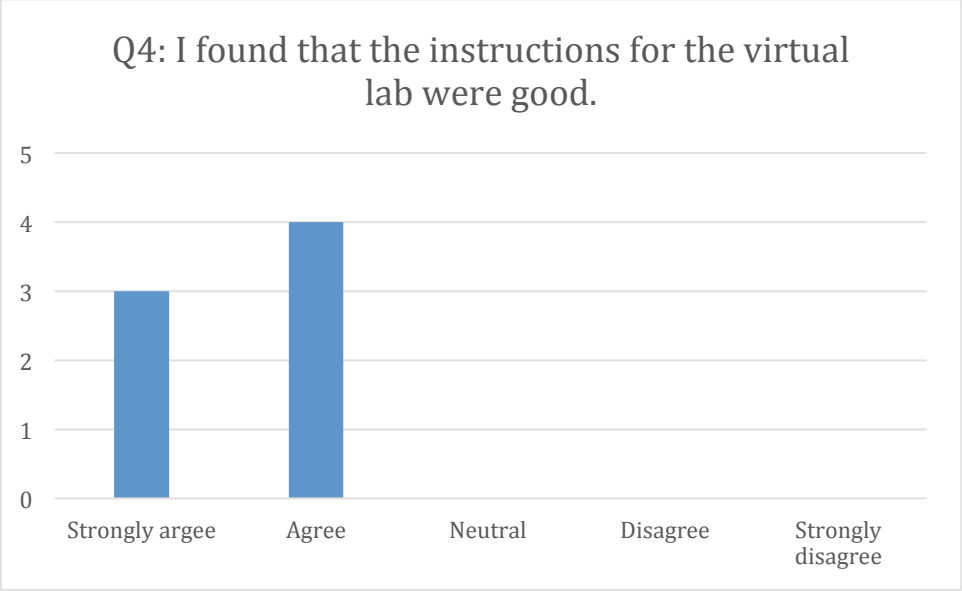

Figure 11: answer distribution among participants for Test A (Q4).

Learning goals (Q5)

In Q5: “The learning goals for the virtual lab are clears” four teachers strongly agreed, one agreed, one was neutral and one disagreed. Most teachers (fours) finds the learning goals completely clear but at least one teacher disagrees with this. Unclear leaning goals can be damaging for the use of the lab, as the teacher will be the determining factor for if the lab will be used for their teaching or not.

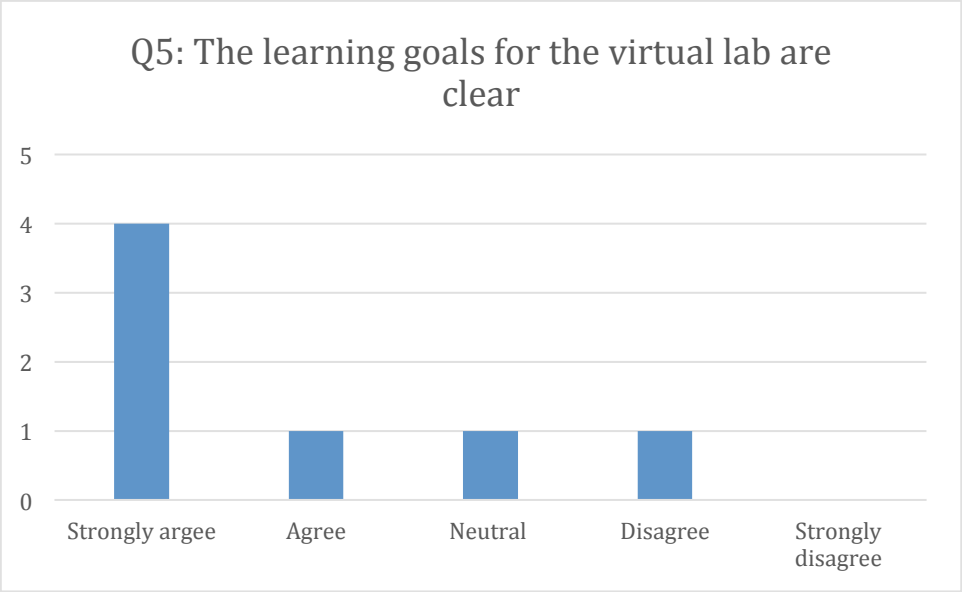

Figure 12: answer distribution among participants for Test A (Q5).

Evaluation of performance (Q6)

In Q6: "It was hard for me to evaluate the student's performance in the virtual lab" one teacher strongly disagreed, one was neutral and one agreed. This means that Q6 received the most negative feedback out of all ten questions. The negative reposes can be linked to responses for Q5 about clear learning goals, because if the learning goal is not clear to the teachers, how are they then supposed to evaluate the performance of the students.

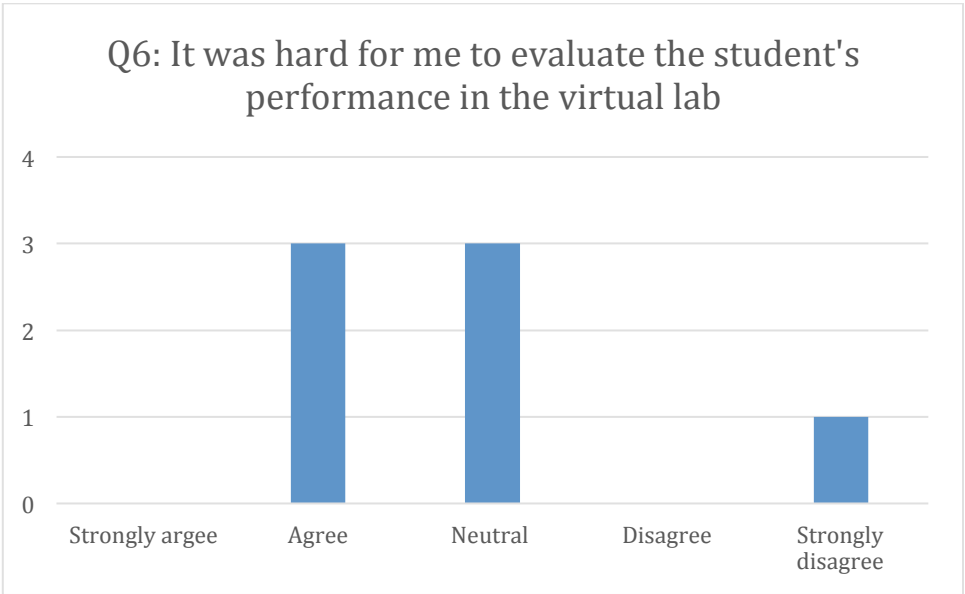

Figure 13: answer distribution among participants for Test A (Q6).

All respondents would use the lab again (Q7)

For question number seven, Q7: "I would use the virtual lab again in my teaching", all seven respondents answered strongly agree. Indicating that all the participating teachers overall had a positive enough experience using the lab in an educational context that they would repeatedly use it.

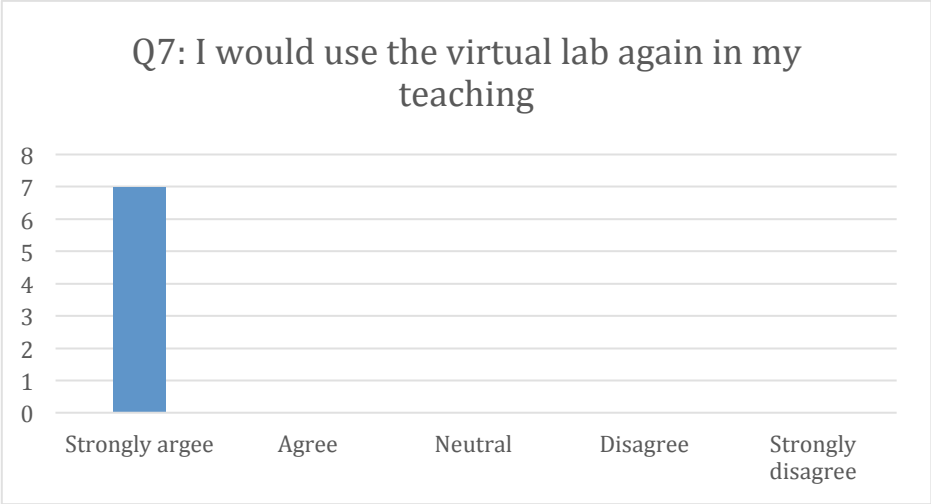

Figure 14: answer distribution among participants for Test A (Q7).

Challenge level of the lab (Q8)

In Q8: "I believe the students found the virtual lab challenging", three teachers stated that they strongly disagree and four stated that they disagreed with the statement. Because Q8 is a negative statement, disagreement with the statement, is a sign of a positive attitude towards the lab and could point towards a perceived balance between challenge of the lab and the student's proficiency level.

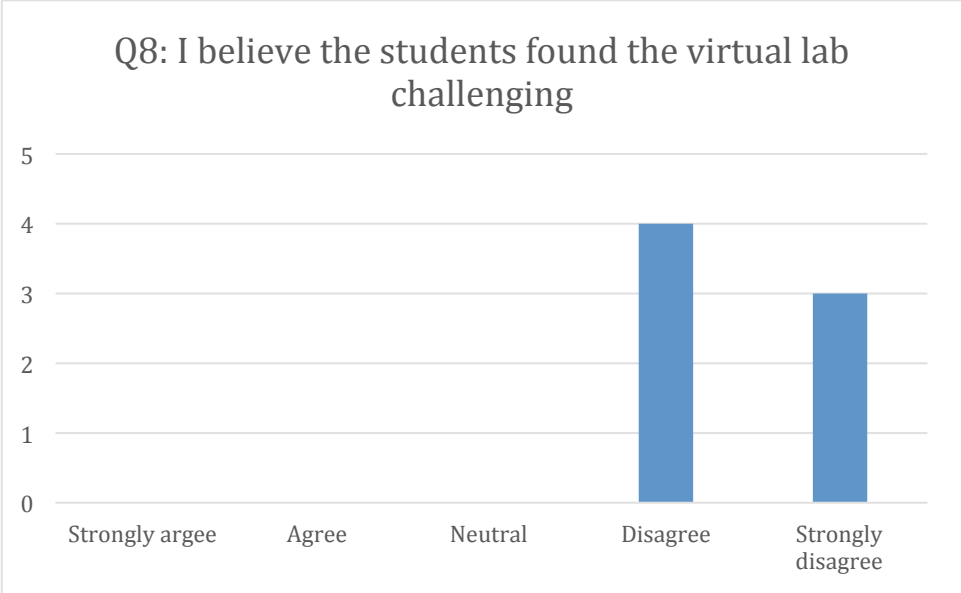

Figure 15: answer distribution among participants for Test A (Q8).

Fun while learning (Q9)

In Q9: "I believe the students enjoyed using the virtual lab", four teachers stated that they strongly agree and three stated that they agreed with the statement. As this statement is also positive, a majority of respondents strongly agreed with the statement could indicate that the teachers experienced the kids having fun while being engaged with the virtual lab.

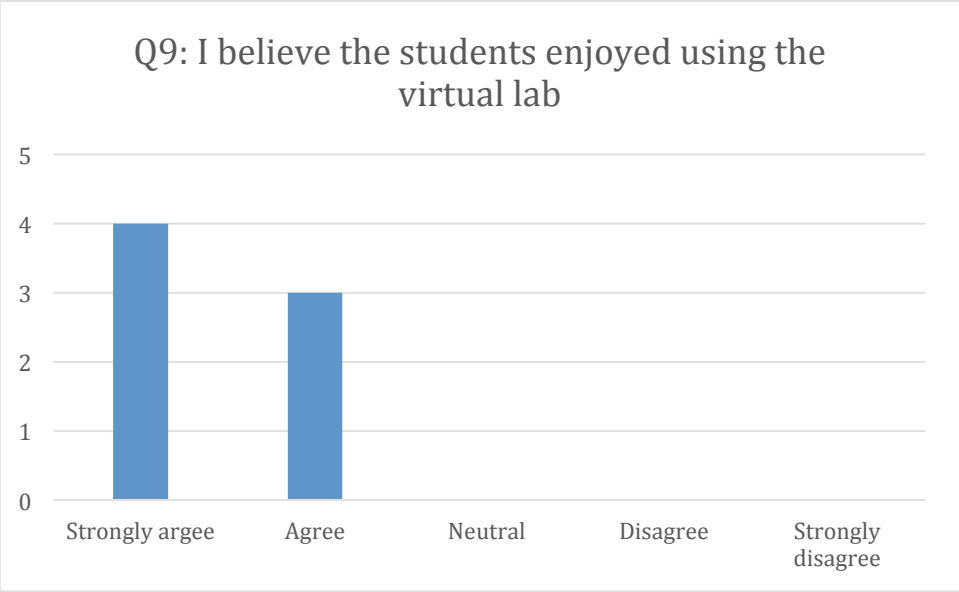

Figure 16: answer distribution among participants for Test A (Q9).

Stimulation of student interest in Wind Energy Lab (Q10)

For Q10: "I believe the virtual lab stimulated the students' interest or curiosity in the subject", all but one teacher responded Strongly agree to the statement. The last teacher responded Agree. This indicates that the teachers perceived the lab as a positive reinforcing factor in generating a natural interest and curiosity for Wind Energy Lab. The lab is thus being viewed as a positive effect on students.

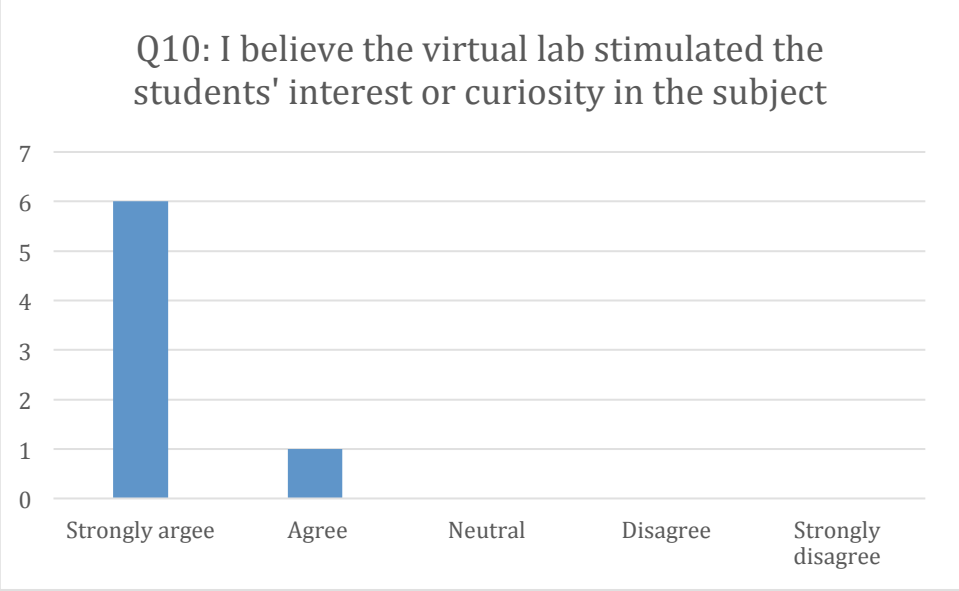

Figure 17: answer distribution among participants for Test A (Q10).

Student's questionnaire responses

The questionnaire was based on a One-group pre-test/post-test design and used a 5-level Likert scale. It contains seven questions, divided into two; three pre-test and four post-test. Seven 6th grade classes counting 170 students in total participated in the test. All 170

students answered the three pre-test questions (Q1-Q3), one student missed Q7 and two students did not answer any of the post-test questionnaire (Q4-Q7).

Expected and experienced ease of use

Before playing the Wind Energy Lab, the students were asked if they predicted the lab to be challenging to use. Below a bar chart and table with distribution of responses for Q1 can be viewed:

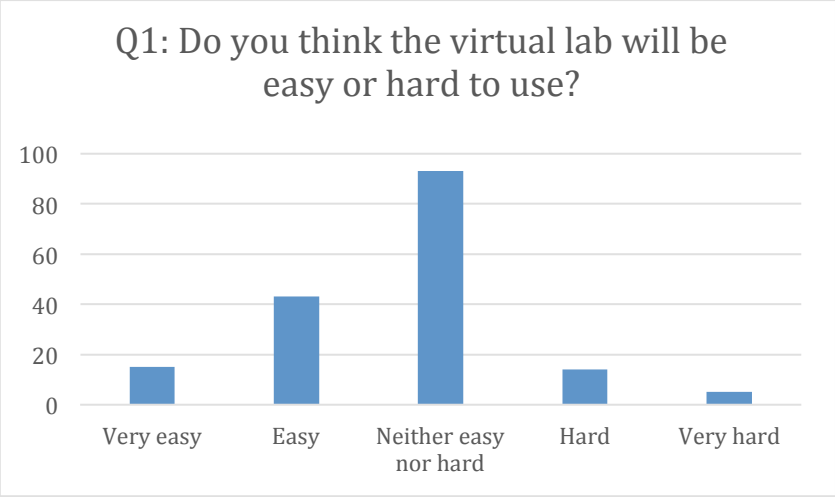

Figure 18: answer distribution among participants for Test A (Q1).

Q1: Do you think the virtual lab will be easy or hard?				
Very easy	Easy	Neither easy nor hard	Hard	Very hard
15	43	93	14	5
8,82%	25,29%	54,71%	8,24%	2,94%

Table 40: answer distribution among participants for Test A (Q1).

After playing the Wind Energy Lab, the students were now asked if they experienced the lab as challenging to use. Below a bar chart and table with distribution of responses for Q5 can be found:

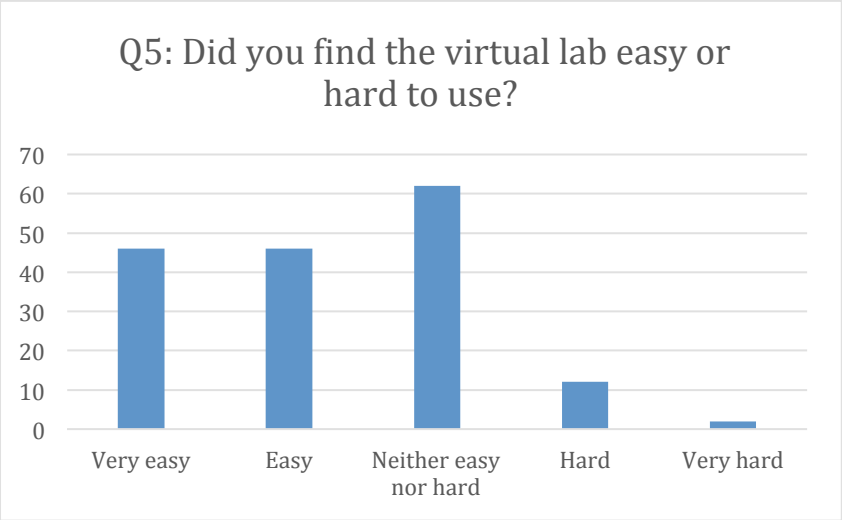

Figure 19: answer distribution among participants for Test A (Q5).

Table 41: answer distribution among participants for Test A (Q5).

Q5: Did you find the virtual lab easy or hard to use?				
Very easy	Easy	Neither easy nor hard	Hard	Very hard
46	46	62	12	2
27,38%	27,38%	36,90%	7,14%	1,19%

34 students moved from “Neither easy nor hard”, “Hard” or “Very hard” towards “Easy” and “Very easy” when asked about their experienced use after the test. This means that the students anticipated the lab to be more challenging to use that what they actually experienced. This might be due to the students perceived level or technical skill or their expertise within the subject of the lab.

Expected and experienced fun

Before playing the Wind Energy Lab, the students were asked if they expected the experience of playing the lab to be fun. Below, is a bar chart and table with distribution of responses for Q2:

Figure 20: answer distribution among participants for Test A (Q2).

Table 42: answer distribution among participants for Test A (Q2).

Q2: Do you think you playing the virtual lab will be fun?				
Not fun at all	slightly fun	Fun	Very fun	Extremely fun
7	15	72	53	23
4,12%	8,82%	42,35%	31,18%	13,53%

After playing the Wind Energy Lab, the students were again answered a question related to fun. However, this time, the question sought to cover their experienced level of fun after having engaged with the lab. Below, is a bar chart and table with distribution of responses for Q6:

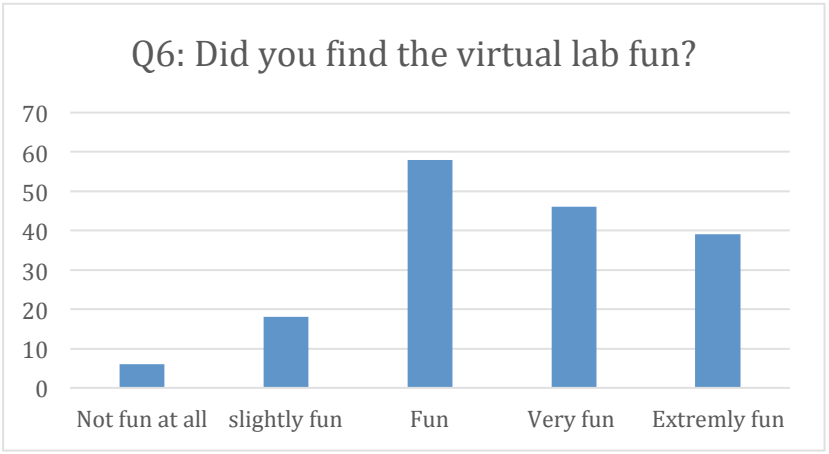

Table 43: answer distribution among participants for Test A (Q6).

Q6: Did you find the virtual lab fun?				
Not fun at all	slightly fun	Fun	Very fun	Extremely fun
6	18	58	46	39
3,59%	10,78%	34,73%	27,54%	23,35%

After playing the lab, 14 students move from saying the lab is fun to either "Slightly fun" (+3) or "Extremely fun" (+16). However, the biggest move is towards "Extremely fun" with 16 more students responding that. This could indicate that the lab to a greater extent positively exceed the students expectations than the opposite.

Expected and experienced learning

The students were asked if they anticipated learning something from playing Wind Energy Lab before the test started. A bar chart and table with distribution of responses for Q3:

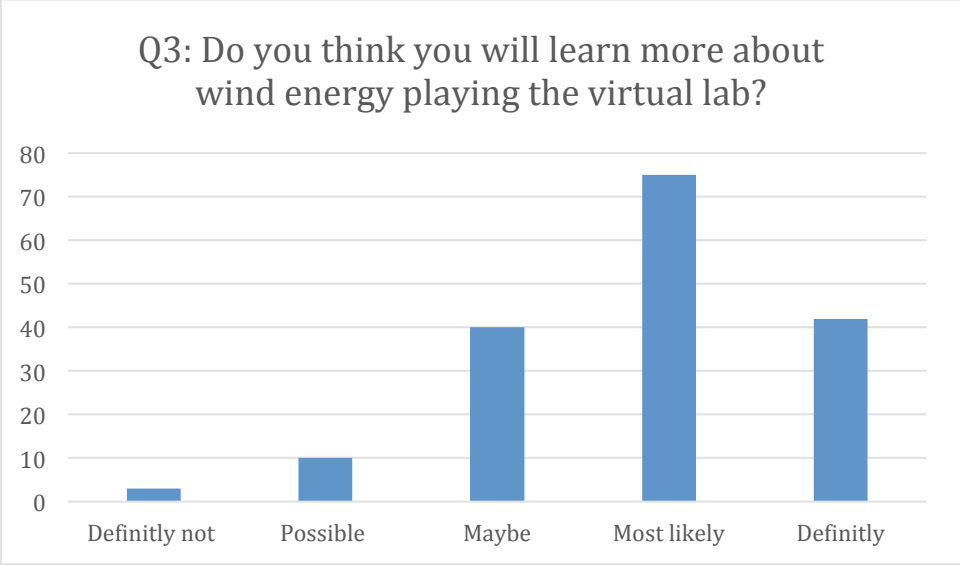

Figure 21: answer distribution among participants for Test A (Q3).

Table 44: answer distribution among participants for Test A (Q3).

Q3: Do you think you will learn more about wind energy playing the virtual lab?				
Definitely not	Possible	Maybe	Most likely	Definitely
3	10	40	75	42
1,76%	5,88%	23,53%	44,12%	24,71%

Here two thirds (117) of the students either anticipate to most likely or definitely learn from playing the lab, whereas only 13 said they possible or definitely did not anticipate to learn from playing the lab. After playing the Wind Energy Lab, the students were asked to answer a question related to their experienced learning outcome. Below, is a bar chart and table with distribution of responses for Q4:

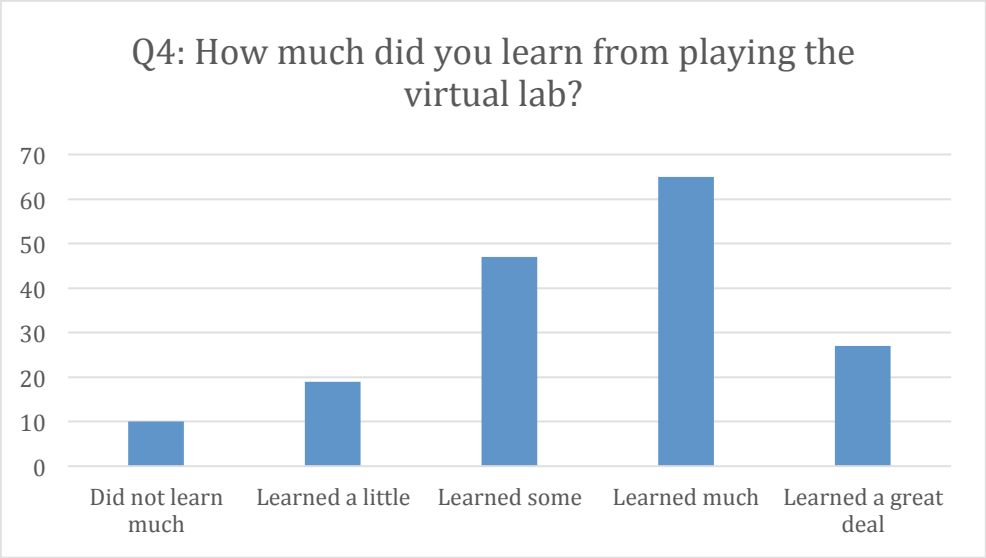

Figure 22: answer distribution among participants for Test A (Q4).

Q4: How much did you learn from playing the virtual lab?				
Did not learn much	Learned a little	Learned some	Learned much	Learned a great deal
10	19	47	65	27
5,95%	11,31%	27,98%	38,69%	16,07%

Table 45: answer distribution among participants for Test A (Q4).

Half of the students report having learn much or a great deal when asked after the test. When comparing this to the two thirds or students who anticipate to either most likely or definitely learn from playing the lab. This means that for 25 of the students the expected learning outcome did not live up to their experienced learning outcome. More students are thus reporting to learning some, a little or not much. Nonetheless, over 50% of the students still report having a large learning outcome and only ten students did not feel like they learned much.

Replaying the lab

After playing the Wind Energy Lab, the students were asked to answer if they would play the lab again after the test. Below, is a bar chart and table with distribution of responses for Q7:

Table 46: answer distribution among participants for Test A (Q7).

Q7: Would you like to play the virtual lab again?				
I would definitely not try again	Would probably not try again	Would maybe try again	Would quite likely try again	Would definitely try again
9	10	34	48	66
5,39%	5,99%	20,36%	28,74%	39,52%

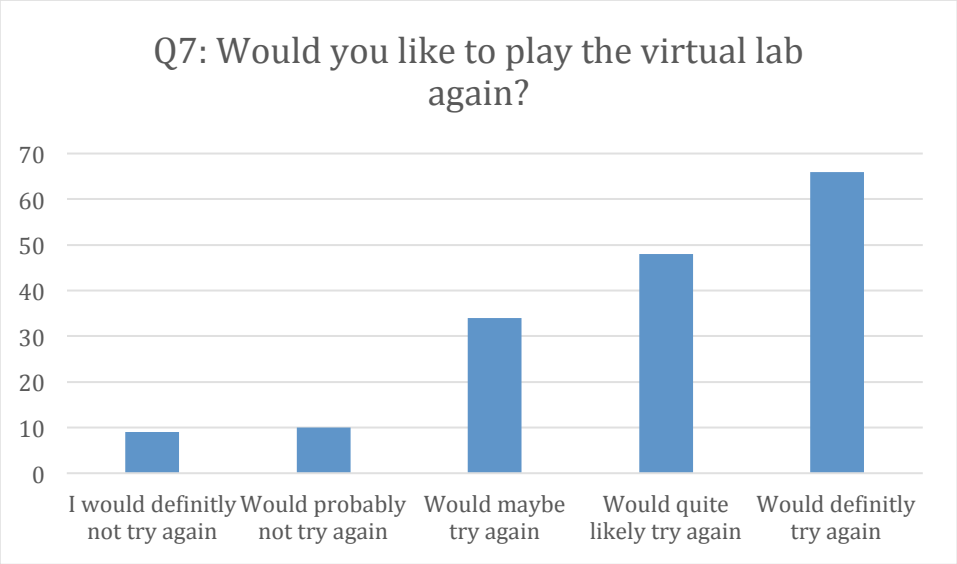

Figure 23: answer distribution among participants for Test A (Q7).

Almost two thirds of the students (114) either said: Would quite likely try again or Would definitely try again. Whereas only a tenth of the students (19) said: I would definitely not try again or Would probably not try again. Compared to this, almost twice as many students (34) would maybe try the lab again. The largest amount of students would therefor maybe, quite likely or definitely try the lab again after the test, indicating that the students have had a positive experience with the lab.

3.3.4 Test B

The following will cover the responses collected through the Test B pilot using the Wind Energy Lab. The two questionnaires targeted students and teachers. The questionnaires are the same for Test B as in Test B

Teacher's questionnaire responses

The questionnaire was based on a one-group test design and used a 5-level Likert scale for the ten questions. The questionnaire was handed to the teachers after the pilots had been conducted.

Seven teachers in total participated in the test with each their own class of students. All seven teachers answered the questions in the questionnaire again. Full questionnaire can be viewed in appendix A.

Content of the lab (Q1 and Q2)

In Q1: “The content presented in the virtual lab is correct and well balanced”, we see a positive move in attitude from only two who strongly agreed in Test A to five in Test B.

Table 47: answer distribution among participants for Test B Wind Energy Lab (Q1).

Q1: The content presented in the virtual lab is correct and well balanced					
Scale	Strongly agree - 1	Agree - 2	Neutral - 3	Disagree - 4	Strongly disagree – 5
Test A	2	4	1	0	0
Scale	Strongly agree - 1	Agree - 2	Neutral - 3	Disagree - 4	Strongly disagree - 5
Test B	5	1	1	0	0

In Q2: “The virtual lab and the learning content did not meet my expectations” two teachers strongly disagreed, four disagreed and one was neutral in Test A. Now four teachers strongly disagreed, two disagreed and one was neutral. The content therefore lived up to the expectations of the teachers to a higher degree in Test B.

Table 48: answer distribution among participants for Test B Wind Energy Lab (Q2).

Q2: The virtual lab and the learning content did not meet my expectations					
Scale	Strongly agree - 1	Agree - 2	Neutral - 3	Disagree - 4	Strongly disagree – 5
Test A			1	4	2
Scale	Strongly agree - 1	Agree - 2	Neutral - 3	Disagree - 4	Strongly disagree – 5
Test B	5	1	1	2	4

Structure and complexity is still a fit for students (Q3)

For question Q3, three teachers stated that they strongly agree and four stated that they agreed in Test A. This question is a positive statement and respondents agreeing to it therefore means that they were satisfied with the Wind Energy Lab. However, even more teacher indicated that they strongly agreed with this statement in Test B. A majority of respondents agreed with the statement (5 participants), signifying that the learning content of the virtual lab is neither too complex, nor too easy for the students current educational level.

Table 49: answer distribution among participants for Test B Wind Energy Lab (Q3).

Q3: The learning material is presented in a structure and complexity that suits the students' competencies					
Scale	Strongly agree - 1	Agree - 2	Neutral - 3	Disagree – 4	Strongly disagree – 5
Test A	3	4			
Scale	Strongly agree - 1	Agree - 2	Neutral - 3	Disagree – 4	Strongly disagree – 5
Test B	5	2			

Teacher instructions (Q4)

For question Q4, three teachers stated that they strongly agree and four stated that they agreed with the statement made in the questionnaire for Test A. Q4: “I found that the

instructions for the virtual lab were good". Two teachers have moved from agree to neutral and one to strongly agree. It could therefore seem like the teachers have not found the instructions for Test B as informative as for Test A. This could however be due to the fact that this is the second pilot and the teachers might have gotten less instructions for Test B than Test A.

Table 50: answer distribution among participants for Test B Wind Energy Lab (Q4).

Q4: I found that the instructions for the virtual lab were good					
Scale	Strongly agree - 1	Agree - 2	Neutral – 3	Disagree – 4	Strongly disagree – 5
Test A	3	4	0	0	0
Scale	Strongly agree - 1	Agree - 2	Neutral – 3	Disagree – 4	Strongly disagree – 5
Test B	4	1	2	0	0

Learning goals (Q5)

For question Q5: "The learning goals for the virtual lab are clears only a small change has occurred from Test A to Test B. One teacher has moved from disagree to neutral, which could point towards a small improvement in the design of the instructions.

Table 51: answer distribution among participants for Test B Wind Energy Lab (Q5).

Q5: The learning goals for the virtual lab are clear					
Scale	Strongly agree – 1	Agree – 2	Neutral – 3	Disagree – 4	Strongly disagree – 5
Test A	4	1	1	1	0
Scale	Strongly agree – 1	Agree – 2	Neutral – 3	Disagree – 4	Strongly disagree – 5
Test B	4	1	2	0	0

Evaluation of performance (Q6)

For Q6: "It was hard for me to evaluate the student's performance in the virtual lab" the teachers indicated a big positive change. In test A, three strongly disagreed, three agreed and one strongly disagreed. This meant that Q6 received the most negative feedback out of all ten questions in Test A. However, now only two teachers agree and five strongly disagrees. This could indicate that the teachers are more confident with evaluating the students' performance in the lab after having used it once.

Table 52: answer distribution among participants for Test B Wind Energy Lab (Q6).

Q6: It was hard for me to evaluate the student's performance in the virtual lab					
Scale	Strongly agree – 1	Agree - 2	Neutral – 3	Disagree – 4	Strongly disagree – 5
Test A	3	3	0	0	1
Scale	Strongly agree – 1	Agree - 2	Neutral – 3	Disagree – 4	Strongly disagree – 5
Test B	0	2	0	0	5

All respondents would the lab again (Q7)

For question number seven, Q7: “I would use the virtual lab again in my teaching”, all seven respondents answered strongly agree during Test A. In Test B one teachers is now indicating agree, while the rest still strongly agrees. This still indicates that all the participating teachers overall had a positive enough experience using the lab in an educational context that they would repeatedly use it.

Table 53: answer distribution among participants for Test B Wind Energy Lab (Q7).

Q7: I would use the virtual lab again in my teaching					
Scale	Strongly agree – 1	Agree - 2	Neutral – 3	Disagree – 4	Strongly disagree – 5
Test A	7	0	0	0	
Scale	Strongly agree – 1	Agree - 2	Neutral – 3	Disagree – 4	Strongly disagree – 5
Test B	6	1	0	0	0

Challenge level of the lab (Q8)

In Q8: “I believe the students found the virtual lab challenging”, all seven teachers now do not believe that the students would find the lab challenging by indicating, “Strongly agree” to the question. This is a sign of a positive attitude towards the lab, which could point towards a perceived balance between the challenge of the lab and the student’s proficiency level.

Table 54: answer distribution among participants for Test B Wind Energy Lab (Q8).

Q8: I believe the students found the virtual lab challenging					
Scale	Strongly agree - 1	Agree - 2	Neutral – 3	Disagree – 4	Strongly disagree – 5
Test A	0	0	0	4	3
Scale	Strongly agree – 1	Agree – 2	Neutral – 3	Disagree – 4	Strongly disagree – 5
Test B	0	0	0	0	7

Fun while learning (Q9)

In Q9: “I believe the students enjoyed using the virtual lab” seven teachers now strongly agree with the statement as appose to only four in Test A. The teachers appear to be experiencing the kids having fun while being engaged with the virtual lab more in Test B than Test A.

Table 55: answer distribution among participants for Test B Wind Energy Lab (Q9).

Q9: I believe the students enjoyed using the virtual lab					
Scale	Strongly agree - 1	Agree - 2	Neutral – 3	Disagree – 4	Strongly disagree – 5
Test A	4	3	0	0	0
Scale	Strongly agree – 1	Agree – 2	Neutral – 3	Disagree – 4	Strongly disagree – 5
Test B	6	1	0	0	0

Stimulation of student interest in Wind Energy Lab (Q10)

For Q10: "I believe the virtual lab stimulated the students' interest or curiosity in the subject", all but one teacher responded strongly agree to the statement in test A. The last teacher responded Agree. In test B five indicated strongly agree, while two agreed. The slight change could be due to the same students' playing the lab twice. The second time may thus not awake as much excitement and curiosity as their first experience using the lab. However, the lab still seems to have a positive effect on the student students.

Table 56: answer distribution among participants for Test B Wind Energy Lab (Q10).

Q10: I believe the virtual lab stimulated the students' interest or curiosity in the subject					
Scale	Strongly agree - 1	Agree - 2	Neutral – 3	Disagree – 4	Strongly disagree – 5
Test A	6	1	0	0	0
Scale	Strongly agree – 1	Agree – 2	Neutral – 3	Disagree – 4	Strongly disagree – 5
Test B	5	2	0	0	0

Student's questionnaire responses

The questionnaire for the students in Test B was the same as in Test A. Based on a One-group pre-test/post-test design and used a 5-level Likert scale. It contains seven questions, divided into two; three pre-test and four post-test. Seven 6th grade classes counting 156 students in total participated in the test. All 156 students answered the three pre-test questions (Q1-Q3), four students missed Q4-Q6 and five students did not answer Q7. All the question missed are in the post-test questionnaire

Expected and experienced ease of use

Before playing the Wind Energy Lab, the students were asked if they predicted the lab to be challenging to use. Below a bar chart and table with distribution of responses for Q1 can be viewed:

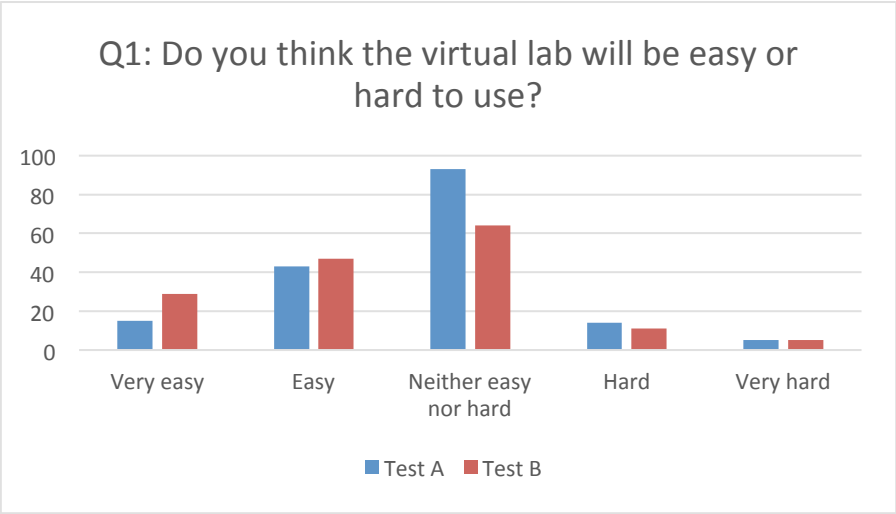

Figure 24: answer distribution among participants for Test B Wind Energy Lab (Q1).

Table 57: answer distribution among participants for Test B Wind Energy Lab (Q1).

Q1: Do you think the virtual lab will be easy or hard?					
	Very easy	Easy	Neither easy nor hard	Hard	Very hard
Test A	15	43	93	14	5
Percentage	8,82%	25,29%	54,71%	8,24%	2,94%
Test B	29	47	64	11	5
Percentage	18,59%	30,13%	41,03%	7,05%	3,21%

For Test B more students are now predicting it to be Very easy or Easy to play, whereas less expected it to be hard. This can be because the students have played the lab before and therefore feels more confident in how they will perform.

After playing the Wind Energy Lab, the students were now asked if they experienced the lab as challenging to use. Below a bar chart and table with distribution of responses for Q5 Test A and B can be found:

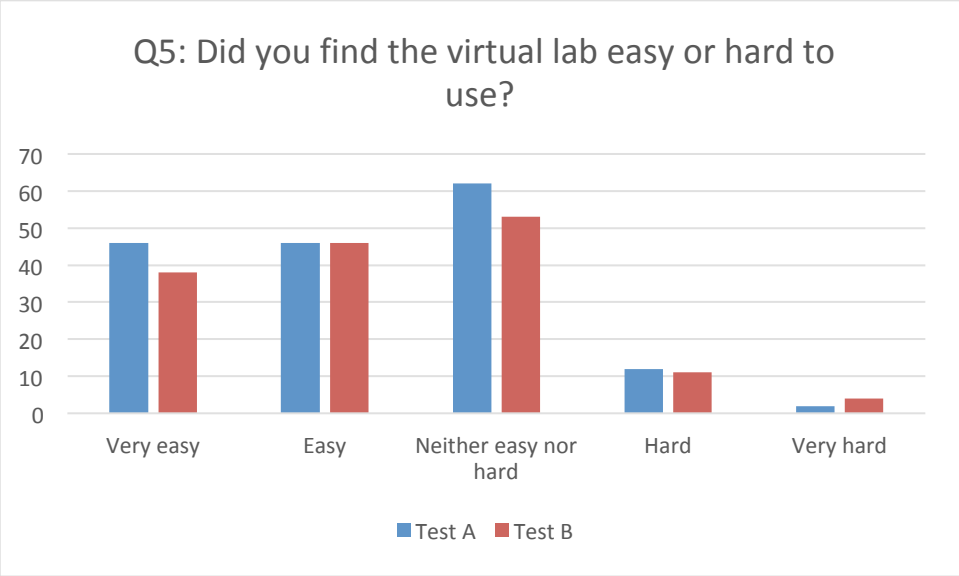

Figure 25: answer distribution among participants for Test B Wind Energy Lab (Q5).

Q5: Did you find the virtual lab easy or hard to use?					
	Very easy	Easy	Neither easy nor hard	Hard	Very hard
Test A	46	46	62	12	2
Percentage	27,38%	27,37%	36,90%	7,14%	1,19
Test B	38	46	53	11	4
Percentage	25,00%	30,26%	34,87%	7,24%	2,63%

Table 58: answer distribution among participants for Test B Wind Energy Lab (Q5).

In Test B, we see the same tendency as for Test A, where the students attitudes moves from neither easy nor hard to very easy and easy. Again, this could indicate that the students anticipated the lab to be more challenging to use that what they actually experienced, even though they have played it before. The lab therefore seems to match the students' academic and technical level well, which is also in confirmed by the teachers' responses.

Expected and experienced fun

Before playing the Wind Energy Lab, the students were asked if they expected the experience of playing the lab to be fun. Below, is a bar chart and table with distribution of responses for Q2, comparing responses from Test A and Test B:

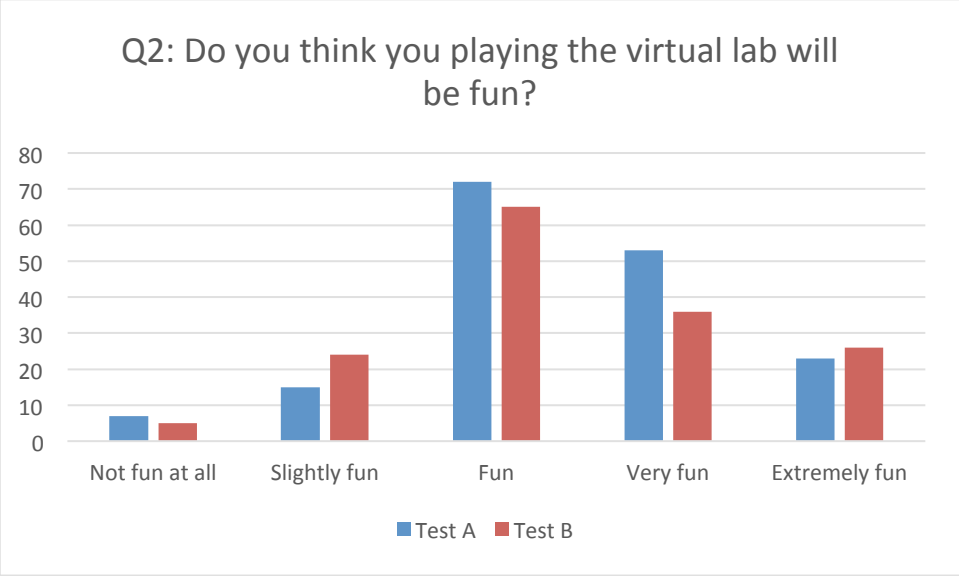

Figure 26: answer distribution among participants for Test B Wind Energy Lab (Q2).

Q2: Do you think you playing the virtual lab will be fun?					
	Not fun at all	Slightly fun	Fun	Very fun	Extremely fun
Test A	7	15	72	53	23
Percentage	4,12%	8,82%	42,35%	31,18%	13,53%
Test B	5	24	65	36	26
Percentage	3,21%	15,38%	41,67%	23,08%	16,67%

Table 59: answer distribution among participants for Test B Wind Energy Lab (Q2).

The distribution of expected fun for Test B is quite similar to the responses from Test A. Most responders put fun, then very fun, extremely fun etc.

After playing the Wind Energy Lab, the students again answered a question related to fun. However, this time, the question sought to cover their experienced level of fun after having

engaged with the lab. Below, is a bar chart and table with distribution of responses for Q6, comparing the responses from Test A to Test B:

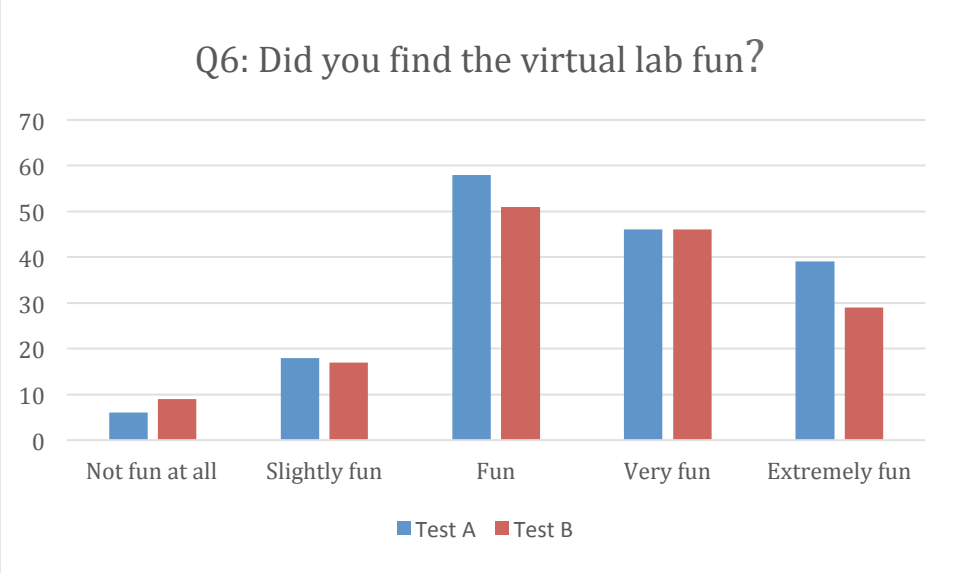

Figure 27 answer distribution among participants for Test B Wind Energy Lab (Q6).

Q6: Did you find the virtual lab fun?					
	Not fun at all	Slightly fun	Fun	Very fun	Extremely fun
Test A	6	18	58	46	39
Percentage	3,59%	10,78%	34,73%	27,54%	23,35%
Test B	9	17	51	46	29
Percentage	5,92%	11,18%	33,55%	30,26%	19,08%

Table 60: answer distribution among participants for Test B Wind Energy Lab (Q6).

After playing the lab, 14 students moved from saying the lab is fun to either Slightly fun (+3) or Extremely fun (+16) In Test A. In Test B, the biggest moves is also from fun (-14) to very fun (+10). More students moved towards extremely fun in Test A than in Test B, indicating that the respondents were more positively surprised after playing the Wind Energy Lab in Test A. Again, the reason for this could be the that the lab is not a new experience for the participants this time, as it was in Test A. Nonetheless, close to eighty percent (77, 63%) of the students find the lab either fun, very fun or extremely fun

Expected and experienced learning

The students were asked if they anticipated learning something from playing Wind Energy Lab before the test started. A bar chart and table with distribution of responses for Q3 from both Test A and Test B:

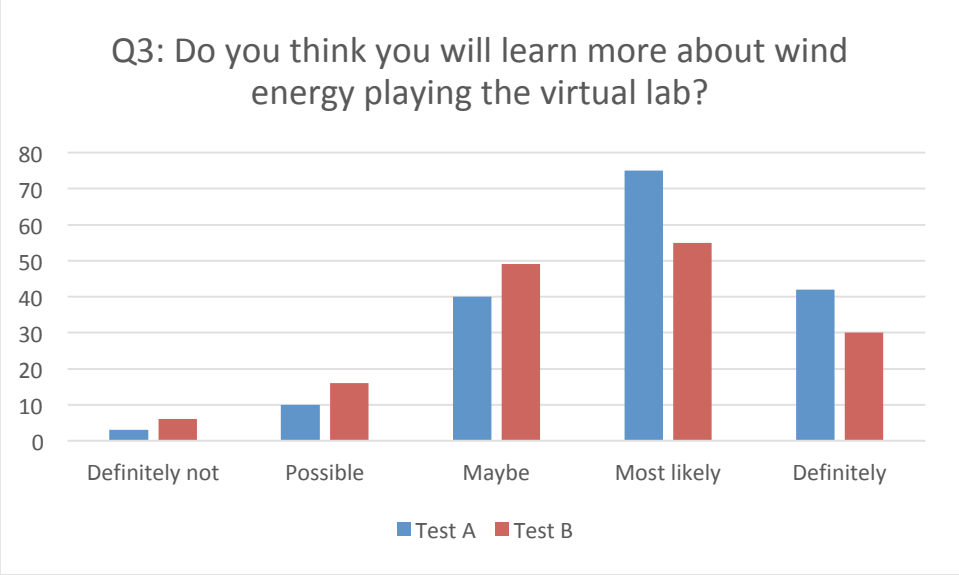

Figure 28: answer distribution among participants for Test B Wind Energy Lab (Q3).

Q3: Do you think you will learn more about wind energy playing the virtual lab?					
	Definitely not	Possible	Maybe	Most likely	Definitely
Test A	3	10	40	75	42
Percentage	1,76%	5,88%	23,53%	44,12%	24,71%
Test B	6	16	49	55	30
Percentage	3,85%	10,26%	31,41%	35,26%	19,23%

Table 61: answer distribution among participants for Test B Wind Energy Lab (Q3).

Here 117 of the students either anticipate to most likely or definitely learn from playing the lab in Test A, whereas in Test B, 85 of the participants in Test B. After playing the Wind Energy Lab, the students were asked to answer a question related to their experienced learning outcome. Below, is a bar chart and table with distribution of responses for Q4 Test A and Test B:

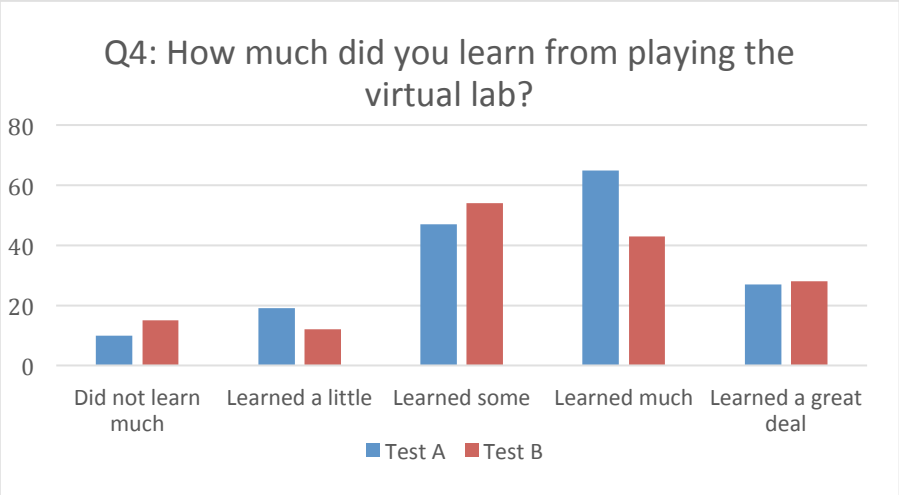

Figure 29: answer distribution among participants for Test B Wind Energy Lab (Q4).

Q4: How much did you learn from playing the virtual lab?					
	Did not learn much	Learned a little	Learned some	Learned much	Learned a great deal
Test A	10	19	47	65	27
Percentage	5,95%	11,31%	27,98%	38,69%	16,07%
Test B	15	12	54	43	28
Percentage	9,87%	7,89%	35,53%	28,29%	18,42%

Table 62: answer distribution among participants for Test B Wind Energy Lab (Q4).

Over half of the students report having learned much or a great deal when asked after the test in Test A. In Test B, a little under half of the students reported having learned much or a great deal. The tendency between the two tests are quite similar, the students expected to learn more than they did. Under 50 % of the students reported having learned much or a great deal when asked after Test B and 15 said they did not learn much. Again, this could be because Test B is the students second time playing the lab and the perceived learning outcome might for that reason be less.

Replaying the lab

After playing the Wind Energy Lab, the students were asked to answer if they would play the lab again after the test. Below, is a bar chart and table with distribution of responses for Test A and B, Q7:

Table 63: answer distribution among participants for Test B Wind Energy Lab (Q7).

Q7: Would you like to play the virtual lab again?					
	I would definitely not try again	Would probably not try again	Would maybe try again	Would quite likely try again	Would definitely try again
Test A	9	10	34	48	66
Percentage	5,39%	5,99%	20,36%	28,74%	39,52%
Test B	9	9	41	31	61
Percentage	5,96%	5,96%	27,15%	20,53%	40,40%

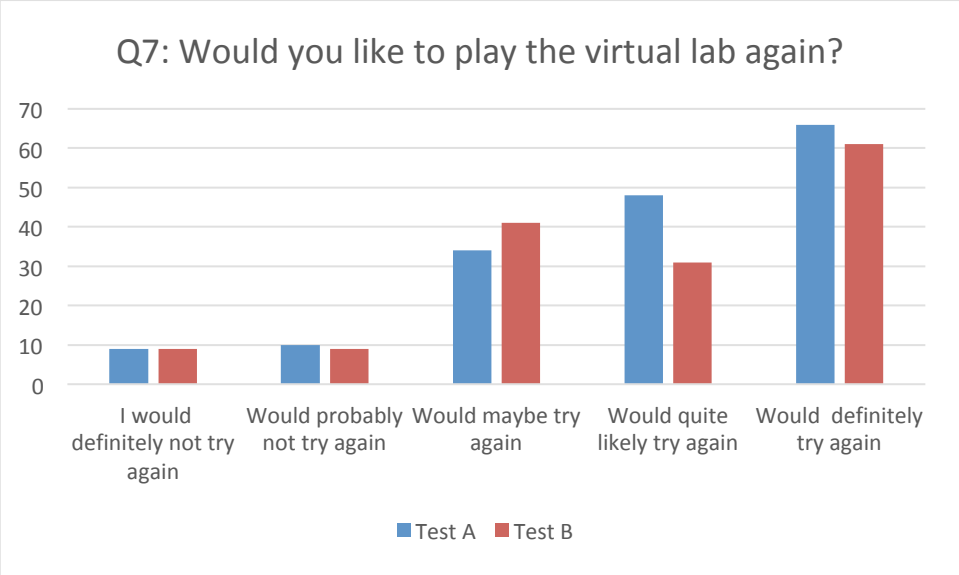

Figure 30: answer distribution among participants for Test B Wind Energy Lab (Q7).

Out of 167 responses, 68,26% (114) of the participants would quite likely try again or would definitely try again in Test A. For Test B, 60,93% (92) said the same. Even though we see a fall in participants who strongly indicates that they would play the lab again in Test B, this is not a bad sign. The participants are playing the lab for the second time and despite this, over 60% would still like to play it again. This indicates that the students have had a positive experience with the lab, even the second time around.

3.3.5 Chemistry Lab

Test A and Test B

Test A and B have been merged as the participant were the same for both. During M19 Test A was conducted using version 1 of the Chemistry Lab. In M21 Test B was conducted using version 2 of the Chemistry Lab. Participants for this pilot was 12 high school students, aged 16-18. The students answered the same questionnaires as for Test A and B for the Wind Energy Lab. This questionnaire is a one-group pre-test/post-test design and using a 5-level Likert scale. Full questionnaire can be viewed in Appendix C. Participants 4 only answered the pre-test questionnaire and Q4-Q7 therefore only had 11 responses.

Expected and experienced ease of use

Before playing the Chemistry Lab, the students were asked if they predicted the lab to be challenging to use. In Q1 "Do you think the virtual lab will be easy or hard?", we see that most students expected the lab to be either easy or neither easy nor hard to use. Below a bar chart and table with distribution of responses for Q1 can be viewed:

Q1: Do you think the virtual lab will be easy or hard?					
	Very easy	Easy	Neither easy nor hard	Hard	Very hard
Test A	1	5	5	1	0
Test B	1	5	4	2	0

Table 64: answer distribution among participants for Test A and B, Chemistry Lab (Q1).

After playing the Chemistry Lab, the students were now asked if they experienced the lab as challenging to use. Below a bar chart and table with distribution of responses for Q5 can be found:

Q5: Did you find the virtual lab easy or hard to use?					
	Very easy	Easy	Neither easy nor hard	Hard	Very hard
Test A	1	4	6	0	0
Test B	4	3	3	2	0

Table 65: answer distribution among participants for Test A and B, Chemistry Lab (Q5).

The answer distribution did not change drastically between Q1 and Q5. We do however see a positive change in more students finding the lab very easy to use for Test B, whereas only one student said this for Test A.

Expected and experienced fun

Before playing the Chemistry Lab, the students were asked if they expected the experience of playing the lab to be fun. Below, is a bar chart and table with distribution of responses for Q2, comparing responses from Test A and Test B:

Q2: Do you think you playing the virtual lab will be fun?					
Scale	Not fun at all	slightly fun	Fun	Very fun	Extremely fun
Test A	0	0	2	8	2
Test B	0	2	5	2	3

Table 66: answer distribution among participants for Test A and B, Chemistry Lab (Q2).

The students seem to be expecting the lab to be more fun to play in Test A than B. This could be due to the participants playing the lab for the second time for Test B and therefore knows what to expect.

Below, is a bar chart and table with distribution of responses for Q6, comparing the responses from Test A to Test B:

Q6: Did you find the virtual lab fun?					
	Not fun at all	slightly fun	Fun	Very fun	Extremely fun
Test A	0	0	1	9	1
Test B	0	0	2	4	6

Table 67: answer distribution among participants for Test A and B, Chemistry Lab (Q6).

After playing the lab, more students now indicate that the lab was actually fun to play. This tendency is apparent for both Test A and Test B. Generally, the students are very positive about the lab and none indicated that they only found the lab slightly fun or not fun at all.

Expected and experienced learning

The students were asked if they anticipated learning something from playing Chemistry Lab before the test started. A bar chart and table with distribution of responses for Q3 from both Test A and Test B:

Q3: Do you think you will learn more about chemistry playing the virtual lab?					
	Definitely not	Possible	Maybe	Most likely	Definitely
Test A	0	0	4	7	1
Test B	0	0	1	6	5

Table 68: answer distribution among participants for Test A and B, Chemistry Lab (Q3).

The students are generally positive and expect to learn more about chemistry by playing the lab. Between Test A and Test B, we even see a positive development where the students' attitude moves form maybe and towards definitely. This could point towards students being more confident about their learning outcome during the second time. Below, is a bar chart and table with distribution of responses for Q4 Test A and Test B:

Table 69: answer distribution among participants for Test A and B, Chemistry Lab (Q4).

Q4: How much did you learn from playing the Chemistry lab?					
	Did not learn much	Learned a little	Learned some	Learned much	Learned a great deal
Test A	0	1	3	6	1
Test B	0	2	3	3	4

After playing the Chemistry Lab, the students were asked if they feel like they learned more about chemistry by playing the lab. The tendency between Test A and Test B is mostly the same. However, we see a move towards learned a great deal and learned a little in Test B. Like for the Wind Energy Lab, the Chemistry Lab experience the same trend where participants expect to learn more than they do.

Replaying the lab

After playing the Chemistry Lab, the students were asked to answer if they would play the lab again after the test. Below, is a bar chart and table with distribution of responses for Test A and B, Q7:

Q7: Would you like to play the virtual lab again?					
	I would definitely not try again	Would probably not try again	Would maybe try again	Would quite likely try again	Would definitely try again
Test A	0	0	2	8	2
Test B	0	2	5	2	3

Table 70: answer distribution among participants for Test A and B, Chemistry Lab (Q7).

Like for the Wind Energy Lab, Test B also shows a decrease in students expressing that they would quite like try it again and an increase in students who would maybe or probably not try it again. This might indicate that the labs are not encouraging replay beyond one to two sessions. However, the labs are still fun and educational.

3.4 Summary

The pilots for evaluating the virtual lab were conducted during M16-M22. In total, six were conducted evaluating the virtual labs from a student and educator perspective. The eCrisis and Panhellenic workshop both tested the Wind Energy Lab and Chemistry Lab, whereas an A and B test evaluating each of the labs also were conducted.

3.4.1 eCrisis and Panhellenic workshop

For the eCrisis workshop in M18 the 3rd version of the Wind Energy and the chemistry lab were played by 18 educators for 1-2 hours. They subsequently, answered a questionnaire about both the educational quality of the labs, as well as usability and usefulness. The educators were generally positive and interested in the labs. A number of bugs and useful suggestions for improvements was also communicated throughout the workshop.

In M18 the 17th Panhellenic Conference of Greek Union of Physicists, with a two-hour workshop named: Design your own Virtual Laboratory. Eighteen secondary and higher education teachers were engaged in the workshop and both played the Chemistry Lab and Wind Energy Lab. For evaluation purposes, all educators answered a questionnaire about the virtual labs. Finally, the workshop additionally offered useful feedback and suggestions for improvements communicated by the participants.

In general, the comments for the Chemistry and Wind Energy virtual labs were positive indicating that the labs are on the right path. When it comes to the quality of the content and presentation of the subjects all participants either agreed or strongly agreed to the statements in the Panhellenic workshop. The biggest issues here were related to student performance, which were already rectified by the development of the analytics tools that allow the teachers to see the student's responses in the games. Apart from that, the microscopes are now used as "gates" of constructing molecules from atoms because microscopes cannot be used for such a process. As it is a virtual lab, staying true to the process of real world chemistry labs are important for the students learning process and immersion. We have therefore replaced the microscopes with laptops, which generally received positive feedback and acceptance from the educators. Comments from the project reviewers reported in the first review meeting were also considered. Danger labels were placed inside the chemistry labs, and the alcohol box was removed in order not to miss-conceive that methanol is a drinking liquid.

For the Ecrises the biggest issues found are evaluating students' performance and integration of the labs. Four out of the 18 participants either agreed or strongly agreed that it would be hard for them to evaluate the students' performance in the virtual labs. As already mentioned, this is remedied by having the analytics functionalities. It therefore also emphasize the need for the analytics as these educators did not use the analytics in connection with playing the labs. Concerning integration, three out of the 18 participants agreed that it would be difficult to integrate the virtual lab a learning context. As the educators participating in this workshop might not teach their students about wind energy and integrating the wind energy lab for their classes might therefore seems tricky to them. Although, this issues is not as serious as others, presenting educational scenarios where the labs could be integrated on the website and during workshops would probably help inspire the educators in terms of utilization. A lesson plan with learning material, books etc. would also make the adaptation of the labs easier for the educators.

3.4.2 Test A and B for Wind Energy and Chemistry Lab

One class at a time, seven 6^{th} grade classes participated in the pilots of the Wind Energy Lab. 170 students participated in Test A during M16 and 156 in Test B during M20. Seven teachers also participated in the pilot and subsequently answered a questionnaire about the quality of the labs. Test A and B of the Chemistry Lab were conducted during M19 and M21 with the same 12 participants. During M19 Test A was conducted using version 1 of the Chemistry Lab and in M21 Test B was conducted using version 2 of the Chemistry Lab. Both groups of students received a questionnaire based on a one-group pre-test/post-test design, using a 5-level Likert scale. It contains seven questions, divided into two; three pre-test and four post-test.

The Wind Energy Lab exceeded the student's expectations with respect to being fun and it proved to be less challenging than the students expected in both Test A and B. Furthermore, 68,26% of the students (114) would either definitely or quite likely try the lab again in Test A. This number decreases to 60,93% (92) for Test B, which could be explained by the lab being played the second time for Test B. Even though we see a fall in participants who strongly indicates that they would play the lab again in Test B, this is not a bad sign. The participants are playing the lab for the second time and despite this, over 60% would still like to play it again. This indicates that the students have had a positive experience with the lab, even the second time around. However, when it comes to the learning outcome experienced by the students after the test, they expected a larger learning output than what they experienced in Test A. This could possibly be due to the lab also being less challenging than first anticipated by the students. One way of trying to counterbalance this, could be to make the learning content of the lab more challenging or maybe make the students learning outcome more clearly through the lab design. The tendency in Test B is quite similar and the students also here expected to learn more than they did. Under 50 % of the students reported having learned much or a great deal when asked after Test B and 15 said they did not learn much. Again, this could be because Test B is the students second time playing the lab and the perceived learning outcome might for that reason be less.

When comparing this to the teacher's questionnaires responses, we also see a generally positive attitude towards the Win Energy lab, i.e. all teachers would use the lab again in their teaching in Test A. For Test B six teacher strongly agreed and one only agreed. However, there is also a few places where improvement could be focused. The learning content of the lab, and more precisely the learning goals, was for one teacher not clear in both Test A and B. As only one teacher perceives the learning goals of the lab to be unclear, this could be deemed a small issue. However, as 25 of the students also experienced a smaller learning outcome than expected before playing, making the learning goals and output more clear to both teachers and students. Three teachers agreed that it was hard for them to evaluate the student's performance when they played the lab, while three said neutral during Test A. In Test B only two teacher agree and five strongly disagrees. This could indicate that the teachers are more confident with evaluating the students' performance in the lab after having used it once. Lastly, we see a great improvement in Q2 "The virtual lab and the learning content did not meet my expectations" two teachers strongly disagreed, four disagreed and one was neutral in Test A. Now four teachers strongly disagreed, two disagreed and one was neutral. The content therefore lived up to the expectations of the teachers to a higher degree in Test B.

Like for the Wind Energy Lab the answer distribution did not changes drastically between Q1 and Q5. Also, we again see a positive change in more students finding the lab very easy to use for Test B, whereas only one students said this for Test A. The students seems to be expecting the lab to be more fun to play in Test A than Test B. This could be due to the participants playing the lab for the second time for Test B and therefore knows what to expect. This is also a pattern, we saw for the Wind Energy Lab. After playing the lab, more students now indicate that the lab was actually fun to play. This tendency is apparent for both Test A and Test B. Generally, the students are very positive about the lab and none indicated that they only found the lab slightly fun or not fun at all. The students are generally positive and expects to learn more about chemistry by playing the lab (Q3). Between Test A

and Test B, we even see a positive development where the students' attitudes moves from maybe and towards definitely. This could point towards the student being more confident about their learning outcome the second time. After playing the Chemistry Lab, the students were asked if they feel like they learned more about chemistry by playing the lab (Q4). The tendency between Test A and Test B is mostly the same. However, we see a move towards learned a great deal and learned a little in Test B. Like for the Wind Energy Lab, the Chemistry Lab experience the same trend where participants expect to learn more than they do. After playing the Chemistry Lab, the students were asked to answer if they would play the lab again after the test (Q7). Like for the Wind Energy Lab, Test B also shows a decrease in students expressing that they would quite like try it again and an increase in students who would maybe or probably not try it again. This might indicate that the labs are not encouraging replay beyond one to two sessions. However, the labs are still fun and educational.

4. Summary and conclusions

In total nine pilots were conducted between M16-22 evaluating the Authoring Process, Analytics and Visualizations and the Virtual Labs. The authoring tool had four: The Panhellenic workshop, the formal evaluation in EA, the EA's Summer School and Teachers Training week in Malta. The Analytics and Visualizations two: The formal evaluation in EA and the Summer School. And the Virtual Labs had six: The Panhellenic workshop, eCrisis workshop, Test A – Wind Energy Lab, Test B - Wind Energy Lab, Test A – Chemistry Lab and Test B – Chemistry. All participants were generally positive about the ENVISAGE assets and the issues found were minor.

3.5 Authoring Process

During the first pilot of this cycle, the Panhellenic workshop provided 18 areas of interest were found. Most of them were related to the usability issues that probably occurred, as the authoring tool were not completed as this point. Also the past user guide based on the step-by-step explanation of usage scenarios was very long and it was difficult for the users to read it. The video tutorial and the guided tour walkthroughs help educators to understand the system-authoring process better. The participants in the formal evaluation at EA are generally positive about the authoring tool and the only issue to report is therefore error messages and recovery issues. Only one participant disagreed to the statement and this participant disagreed to all the questions in the questionnaire. The issues related to error recovery might therefore not be as strong as first anticipated but improvements have still been made to improve this, as it also came up in other evaluations.

In connection with the summer school, the biggest issue is that none of the participants felt completely comfortable using the authoring tool (Q3:"I feel comfortable using the system**"**). This is probably due to the authoring tool performing quite complex tasks and understanding it can thus be hard, especially for novice users, who are not confident with their own computer literacy skills. Once again error messages and recovery, is problem as most participants responded with a neutral response or disagreed to Q5 add its text here. This could be because they did not experience error messages and had an instructor helping them with what steps to perform. However, had issues with getting "the system to do what I wanted". The participant must thus have had issues getting the authoring tool to perform the task they were instructed to perform.

The participants at the summer school generally agreed that they would easily become skilful at using the systems (Q12: "I think it would be easy for me to become skilful at using the system") and that it was easy to learn how the system worked (Q4: "It was easy to learn to use this system"). In this pilot the participants were also quite neural on the question related to satisfaction of using the authoring tool. None of the participants disagreed with the any of the statements in Q1 ("Overall, I am satisfied with how easy it is to use this system") or Q2 ("It was simple to use this system"), which is a good sign. The usability does therefore not seem to be the biggest issue for the authoring tool anymore. Error messages and recovery generally gets a negative response from the educators, with 10 disagreeing to the authoring tool providing clear messages on how to fix the problems and 7 somewhat disagreeing to it being easy to recover from mistakes when using the authoring tool. Some participants made comments in their questionnaire and some pointed out that they did not

make any mistakes because they followed the instructions but still scored it low. When reading the comments made for Q8 (“The information provided for the system is easy to understand”) and Q7 (“The information (such as online help, on-screen messages, and other documentation) provided with this system is clear”), some participants point out that they have not seen any help messages or similar even though more tool tips and help buttons have been added after the first evaluation cycle discovered the same thing. It could therefore seem like the users do notice them. This could be because they are sticking to the instructions and scenarios they were given. Exploring the authoring tool would in that case be a less likely behavior. However, it could also be the design, color and shape that needs to be made more obvious to the end-users. The participants overall satisfaction with the authoring tool also received mostly neutral responses (Q10:” Overall, I am satisfied with the system”). The participants do not seem to be completely satisfied with the authoring tool but nor do they disagree with the statement. The mostly neutral score for overall satisfaction aligns with the participant’s confidence self-confidence in using the authoring tool and their view of the usability. However, the participants also believed that they would easily become skilful at using the authoring tool. Many participants also added that their scores were based on getting help from scenarios or instructor. This could mean that the participants would likely be more positive about the authoring tool, once they get more confident with using it.

3.6 Analytics and Visualizations

Results from the Analytics and Visualizations evaluation shows that most educators understood the functionality of the analytics but needed more practical examples and instructions to be able to apply it on their own. The educators gave the students-at-risk prediction and the Dynamic Difficulty Adjustment more negative responses than the analytics dashboard, due to the high complexity of the functionalities and lack of information describing it. Additional information could be added within the system, as e.g. tooltips or external links for in-depth tutorials on how to use it.

3.7 Virtual Labs

The results for the virtual labs shows that the student expects the labs to be less fun than what they actually experienced. This means that more students strongly agrees to the labs being fun to play after the play sessions. They also expected to learn more from the labs than what they did but the students were also extremely positive about their learning outcomes even before the play sessions. In addition, they generally find the labs easy to use and even more so for Test B than for Test A. This could be due to the participants playing the lab for the second time for Test B and therefore knows what to expect. After playing the labs, the students were asked to answer if they would play the lab again after the test (Q7). Test B shows a decrease in students expressing that they would quite likely try it again and an increase in students who would maybe or probably not try the Chemistry Lab again and the same tendency can be seen for the Wind Energy Lab as well. Here 68,26% of the students (114) would either definitely or quite likely try the lab again in Test A. This number decreases to 60,93% (92) for Test B. This might indicate that the labs are not encouraging replay beyond one to two sessions. However, the labs are still fun, easy to use and

educational. Besides, replayability, beyond one to three sessions, has never been within scope of the project.

5. Bibliography

Consortium, E. (2016). *Grant Areement .* European Commission.

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Ververidis, D. (2018). *D4.4 – Final version of the "Virtual labs authoring tool.* ENVISAGE.

6. Appendix

A Appendix

A.1. Teacher questionnaire for lab evaluation

Below are several statements regarding the virtual lab in an educational setting.

Please indicate to what extent you agree or disagree with each statement.

	strongly agree	agree	neutral	disagree	strongly disagree
The content presented in the virtual lab is correct and well balanced					
The virtual lab fits well with the curricula					
The virtual lab presents the learning content in a relevant manner for the students					
The quality of the learning content did not meet my expectations					
It is difficult to integrate the virtual lab into a learning context					
The learning material is presented in structure and complexity that suits the students' competencies					
I found that the instructions for the virtual lab were good					
In general, the students found the virtual lab difficult to navigate					
The interface of the was easy to understand					
The virtual lab gave the student a better understanding of the topic					
The students preformed as I expected in the virtual lab					
The learning goals for the virtual lab are clear.					
It was hard for me to evaluate the student's performance in the virtual lab					
I had a good sense of how the students were working with the virtual lab					
The virtual lab supports differentiated learning					
I would use the virtual lab again in my teaching					

I would like to change part of the virtual lab to better support my teaching					
The students found the virtual lab engaging					
The students found the virtual lab challenging					
The students enjoyed using the virtual lab					
The virtual lab simulated the students' interest or curiosity in the subject					

B Appendix

B.1. Usefulness, Ease of use and Usability

B.1.1 Usefulness and Ease of use

PERCEIVED USEFULNESS		1	2	3	4	5	6	7		NA
1. Using the system in my job would enable me to accomplish tasks more quickly	unlikely	○	○	○	○	○	○	○	likely	○
Comments:										
2. Using the system would improve my job performance	unlikely	○	○	○	○	○	○	○	likely	○
Comments:										
3. Using the system in my job would increase my productity	unlikely	○	○	○	○	○	○	○	likely	○
Comments:										
4. Using the system would enhance my effectiveness on the job	unlikely	○	○	○	○	○	○	○	likely	○
Comments:										
5. Using the system would make it easier to do my job	unlikely	○	○	○	○	○	○	○	likely	○
Comments:										
6. I would find the system useful in my job	unlikely	○	○	○	○	○	○	○	likely	○
Comments:										
PERCEIVED EASE OF USE		**1**	**2**	**3**	**4**	**5**	**6**	**7**		**NA**
7. Learning to operate the system would be easy for me	unlikely	○	○	○	○	○	○	○	likely	○
Comments:										
8. I would find it easy to get the system to do what I want it to do	unlikely	○	○	○	○	○	○	○	likely	○
Comments:										
9. My interaction with the system would be clear and understandable	unlikely	○	○	○	○	○	○	○	likely	○
Comments:										
10. I would find the system to be flexible to interact with	unlikely	○	○	○	○	○	○	○	likely	○
Comments:										
11. It would be easy for me to become skillful at using the system	unlikely	○	○	○	○	○	○	○	likely	○
Comments:										
12. I would find the system easy to use	unlikely	○	○	○	○	○	○	○	likely	○
Comments:										
		1	**2**	**3**	**4**	**5**	**6**	**7**		**NA**

List the most **negative** aspect(s):

1.
2.
3.

List the most **positive** aspect(s):

1.
2.
3.

B.1.2 Usability

			1	2	3	4	5	
1.	Overall, I am satisfied with how easy it is to use this system	strongly disagree	○	○	○	○	○	○
2.	It was simple to use this system	strongly disagree	○	○	○	○	○	○
3.	I can effectively complete my work using this system	strongly disagree	○	○	○	○	○	○
4.	I am able to complete my work quickly using this system	strongly disagree	○	○	○	○	○	○
5.	I am able to efficiently complete my work using this system	strongly disagree	○	○	○	○	○	○
6.	I feel comfortable using this system	strongly disagree	○	○	○	○	○	○
7.	It was easy to learn to use this system	strongly disagree	○	○	○	○	○	○
8.	I believe I became productive quickly using this system	strongly disagree	○	○	○	○	○	○
9.	The system gives error messages that clearly tell me how to fix problems	strongly disagree	○	○	○	○	○	○
10.	Whenever I make a mistake using the system, I recover easily and quickly	strongly disagree	○	○	○	○	○	○
11.	The information (such as online help, on-screen messages, and other documentation) provided with this system is clear	strongly disagree	○	○	○	○	○	○
12.	It is easy to find the information I needed	strongly disagree	○	○	○	○	○	○
13.	The information provided for the system is easy to understand	strongly disagree	○	○	○	○	○	○
14.	The information is effective in helping me complete the tasks and scenarios	strongly disagree	○	○	○	○	○	○
15.	The organization of information on the system screens is clear	strongly disagree	○	○	○	○	○	○
16.	The interface of this system is pleasant	strongly disagree	○	○	○	○	○	○
17.	I like using the interface of this system	strongly disagree	○	○	○	○	○	○
18.	This system has all the functions and capabilities I expect it to have	strongly disagree	○	○	○	○	○	○
19.	Overall, I am satisfied with this system	strongly disagree	○	○	○	○	○	○
			1	2	3	4	5	

List the most **negative** aspect(s):

1.
2.
3.

List the most **positive** aspect(s):

1.
2.

C Appendix

C.1. Student questionnaire for lab evaluation

1. Fill before playing the virtual lab

Nickname: _____

1. **Do you think you the virtual lab will be easy or hard?**

☐	☐	☐	☐	☐
Very easy	Easy	Neither easy nor hard	Hard	Very hard

2. **Do you think you playing the virtual lab will be fun?**

☐	☐	☐	☐	☐
Not fun at all	Slightly fun	Fun	Very fun	Extremely fun

3. **Do you think you you will learn more about wind energy playing the virtual lab?**

☐	☐	☐	☐	☐
Definitely not	Possible	Maybe	Most likely	Definitely

7. **Would you like to play the virtual lab again?**

☐	☐	☐	☐	☐
Would definitely not try again	Would probably not try again	Would maybe try again	Would quite likely try again	Would definitely try again

6. **Did you find the virtual lab fun?**

☐	☐	☐	☐	☐
Not fun at all	Slightly fun	Fun	Very fun	Extremely fun

5. **Did you find the virtual lab easy or hard to use?**

☐	☐	☐	☐	☐
Very easy	Easy	Neither easy nor hard	Hard	Very hard

4. **How much did you learn from playing the virtual lab?**

☐	☐	☐	☐	☐
Didn't not learn much	Learned a little	Learned some	Learned much	Learned a great deal

D Appendix

D.1. Authoring tool questionnaire

Wind Energy Lab, authoring questionnaire

Please indicate to what extent you agree or disagree with each of the statements.

1. Overall, I am satisfied with how easy it is to use this system

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Disagree Agree

2. It was simple to use this system

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Disagree Agree

3. I feel comfortable using the system

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Disagree Agree

4. It was easy to learn to use this system

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Disagree Agree

5. The system gives error messages that clearly tell me how to fix problems

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Disagree Agree

6. Whenever I make a mistake using the system, I recover easily and quickly

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Disagree Agree

7. The information (such as online help, on-screen messages, and other documentation) provided with this system is clear

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Disagree Agree

8. The information provided for the system is easy to understand

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Disagree Agree

9. I like using the interface of this system

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Disagree Agree

10. Overall, I am satisfied with the system

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Disagree Agree

11. I found it easy to get the system to do what I wanted

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Disagree Agree

12. I think it would be easy for me to become skilful at using the system

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Disagree Agree

13. It was clear for me how I could use the information presented in the Analytics dashboard

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Disagree Agree

14. It was clear for me how I could use the student-at-risk prediction

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Disagree Agree

15. It was clear for me how I could use the DDA

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Disagree Agree

E Appendix

E.1. Wind Energy Lab Scenarios

1.1.1. Scenario 1: Creating a virtual Wind-Energy lab.

This scenario will take you through the basis of generating a virtual Wind-Energy lab. A Wind-Energy lab template contains scenes and assets that help you generate the virtual lab. A lab in development is referred to as a project. A Wind-Energy project by default consists of five scenes: three Scenes of type Mountains, Seashore and Field, Credits and Main Menu. Appropriate Assets will already have been uploaded to the templates, e.g., textbooks, laptops and microscopes for the Wind-Energy lab template. These can be placed around the scene.

Phase 1: Create a Wind-Energy Project

Before you start the scenario, as described below, you should be logged in and the authoring tool should be running. Upon login, the interface presented in Figure 52 should be presented.

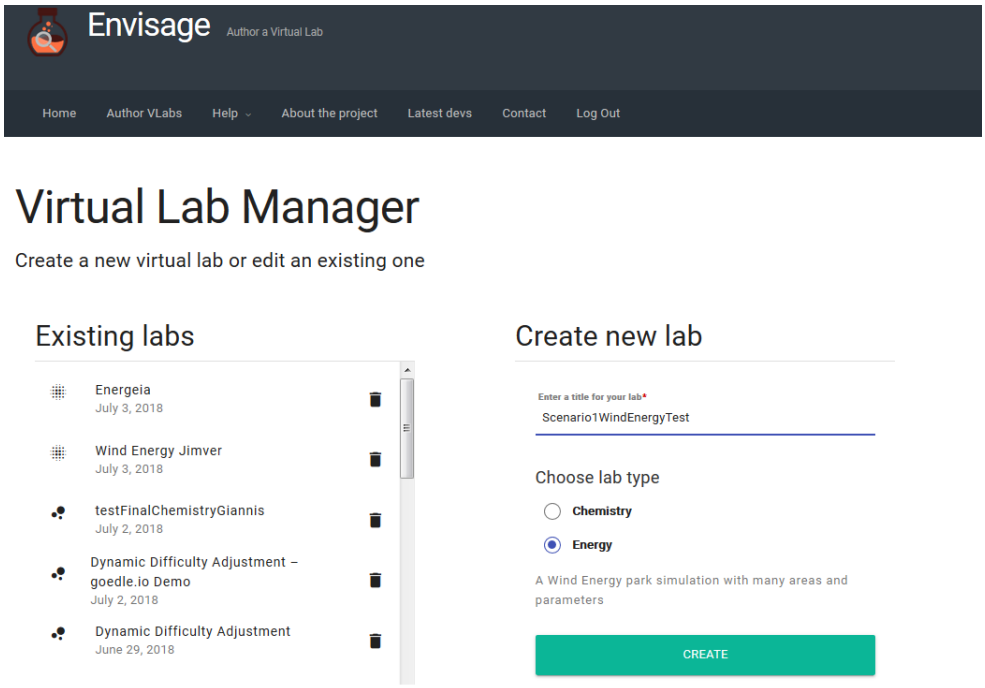


Figure 31: The Virtual Lab Manager allows creating, editing or deleting a project.

What you see in Figure 52 is the Virtual Lab Manager. It is the central interface for creating a new project, editing or deleting an existing one. A new lab can be created using “Create new project” shown in the right side of Figure 52.

a) Enter a title (it is “Scenario1WindEnergyTest” in this example), select the lab type to be “Energy” and create the project by pressing the “CREATE” button.

Phase 2: Add assets to scenes

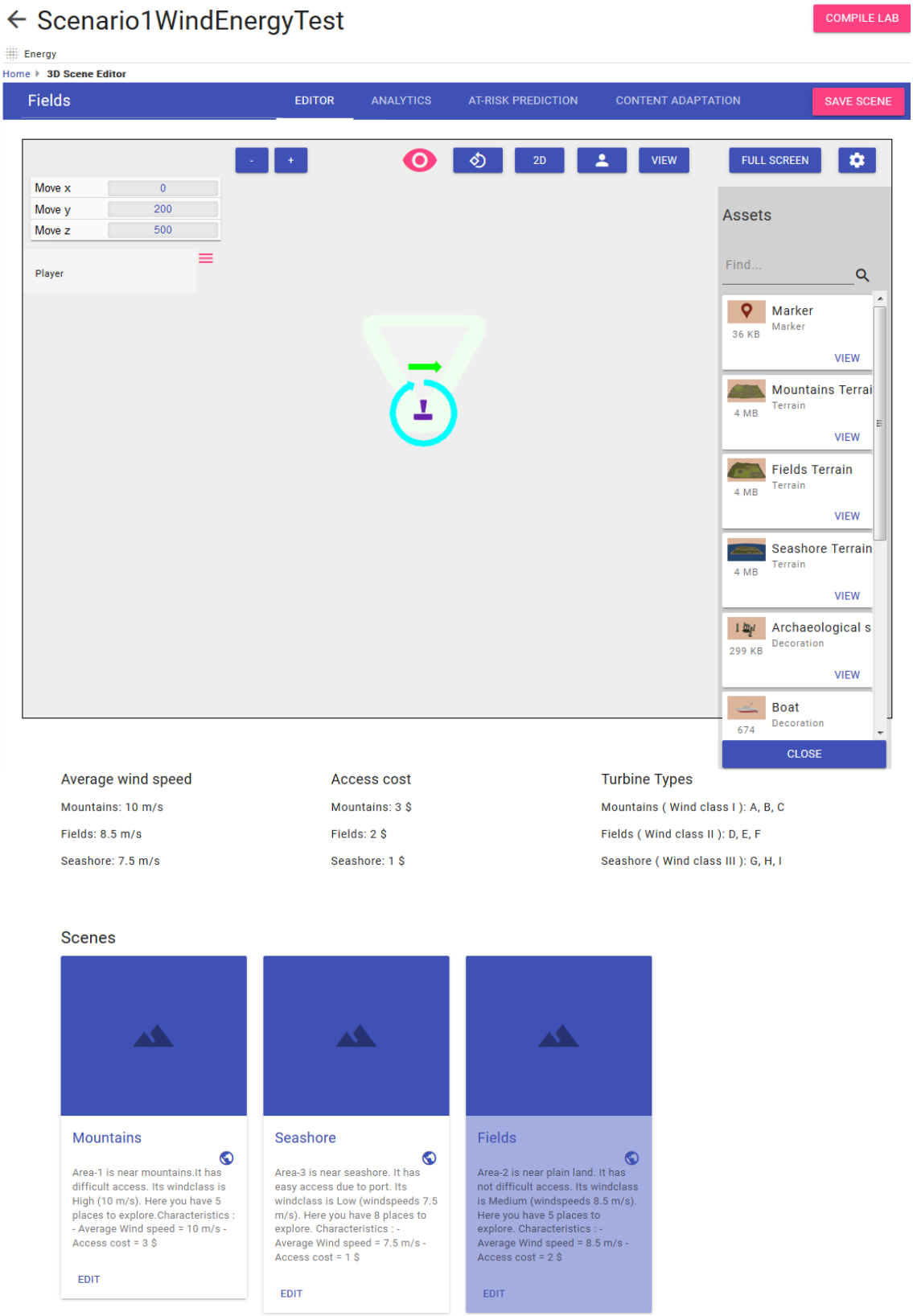


Figure 32:Initial page presented after creating a project. The user can select to edit an existing scene with the the 3D editor, create a new one and add new assets. The text

between the Scene cards and the editor give the details about the wind speed, access costs and types of theavailable turbines for the selected Scene (the Fields scene for this particular example).

After creating the new project:

- the lab name (Scenario1WindEnergyTest in this example), type (Energy) and available Scenes will appear, as presented in Figure 32.
- You can edit a Scene with the 3D editor shown in Figure 32 by adding assets and place them appropriately in the 3D scene.
- The list of available assets is on the right side of the editor. You can toggle the “OPEN/CLOSE” button to show/hide the list.

a) Enter a Scene (choose Mountains, Seashore or Fields). The scene editor appears like in **Error! Reference source not found.**. Note that, by default, the “Fields” scene has been loaded in the 3D editor when first creating (or opening) the project.

Notes:

- Initially, the camera is the only item located in the editor, which is used to determine the starting point for the playable character in the lab.
- The icon showing a person in the top of the 3D editor (between the 2D and view tab) is used to investigate what the player will see.

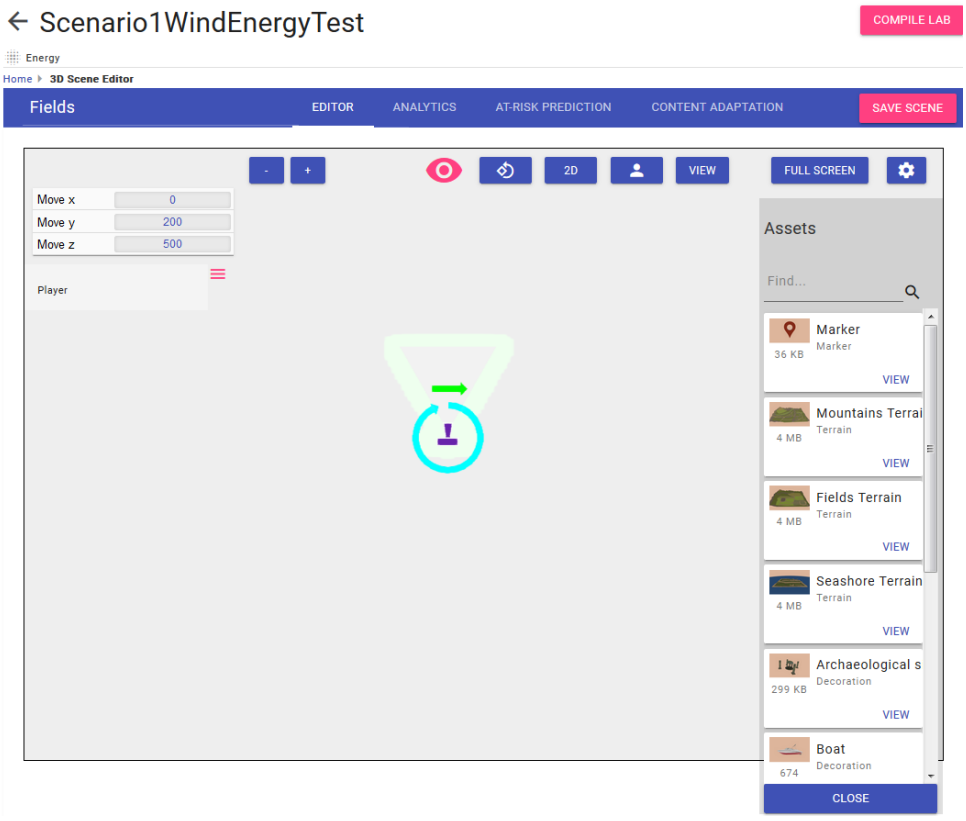


Figure 33: Lab Editor for First scene, where the playable scene can be modified.

a) Drag and drop Fields Terrain 1 from the list of Assets (located in the right side of the screen) into the Scene Editor.

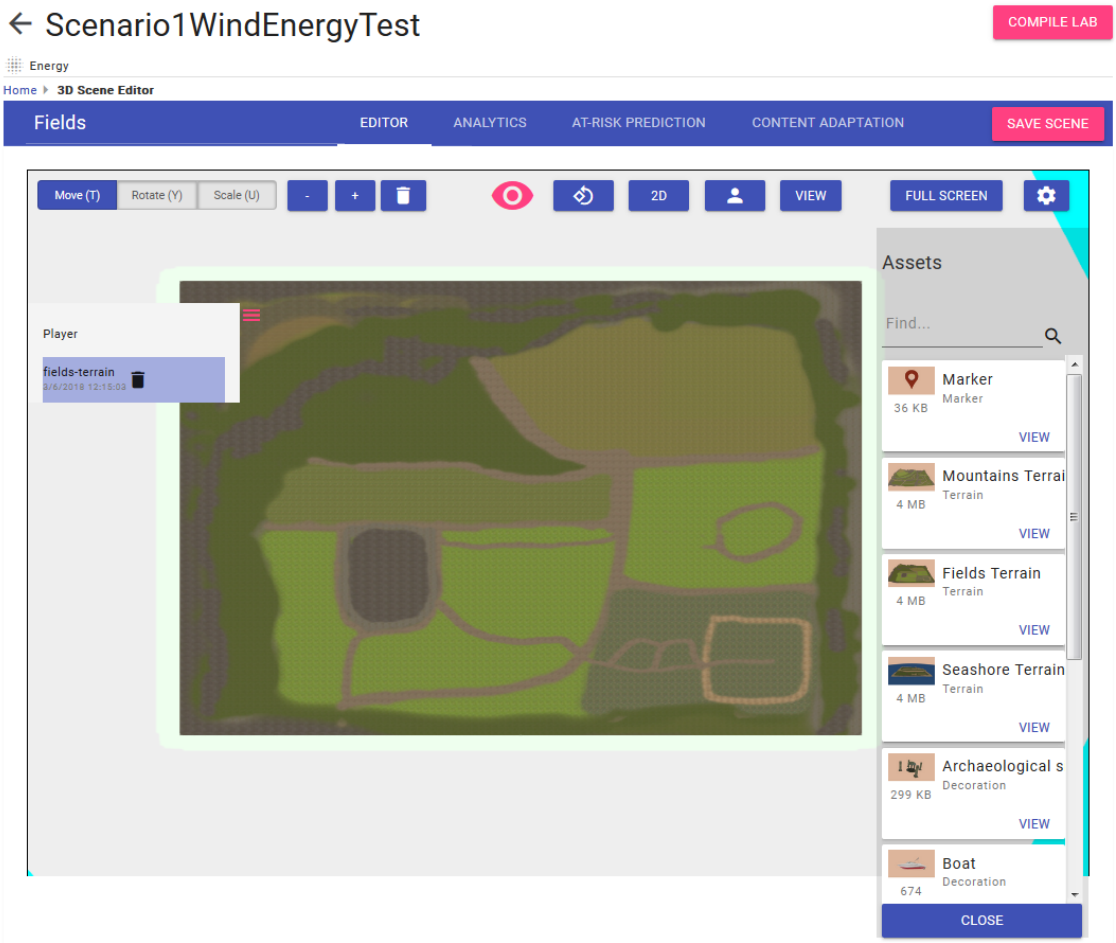


Figure 34: View of a scene with a field terrain, dragged-and-dropped from the list of assets.

b) Adjust the view if need to see the whole terrain by zooming out (see Figure 34 the result of zooming out): try the following four controls out for navigating in the 3D editor:
   - Zooming in and out
   - Moving around the 3D environment
   - Rotating the view (more information about controls are available in Table 74)

When feeling more comfortable with the controls move on to the next step.

Action	Description	Example
Navigating 2D/3D environment (rotation)	Rotate the view by holding down the left mouse button and moving the mouse.	
Navigating 2D/3D environment (moving)	Move around the lap by holding down the right mouse button and moving the mouse in the desired direction.	
Zoom in and out	Use either the mouse scroll	

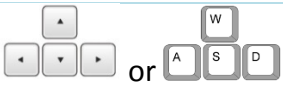
	or plus and minuses on the keyboard.	
Navigating player camera	Use the arrows or W, A, S and D keys on the keyboard or the controls on the screen.	
Navigating avatar	Use the arrows or W,A, S and D keys on the keyboard	

Table 71: describing the controls in the editor for manipulating the view.

c) Drag and drop Marker from the list of Assets (located in the right side of the screen) into the Scene Editor.
Tip: Aim for the area of the terrain that you want to be a candidate for wind farm installation. This means that the marker enables the player to choose the area of the terrain where the regional scene will be associated with. See below about the regional scenes.

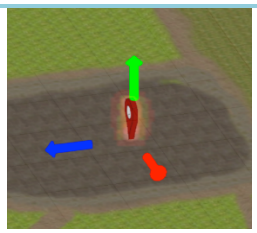
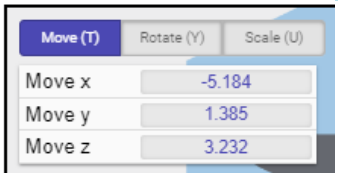
d) Adjust the marker if needed so that it stands on top of the terrain and in a plausible place (see Table 75 for more information on controls for moving the assets).
Tip: You can also delete and repeat the action in step c if adjusting it gets too hard. An asset can be deleted by using the trashcan icons (see Figure 56, red square, for more information).

e) Follow step c and d one more time, thus, adding in this way a second marker, so as to create the scene in Figure 56.

Tip: If the controls are difficult, entering full screen view might help (button located in the top right corner of the screen, Figure 56).

f) Add decoration assets (e.g., boat, tree) to enhance the visual appeal of the scene. Add 3 decorations or as many you like (they play no role at the game mechanics at all). The available decoration assets are:

- archaeological site,
- boat,
- tree cluster,
- tree.

Action	Description	Example
Moving assets	Use the green, red and blue arrows to move the assets the around the terrain (for the example on the right, see markers in Figure 56).	
Moving assets	The markers can also be rotated and scaled when the tabs, located at the upper left corner, are selected. The X, Y and Z input fields could	

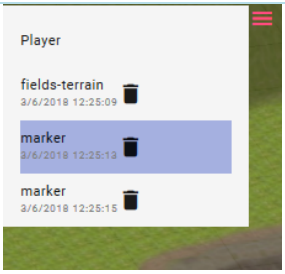
	also be used to navigate the asset by modifying the numbers.	
Finding assets	If an assets, which has been added in the scene, is hard to find or clicked, it can be re-reselected by clicking the asset name (see blue square in Figure 56).	

Table 72: describing the controls for moving and adjusting assets.

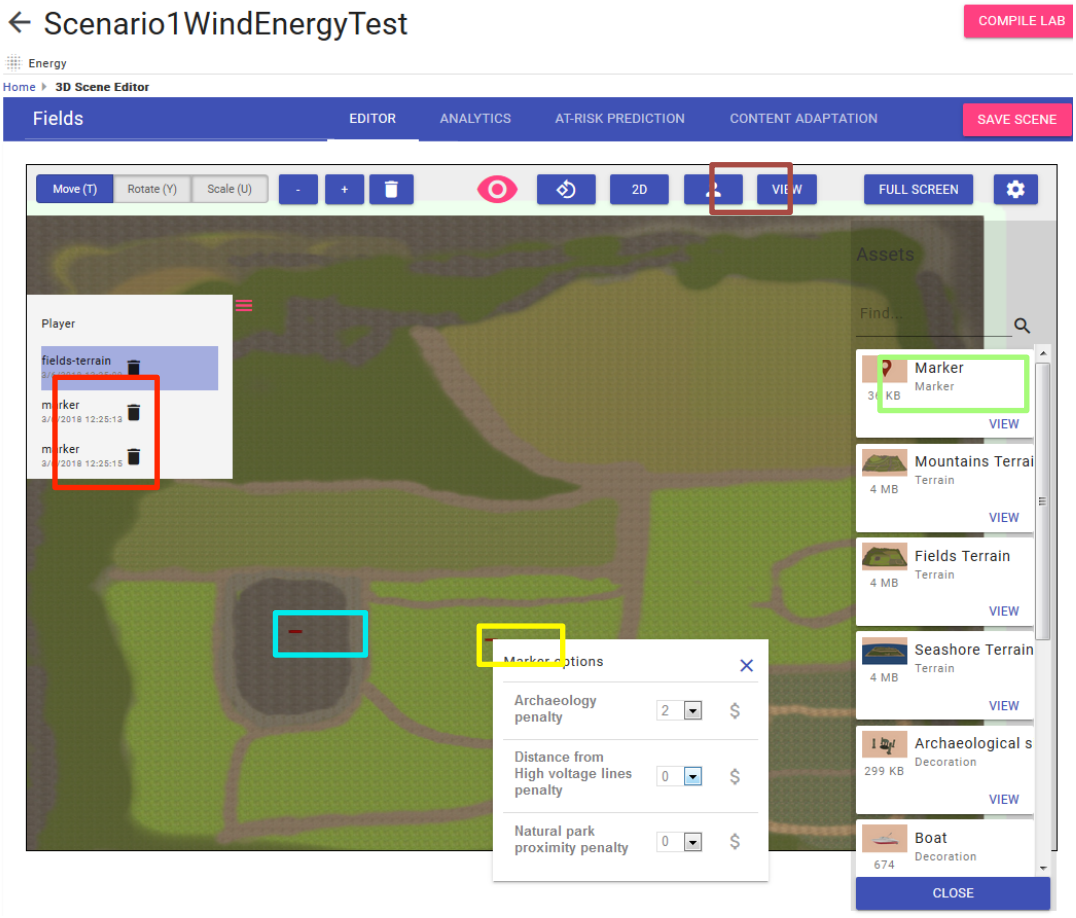


Figure 35: Marker asset placed on the terrain twice. The squares are indicating: list of added assets (red), first marker (yellow), second marker (blue) and marker asset in the list (green). Also, the pop-up window for setting the penalties of installing wind form to the area designated by the marker is shown (yellow marker).

g) Click Full Screen (button located in the top right corner of the screen).

h) Now click the avatar icon in the top of the window (see brown square in Figure 56) and navigate the avatar to where the first marker is located (for avatar controls see Table 73).

Check if the marker is placed correctly on the terrain and is not, e.g., elevated. Correct location of the marker if needed by following the instruction of the previous bullet f.

i) To exit avatar mode click the “Esc” key.

Phase 3: Edit Mountain and Seashore scenes

At this point, it is necessary to explain the gameplay. Each one of the three scenes, i.e., Mountains, Seashore, Fields, serves as the scenes presented to the player at the beginning of the game. As soon as the player selects one of the three initial scenes, the selected scene opens and presented to the player, asking the player to select a marker pinpointing the place for installing the wind farm. This means that each place that is pinpointed by a marker that is associated with a smaller scene, it is unique for each of the three scenes and it has been designed by the authoring tool developers (thus cannot be edited by the tool) for each type of scene (mountains, seashore and fields).

Next, we describe the procedure, in short, for the other two Scenes, i.e., Mountains and Seashore. For Mountains, follow the steps:

a) Click on the “Edit” button, residing at the bottom of the “Mountains” card, at the main page of the project shown in Figure 32.
b) Add the “Mountains Terrain”, as done in Phase 2 described previously:
c) Add four markers this time
d) Adjust the location of the markers at these places that will be candidates for wind-farm installation.
e) Adjust the marker parameters by right clicking each one in the pop-up menu that will appear. Set Archaeology penalty: 2 and 0, Distance from High Voltage penalty: 2 and 2, and Natural Park proximity penalty: 0 and 0, for the first and second marker, respectively.
f) Add optional decorations (e.g., trees, tree clusters).
g) Click “Save Scene"

Repeat the same but for the Seashore scene and with different marker parameters, say Archaeology penalty: 0 and 0, Distance from High Voltage penalty: 0 and 2, and Natural Park proximity penalty: 0 and 2, for the first and second marker, respectively.

Phase 4: Main Menu, Credits and Compile

a) Navigate to the Main Menu scene editor (see Figure 60).

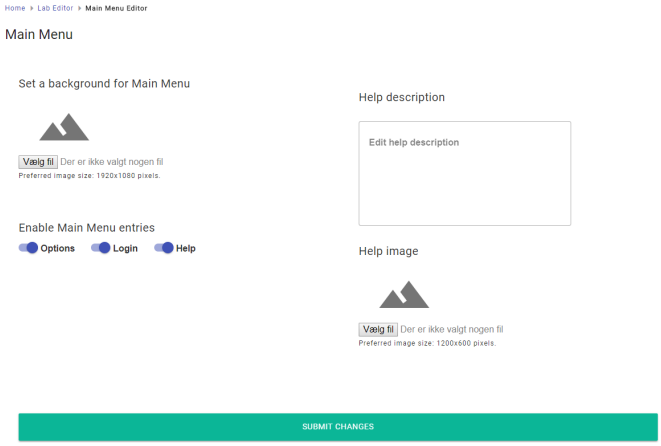


Figure 36: Main Menu scene editor.

b) Set a background for the Main Menu.
c) Set background for the Help function and add a description.
d) Save all changes
e) Navigate to the Credits scene editor (see Figure 61).

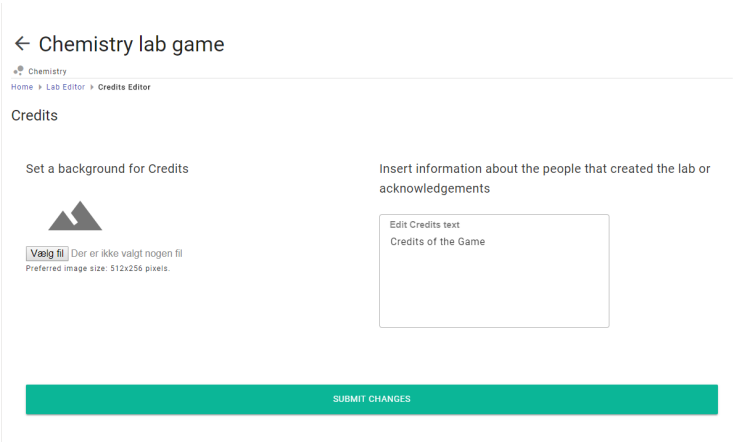


Figure 37: Credits scene editor

f) Set a background for the Credits
g) Set background for the Credits and add a description.
h) Save all changes.
i) Compile the game, choose your operating system and proceed.
j) Open the file containing the compiled Wind-Energy lab and try it out

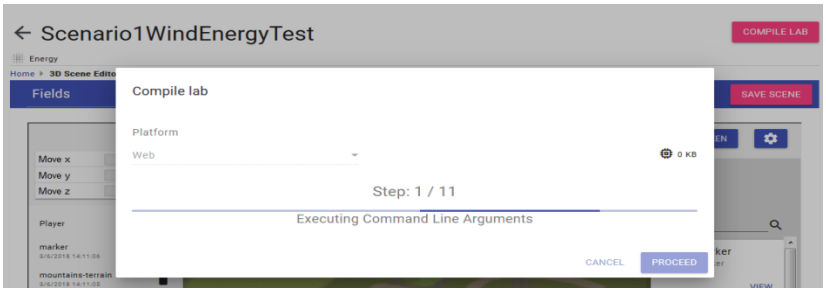


Figure 38: Compiling menu.

1.1.2. Scenario 2: Using the Analytics front-end

Game analytics are incorporated in the 3D scene editor and can be accessed through the Analytics tab.

a) Go to the editor
b) Press the “Analytics” tab in the blue ribbon as shown in the interface. The analytics of the Wind-Energy lab appear.

On the left side, the distribution of students into the PISA categorization is shown according to their achieved score, which is measured based on the crucial operations completed. On the tables, the achieved goals are shown per user (an anonymous code is used as id).

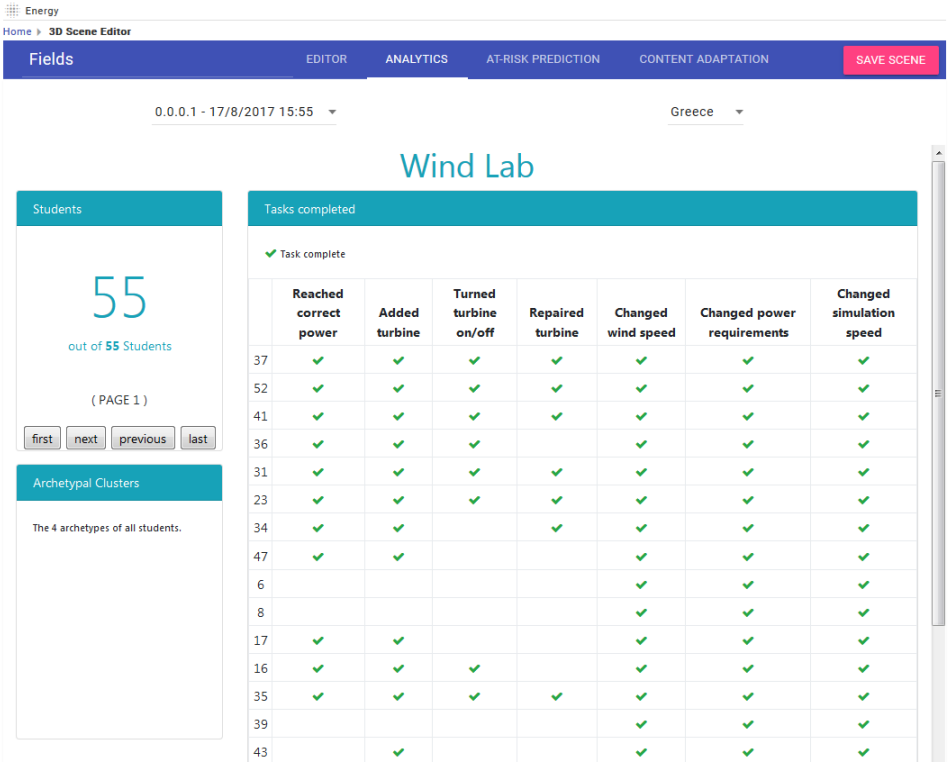
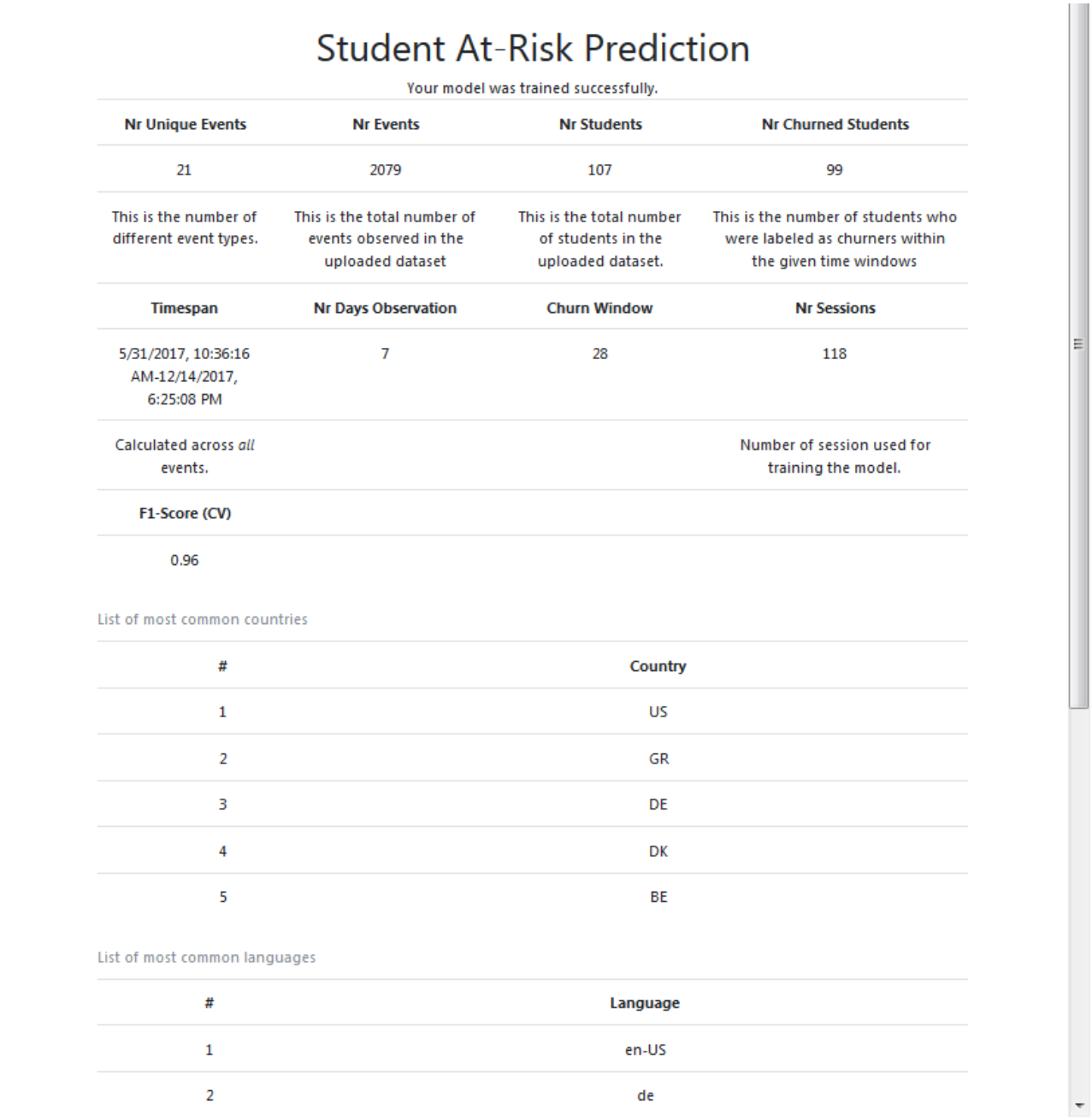


Figure 39: Observing analytics for the Wind-Energy lab inside the authoring tool.

c) Go to the Student-at-risk tab (see **Error! Reference source not found.**)

The page presents the statistics related to a) the number of students who played the game, b) who left the lab (churned); c) the timespan where the data was gathered



Student At-Risk Prediction

Your model was trained successfully.

Nr Unique Events	Nr Events	Nr Students	Nr Churned Students
21	2079	107	99
This is the number of different event types.	This is the total number of events observed in the uploaded dataset	This is the total number of students in the uploaded dataset.	This is the number of students who were labeled as churners within the given time windows
Timespan	**Nr Days Observation**	**Churn Window**	**Nr Sessions**
5/31/2017, 10:36:16 AM-12/14/2017, 6:25:08 PM	7	28	118
Calculated across *all* events.			Number of session used for training the model.
F1-Score (CV)			
0.96			

List of most common countries

#	Country
1	US
2	GR
3	DE
4	DK
5	BE

List of most common languages

#	Language
1	en-US
2	de

Figure 40: Student-at-risk tab shows the shallow analytics.

1.1.3. Scenario 3: Administration user

The administration user scenario will show how to undertake crucial administrator tasks, such as creating assets to be used by a regular teacher. The scenario assumes that you have already completed all the previous scenarios and that you have experience in authoring labs with the tool.

1. The main responsibility of the administrator is to create new assets that will be available to all projects created by teachers. More specifically, the administrator has the ability to create assets that differ from the assets created by regular teachers when they author games at the point that they are visible to all projects.
2. Moreover, the administrator has the responsibility, and thus the ability, to monitor other projects, edit them or propose corrections in order to ensure that the produced authored labs are of sufficient quality. Also, this will help new authors to learn the tool faster and more easily.
3. The procedure of creating global assets is based on the existing by default “joker games”, i.e., projects created prior to any other and that are not meant to be used for lab production but only for creation of new assets.
   Thus, there is no need to create a joker game; instead, go to the main menu and select the already existing “energy joker” game.

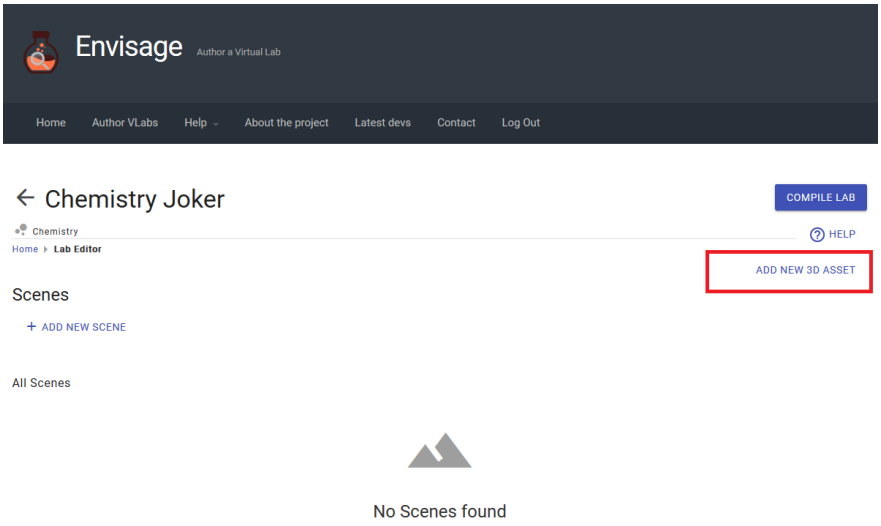


Figure 41: Adding new assets in the Wind-Energy joker game (red rectangle).

Create Assets

What we need is to create assets, i.e., the 3D models , their names and descriptions of the items to be inserted in the Scenes via the editor. In other words, we will create the assets listed in the right side of the 3D editor, shown in Figure 33. For this, go to the initial page shown in Figure 52, find the Energy Joker game and click on its name. Then, in the first page that will appear, shown in Figure 63, by clicking on the ”Add new 3D Asset” button, you can create new assets. In the Asset Creator page that will be loaded after clicking on the ”Add new 3D Asset” button, as shown in **Error! Reference source not found.**, select in the category dropdown widget the option “Terrain”. Several fields will popup. Select the type of the asset you want to create. Proceed and create the following assets:

a) Add the Marker asset (select the Marker category), as shown in **Error! Reference source not found.**,
b) add the three terrains: Mountain, Seashore and Fields terrain (select the Terrain category), as shown in **Error! Reference source not found.**, Figure 45 and Figure 46
c) Create the decoration assets (select the Decoration category):
    a. Archaeological site, Figure 47,
    b. Boat, Figure 48,
    c. High Voltage Towerm Figure 49,
    d. Trees clusterm Figure 50
    e. Tree, Figure 51.

For each asset, regardless of the type, there should be three files that constitute its 3D model. More specifically, every Asset has a 3D model as a representation in the game. The 3D model format supported is the Wavefront Obj format that consists of an mtl (material) file that contains color and texture information, an obj file that consists the coordinates of the geometric shape of the model, and a jpg file that consist of the texture of the model. Uploading the mtl, obj, and the jpg for texture. Then, when creating an asset, go to the 3D model preview window, zoom in-out with the mouse and press “Create a screenshot” to make an thumbnail for your asset. Lastly, click on the “Create Asset” button to insert the asset in the authoring tool repository.

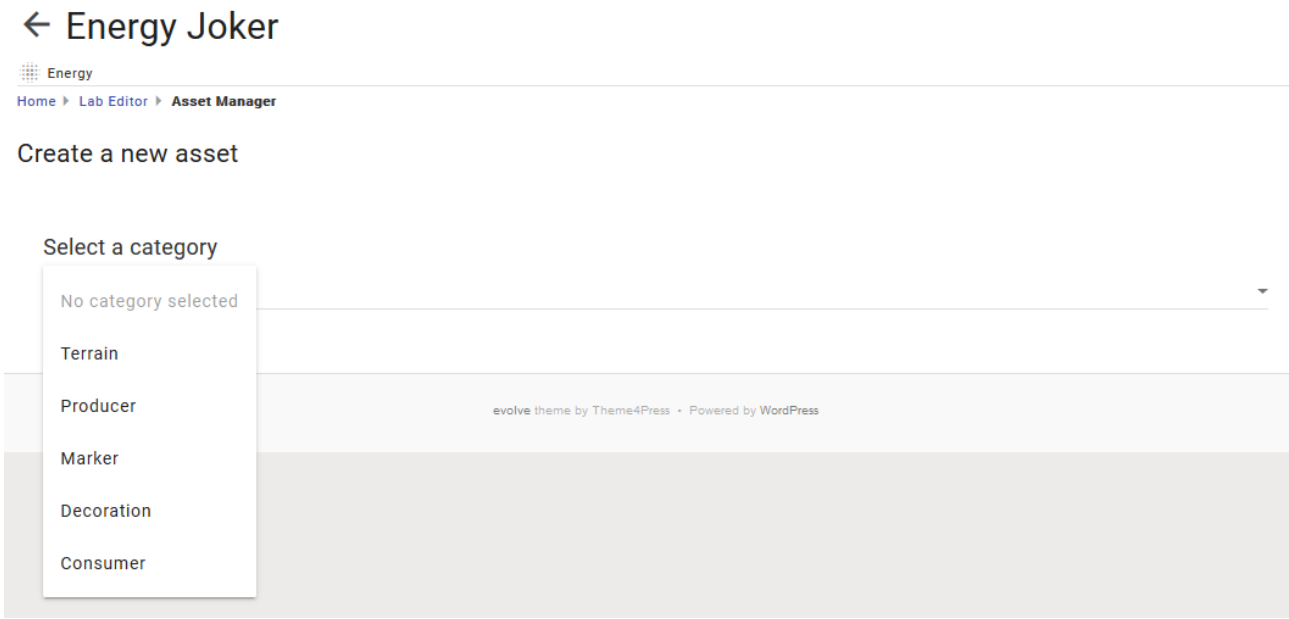


Figure 42: Selecting a category for the asset.

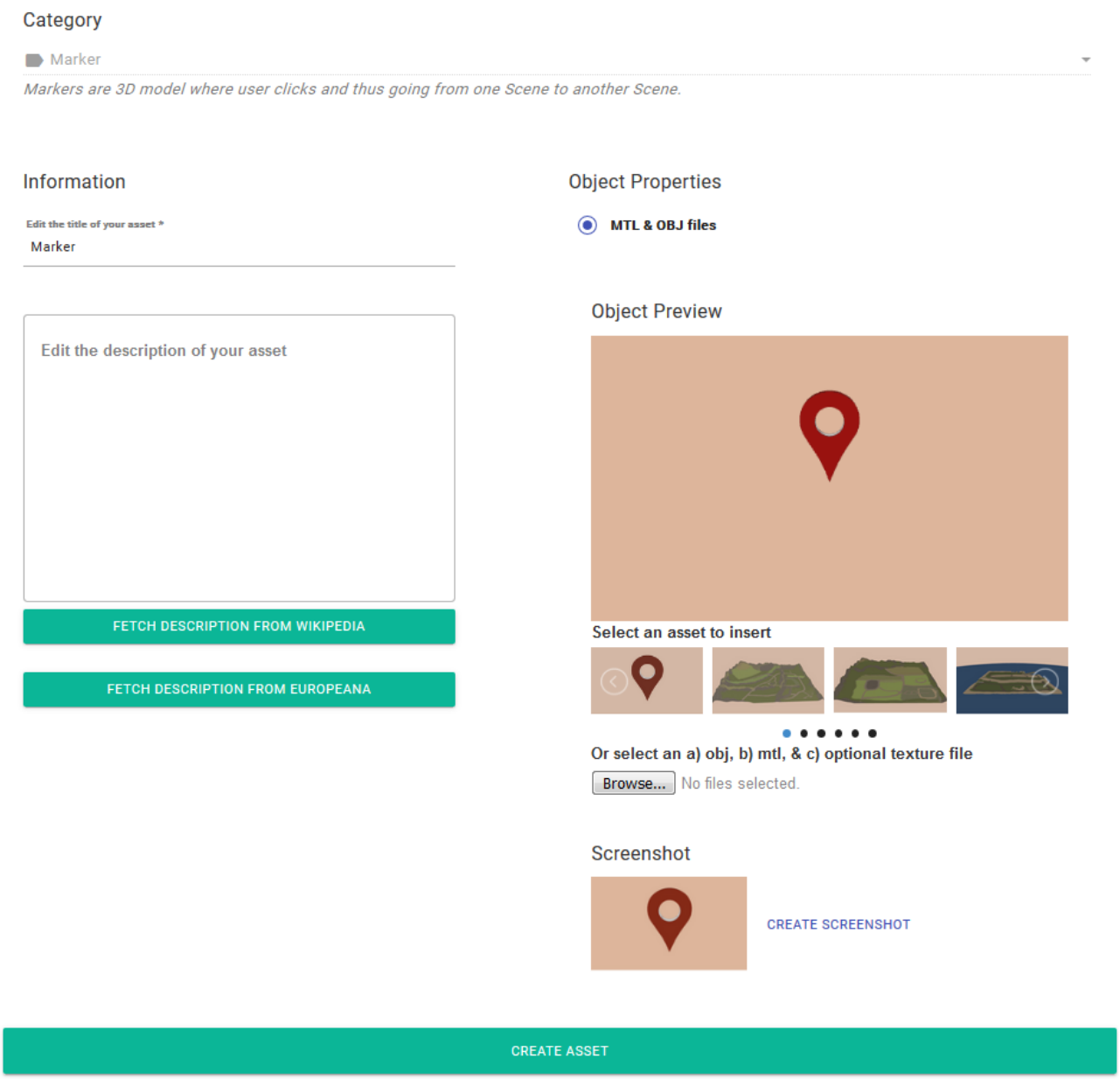


Figure 43: Creating a Marker asset.

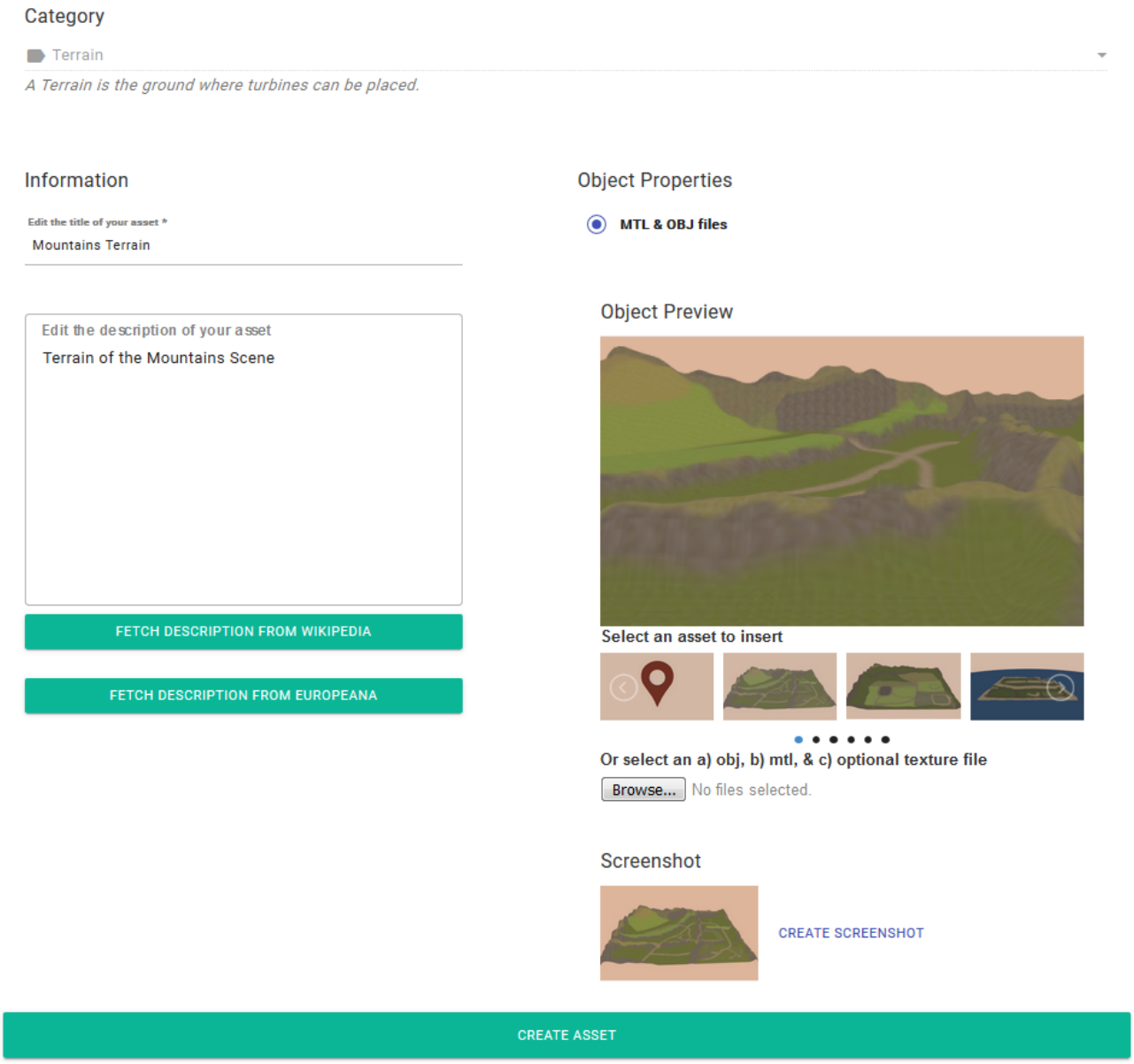


Figure 44: Creating Mountains Terrain asset.

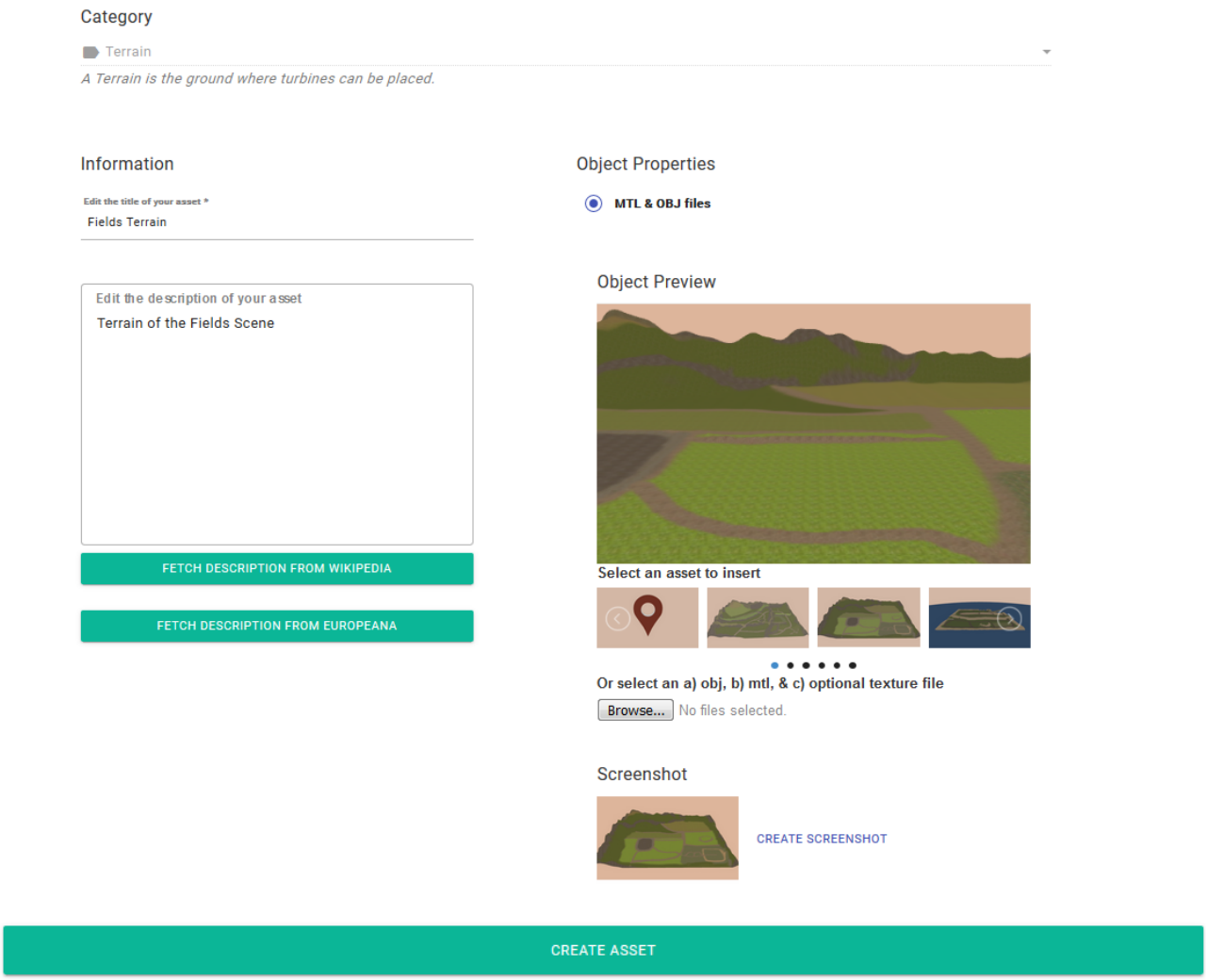


Figure 45: Creating Fields Terrain asset.

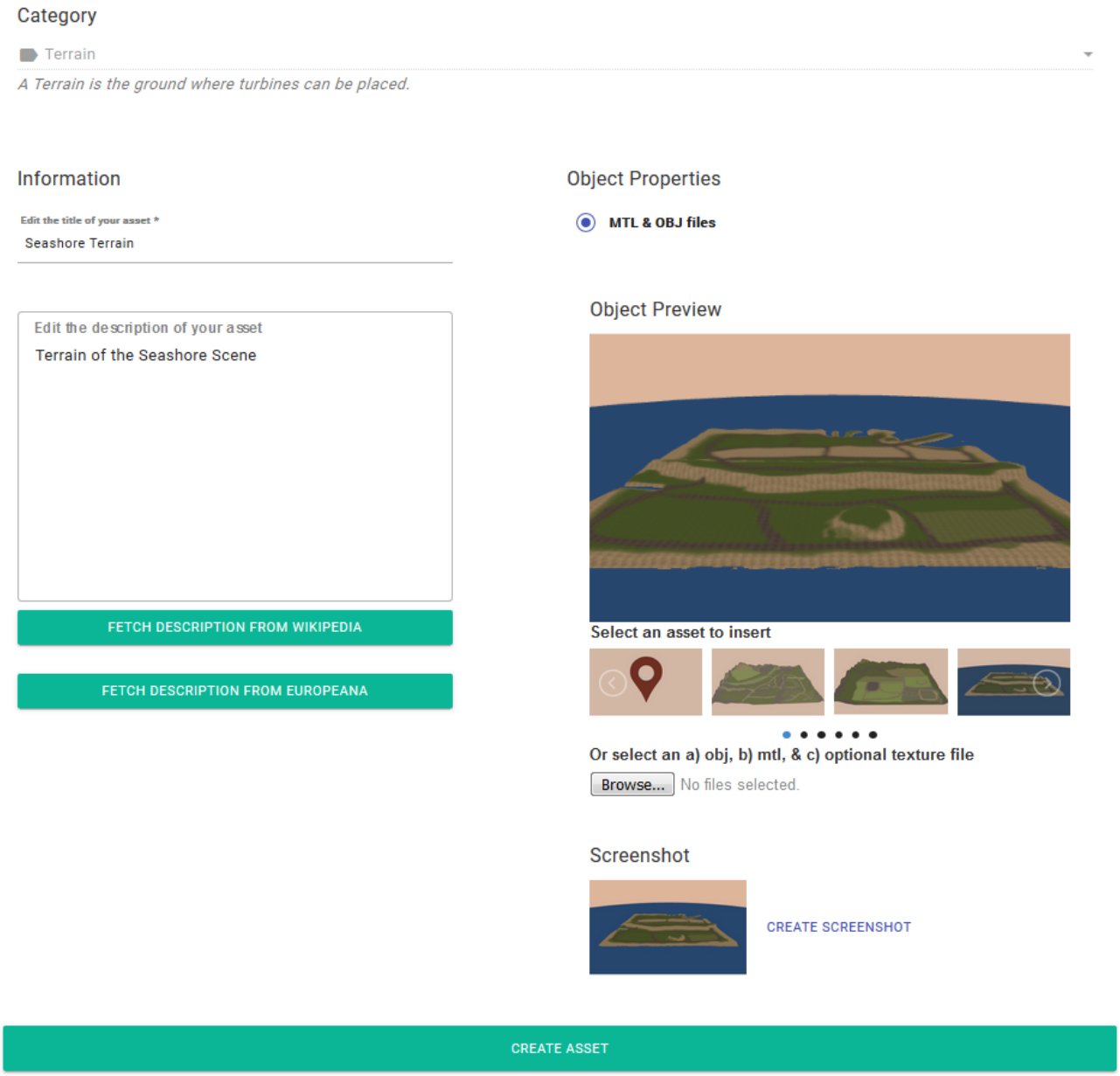


Figure 46: Creating Seashore Terrain asset.

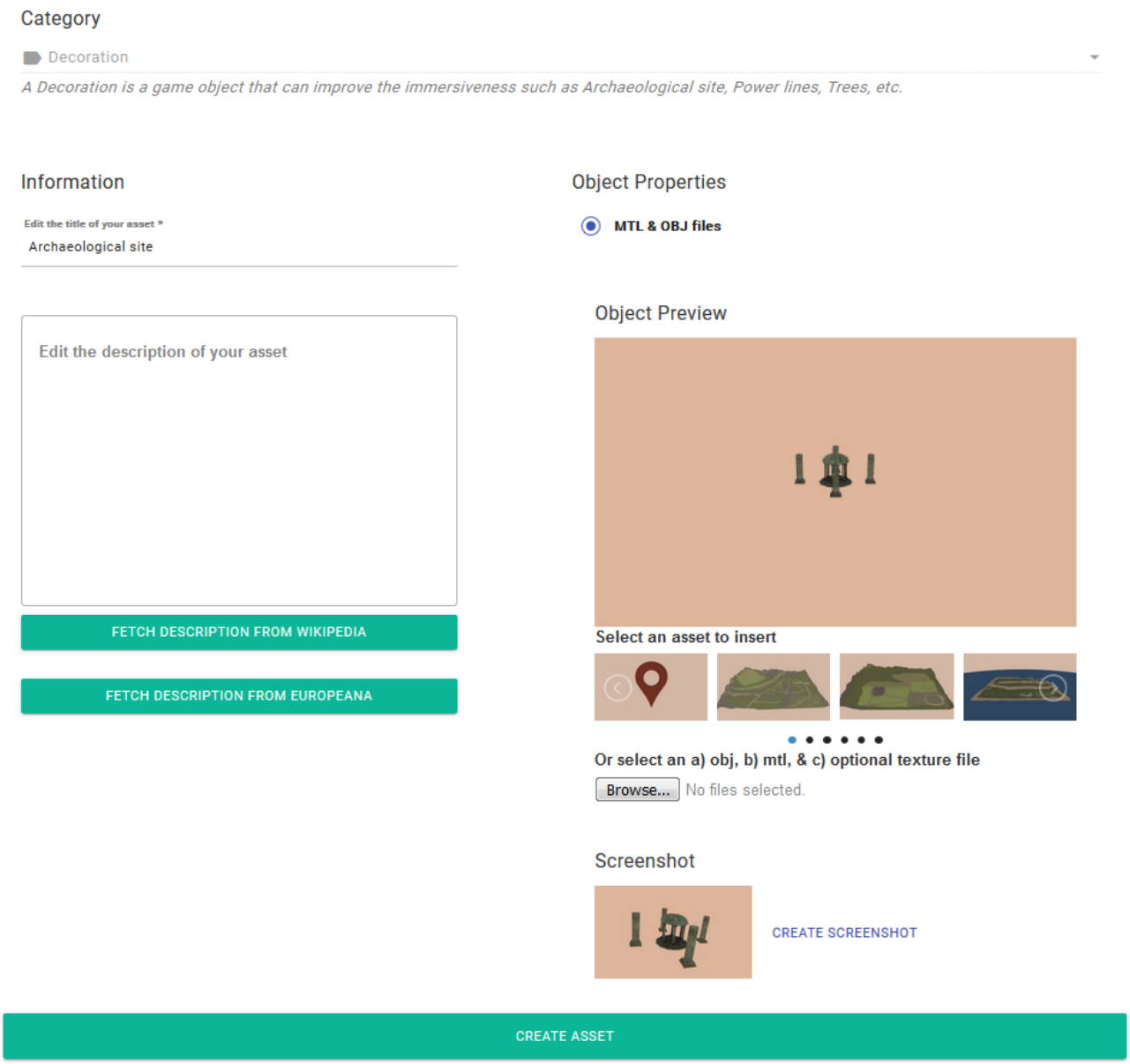


Figure 47: Creating an Archaeological site (decoration) asset.

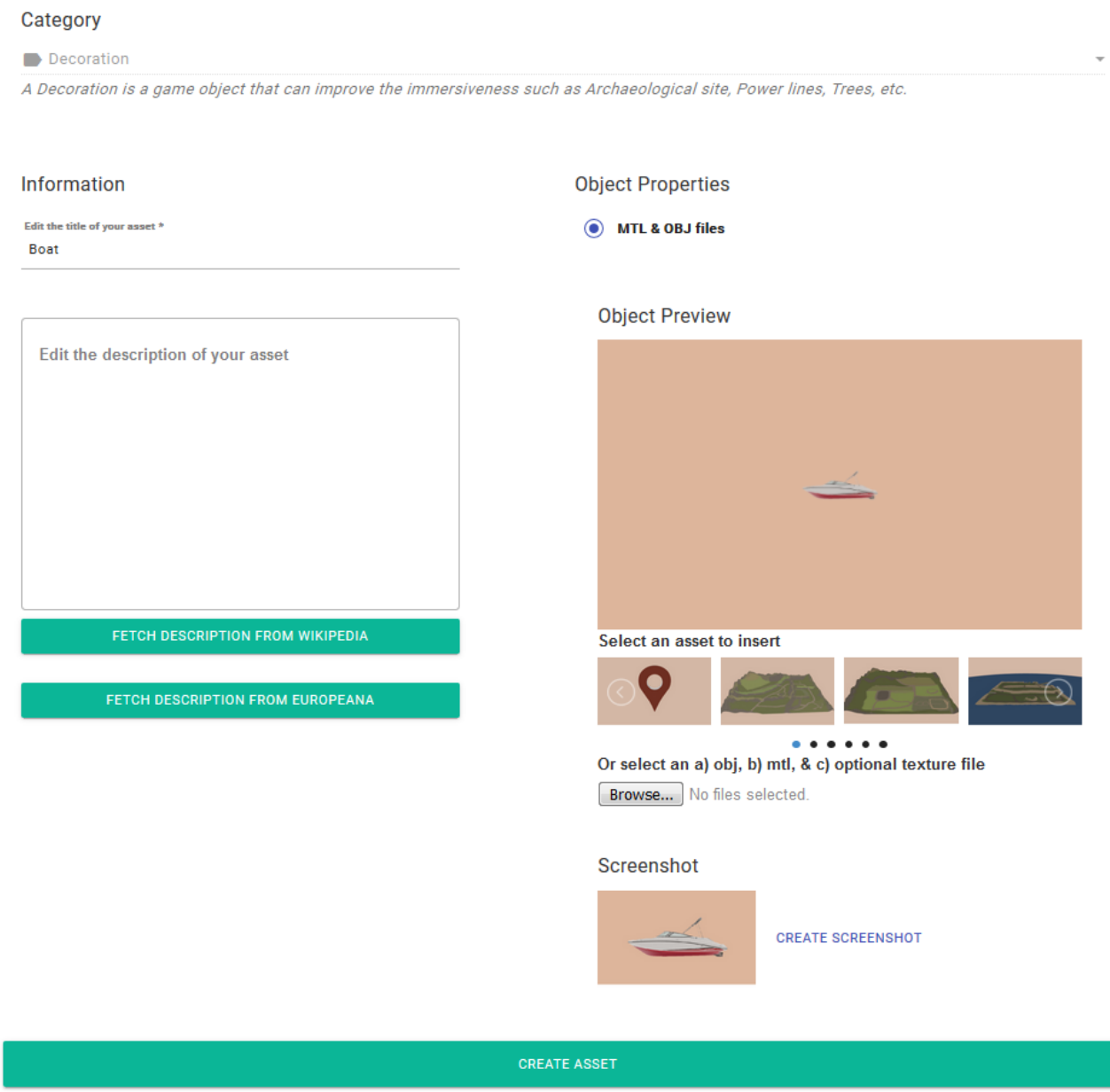


Figure 48: Creating a Boat (decoration) asset.

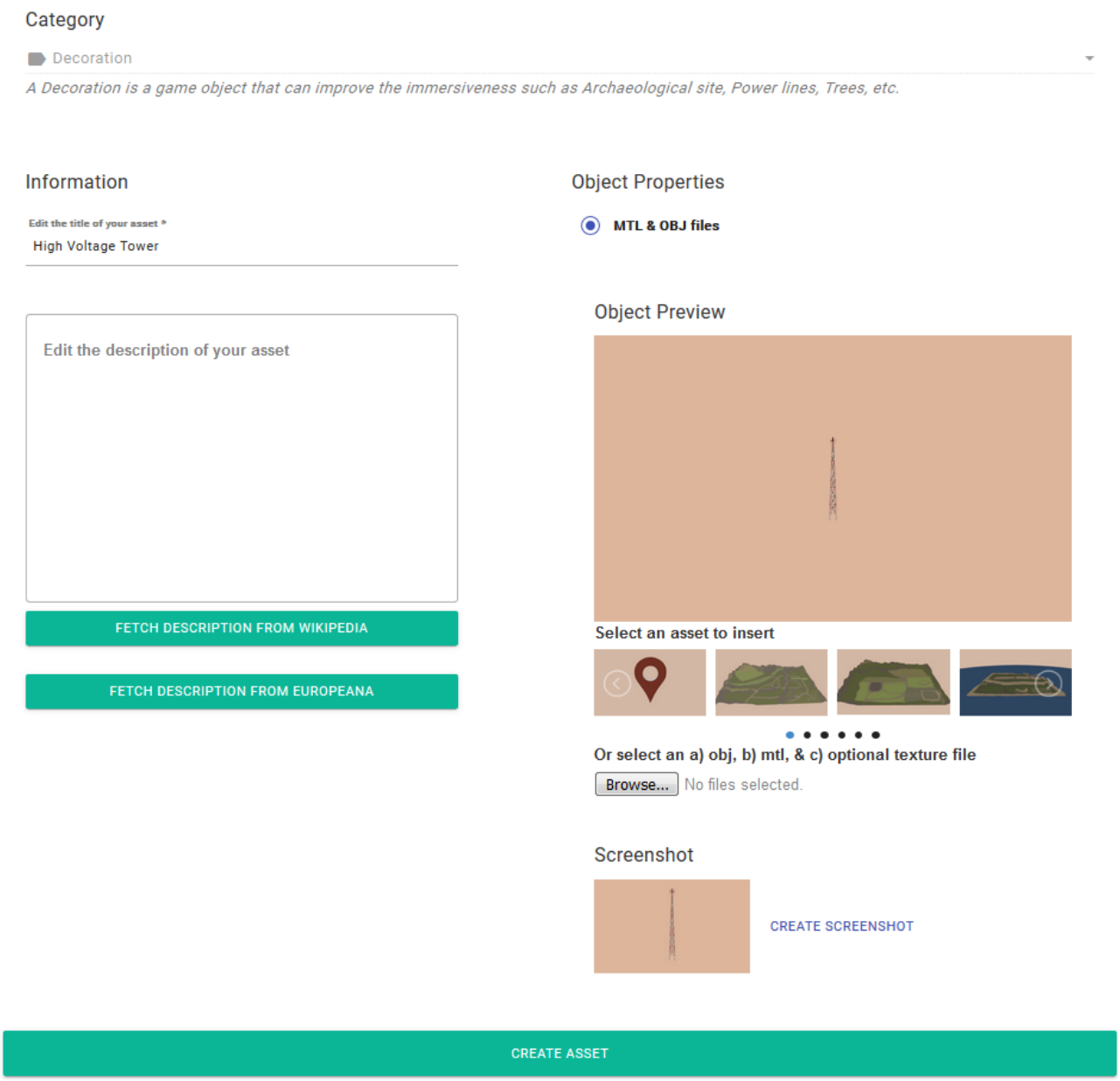


Figure 49: Creating a High Voltage Tower (decoration) asset.

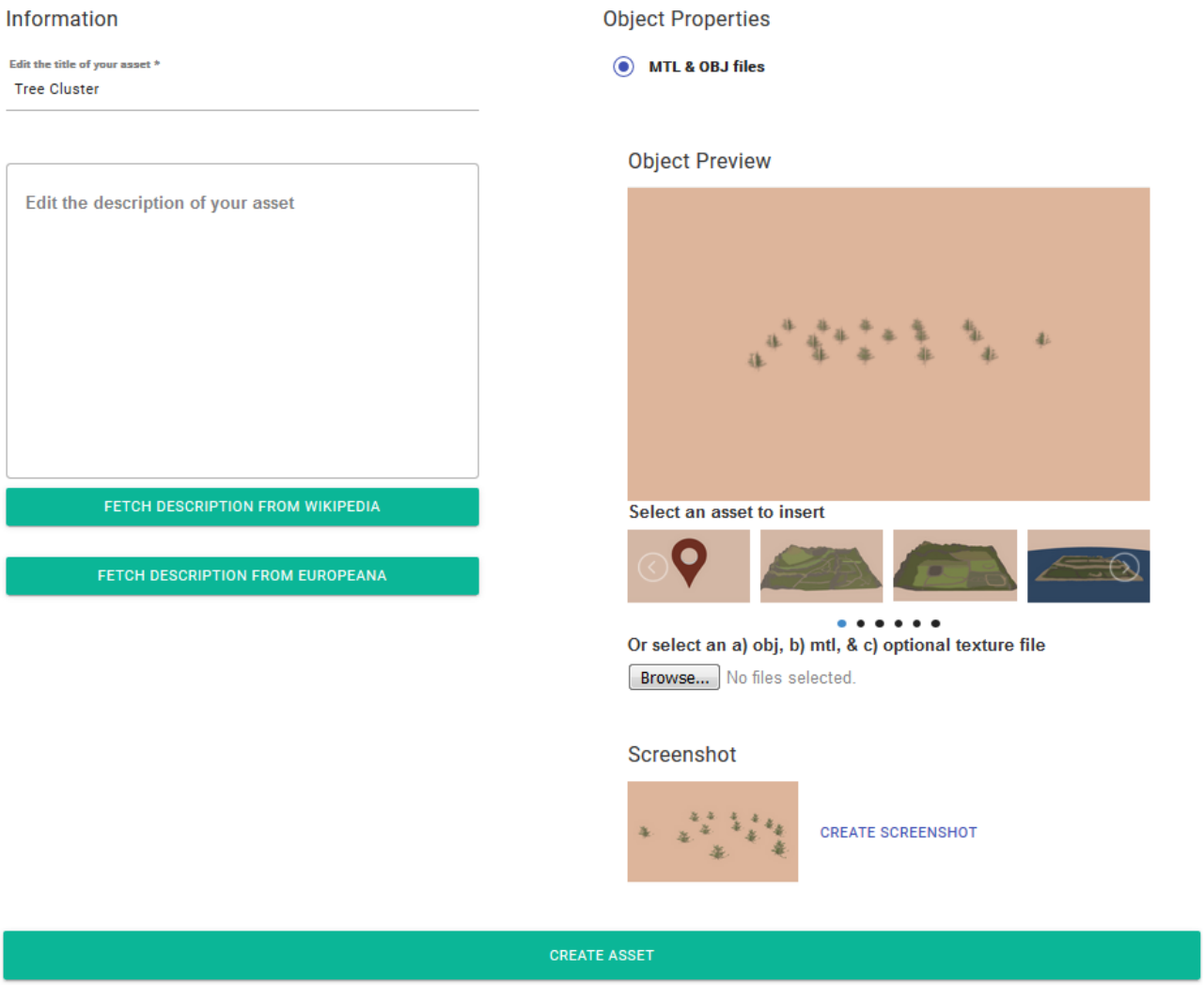


Figure 50: Creating a Tree Cluster (decoration)asset.

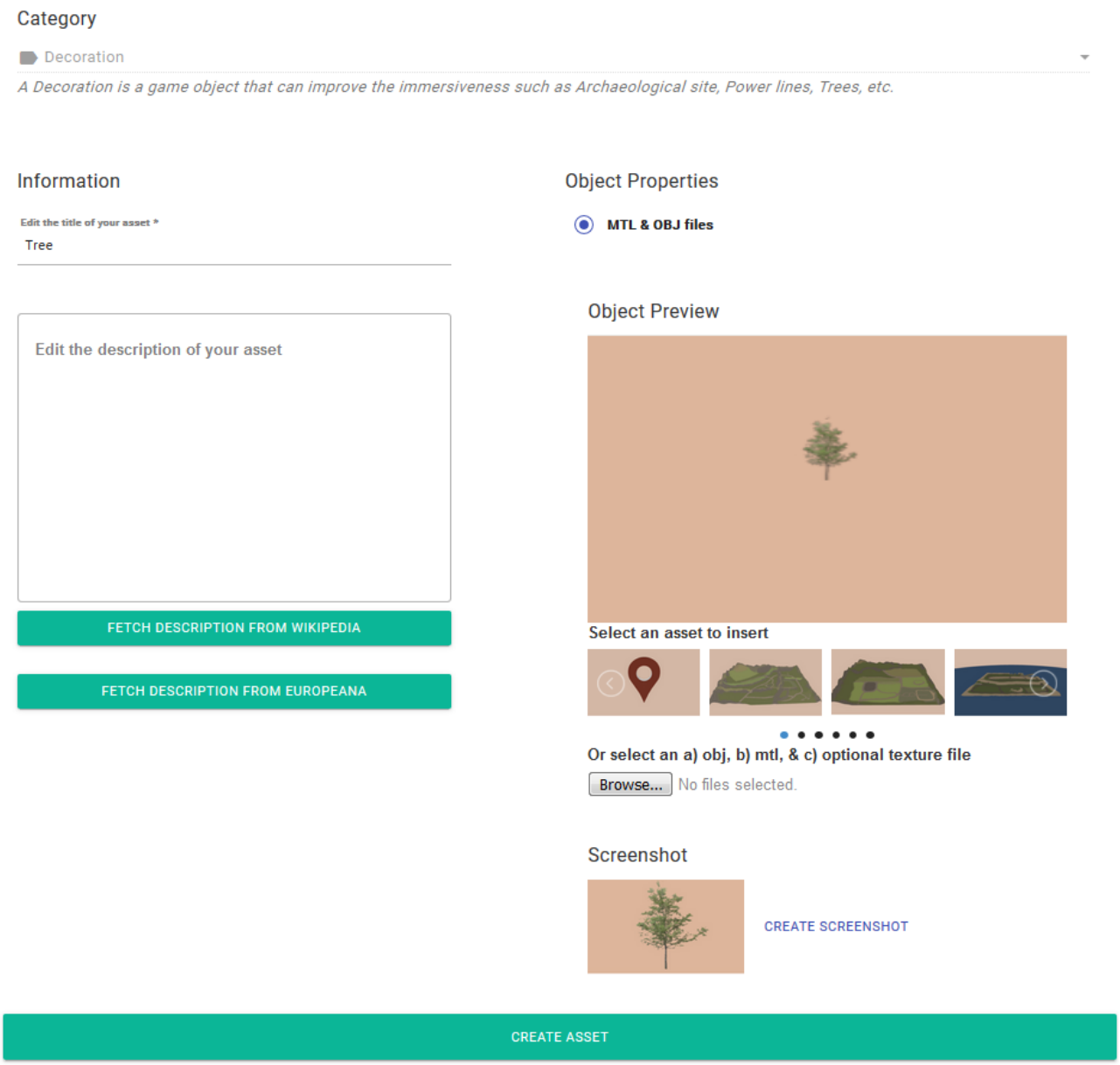


Figure 51: Creating a Tree (decoration) asset.

F Appendix

3.8 Chemistry Lab Scenarios

1.1.4. Scenario 1: Creating a virtual chemistry lab.

This scenario will take you through the basis of generating a virtual chemistry lab. A chemistry lab template containing scene and assets that helps you generate the virtual lab. A lab in development is referred to as a project. A chemistry project by default consists of five scenes: First Scene, Exam 3D construction puzzle, Exam 2D naming, Credits and Main Menu. The first scene will, when the lab is compiled, be the playable scene of the lab, meaning the virtual world the player moves around in. Appropriate Assets will already have been uploaded to the templates, like e.g. textbooks, laptops and microscopes for the Chemistry lab template. These can be placed around the scene.

Phase 1: Create a Wind Energy Project

Before you start the scenario, as described below, you should be logged in and the authoring tool should be running. Upon login, the interface presented in Figure 52 should be presented.

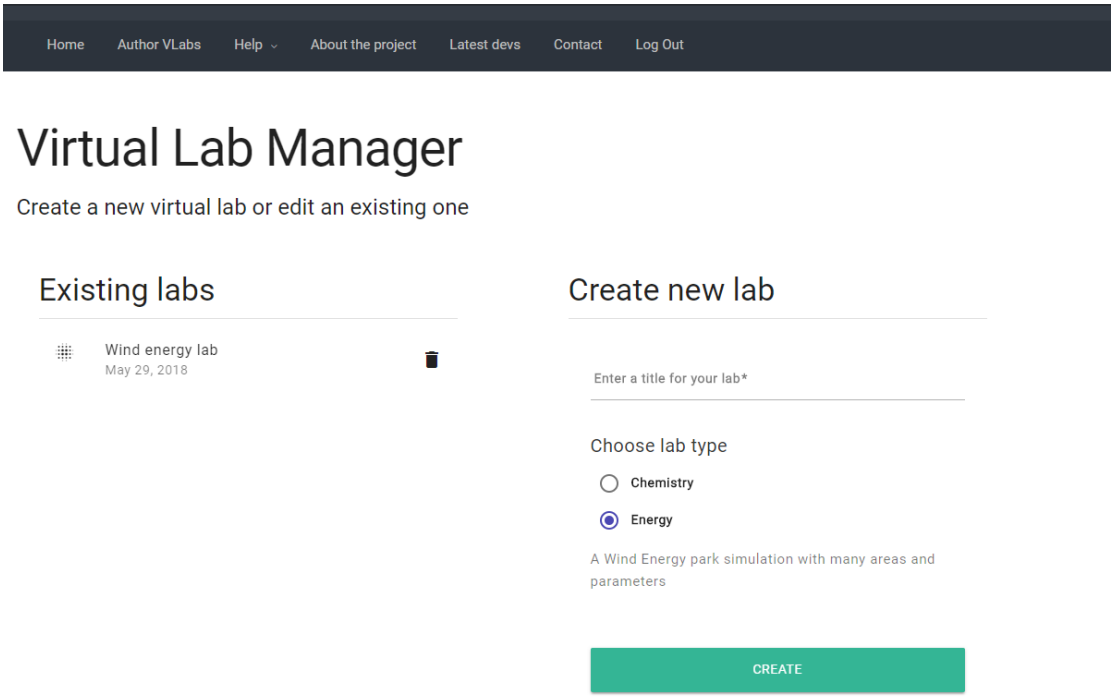


Figure 52: The Virtual Lab Manager allows creating, editing or deleting a project.

What you see in Figure 52 is the Virtual Lab Manager. It is the central interface for creating a new project, editing or deleting an existing one. A new lab can be created using “Create new project” shown in the right side of Figure 52.

b) Enter a title, select the type (Chemistry) and create the project.

Phase 2: Add assets to scenes

After creating the new project, the selected lab name, lab type and Scenes appears (as presented in Figure 53).

b) Enter First Scene (First Scene editor appears like in **Error! Reference source not found.**)

The camera that is the only item located in the editor is used to determine the starting point for the playable character in the lab. The icon showing a person in the top of the 3D editor (between the 2D and view tab) is used to investigate what the player will see.

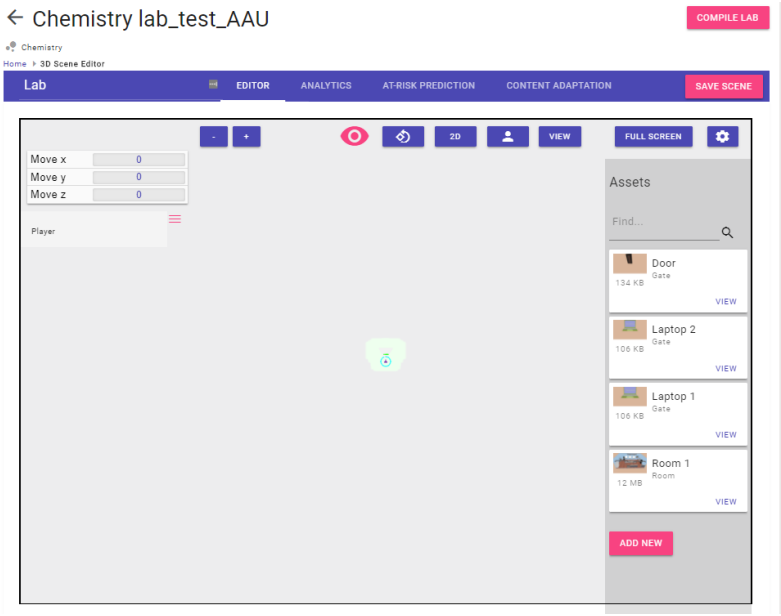


Figure 54: Lab Editor for First scene, where the playable scene can be modified.

j) Drag and drop Lab room 1 from the list of Assets (located in the right side of the screen) into the Scene Editor. Adjust the view if need to see the whole room (see **Error! Reference source not found.**).

Figure 55: Lab room 2 view from the top.

k) Try the following four controls out for navigating in the 3D editor:

- Zooming in and out
- Moving around the 3D environment
- Rotating the view (more information about controls are available in Table 74)

When feeling more comfortable with the controls move on to the next step.

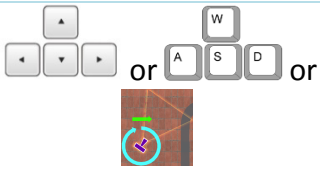
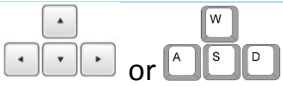
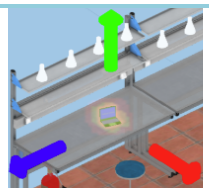
Action	Description	Example
Navigating 2D/3D environment (rotation)	Rotate the view by holding down the left mouse button and moving the mouse.	
Navigating 2d/3D environment (moving)	Move around the lap by holding down the right mouse button and moving the mouse in the desired direction.	
Zoom in and out	Use either the mouse scroll or plus and minuses on the keyboard.	
Navigating player camera	Use the arrows or W,A, S and D keys on the keyboard or the controls on the screen.	
Navigating avatar	Use the arrows or W,A, S and D keys on the keyboard	

Table 74: describing the controls in the editor for manipulating the view.

l) Drag and drop Laptop 1 from the list of Assets (located in the right side of the screen) into the Scene Editor.
Tip: Aim for one of the tables. This way you might place it where you wanted without having to adjust.

m) Adjust the Laptop if need so that it stands on top of one of the tables in the Lab Room (see Table 75 for more information on controls for moving the assets).
Tip: You can also delete and repeat the action in step c if adjusting it gets too hard. An asset can be deleted by using the trashcan icons (see Figure 56, blue square, for more information).

n) Repeat step c and d but add a textbook asset instead of the laptop this time.

Action	Description	Example
Moving assets	Use the green, red and blue arrows to move the assets the around the lab (see yellow square in Figure 56).	

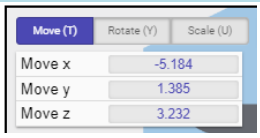
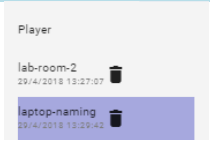
Moving assets	The laptop can also be rotated and scaled (see red square in Figure 56) when the tabs are selected. The X, Y and Z input fields could also be used to navigate the asset by modifying the numbers.	
Finding assets	If an assets is hard to find it can be re-reselected by clicking the asset name (see blue square in Figure 56).	

Table 75: describing the controls for moving and adjusting assets.

Tip: If the controls are difficult, entering full screen view might help (button located in the top right corner of the screen, green square in Figure 56).

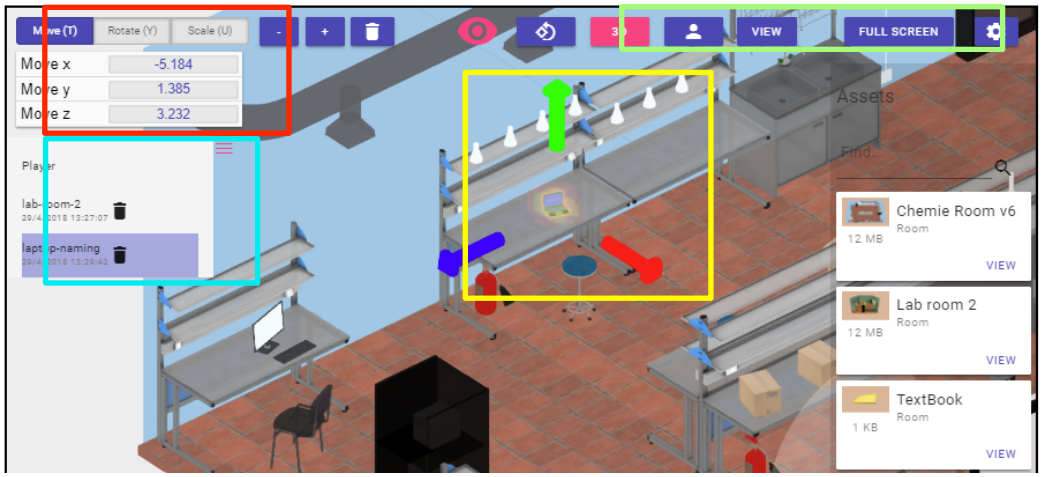


Figure 56: Laptop asset placed on a table on the Lab Room. The squares are indicating: modification of asset (red), arrows that can be used to manipulate the assets location (yellow), list over assets in the scene (blue) and screen view (green).

o) Click Full Screen (button located in the top right corner of the screen).
p) Now click the avatar icon in the top of the window (see green square in Figure 56) and navigate the avatar to where the laptop is located (for avatar controls see Table 76). Check if the computer is located on the table and not e.g. flying over the table. Correct location of laptop asset if needed by repeating the previous bullet f as described above.
q) Repeat step C to G for Laptop 2 as well.
r) To exit avatar mode click the “Esc” key

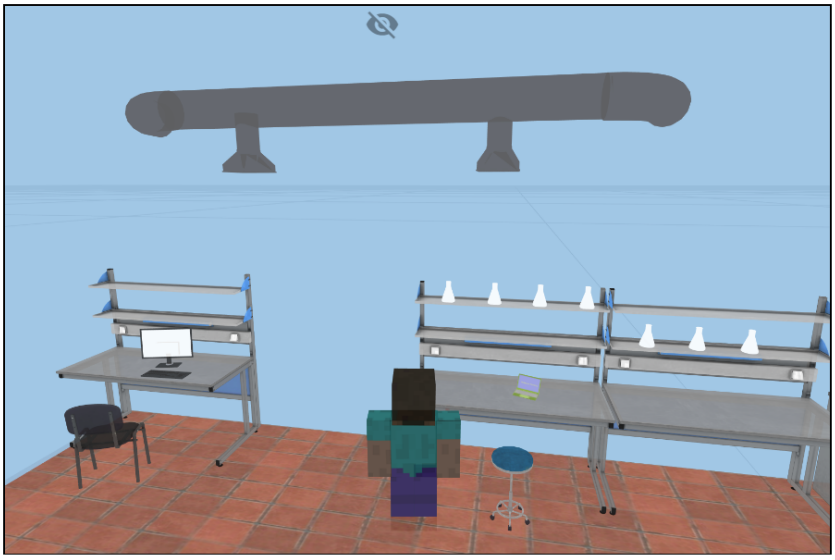


Figure 57: Avatar view of the Lab Room and laptop asset.

Phase 3: Connecting assets with other scenes

a) Exit full screen and navigate towards the laptop
b) Right click on the laptop (menu appears, see **Error! Reference source not found.**) and choose the Molecule Construction scene.
c) Navigate to the other laptop and right click on the laptop (menu appears, see **Error! Reference source not found.**) and choose Molecule Naming scene.

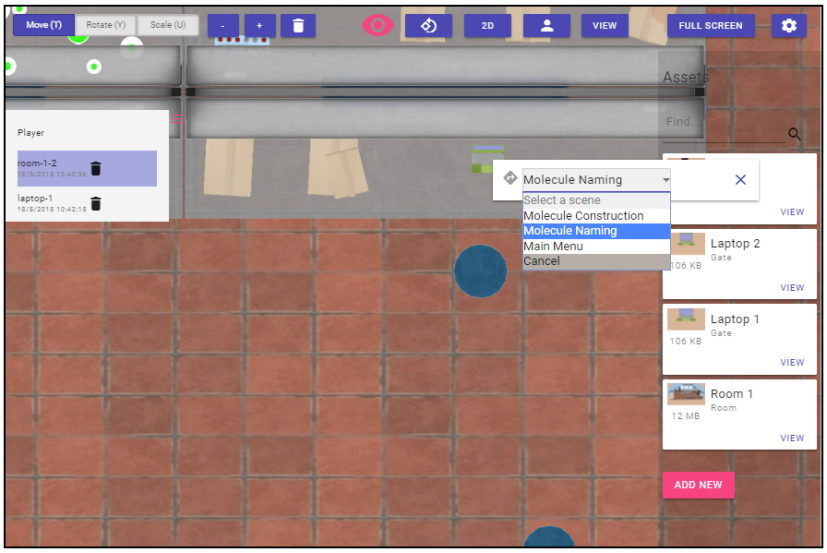


Figure 58: Menu for combining the first scene with the 2D naming and 3D construction puzzle.

a) Drag and drop the Door asset into the scene along one of the walls in the lab. Adjust it if needed.
b) Right click on the door and select Main Menu
c) Save the scene in the top menu of the 3D editor

d) Navigate to the Molecule Construction scene by scrolling down on the 3D editor page

e) Go to the Select Molecule tab in the top menu of the page (see **Error! Reference source not found.**).
f) Choose at all three molecules and submit them.
g) Start constructing strategies by dragging and dropping the molecules into the pink input field. Remember to click add between constructions.
h) Now save all the strategies.
i) Repeat step e to i but for the Molecule Naming scene.

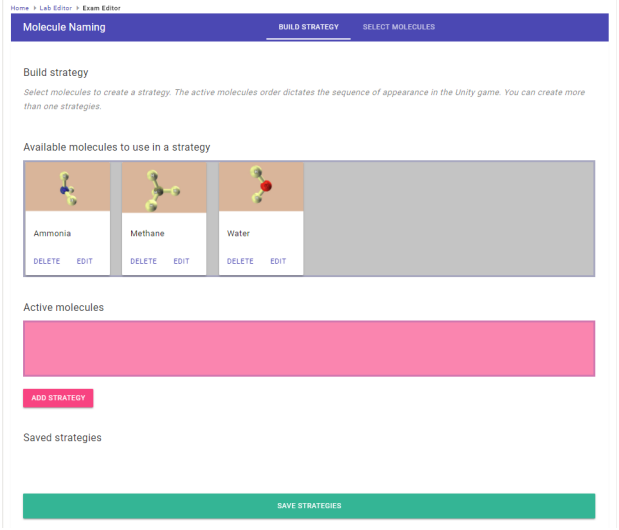


Figure 59: Exam 3D construction puzzle scene editor.

Phase 4: Main Menu, Credits and Compile

k) Navigate to the Main Menu scene editor (see Figure 60).

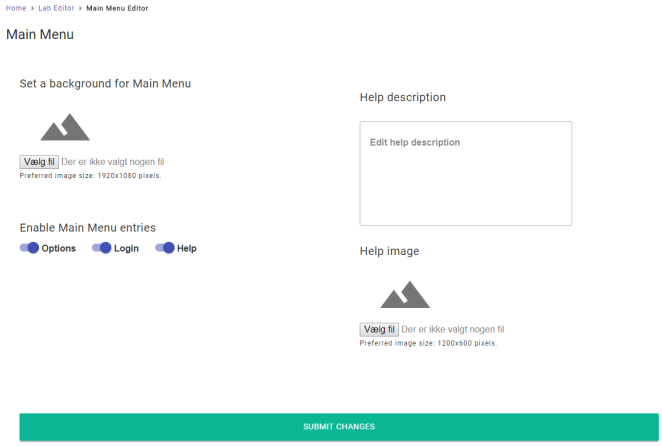


Figure 60: Main Menu scene editor.

l) Set a background for the Main Menu.
m) Set background for the Help function and add a description.
n) Save all changes
o) Navigate to the Credits scene editor (see Figure 61).

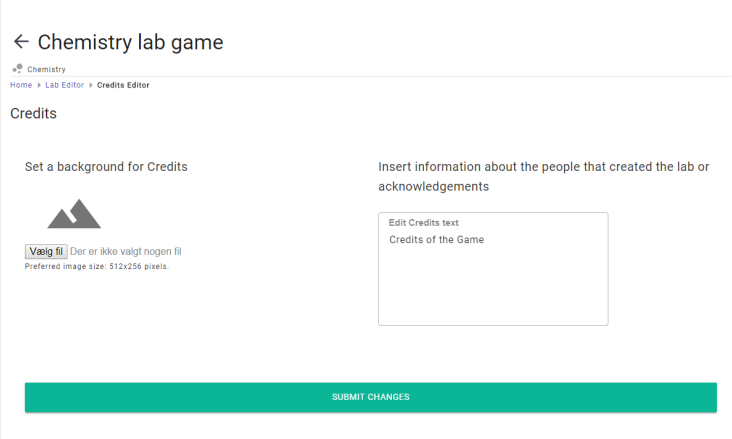


Figure 61: Credits scene editor

p) Set a background for the Credits
q) Set background for the Credits and add a description.
r) Save all changes.
s) Compile the game, choose your operating system and proceed.
t) Open the file containing the compiled chemistry lab and try it out

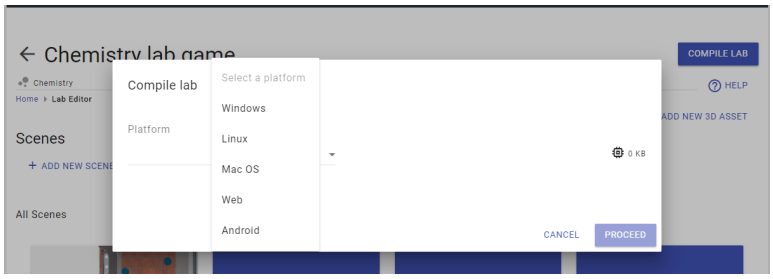


Figure 62: Compiling menu.

1.1.5. Scenario 2: Using the Analytics front-end

Game analytics are incorporated in the 3D scene editor and can be accessed through the Analytics tab.

d) Go to the editor
e) Press the “Analytics” tab in the blue ribbon as shown in the interface. The analytics of the Chemistry lab appear.

On the left side, the distribution of students into the PISA categorization is shown according to their achieved score, which is actually the molecules completed in naming and 3D construction exam. On the tables, the achieved molecules are shown per user (an anonymous code is used as id).

1.1.6. Scenario 3: Administration user

The administration user scenario will show how to undertake crucial administrator tasks, such as creating assets to be used by a regular teacher. The scenario assumes that you have already completed all the previous scenarios and that you have experience in authoring labs with the tool.

4. The main responsibility of the administrator is to create new assets that will be available to all projects created by teachers. More specifically, the administrator has the ability to create assets that differ from the assets created by regular teachers when they author games at the point that they are visible to all projects. This means that when creating a new project, a teacher will find available assets in the editor asset list, which have been created by the administrator.
5. Moreover, the administrator has the responsibility, and thus the ability, to monitor other projects, edit them or propose corrections in order to ensure that the produced authored labs are of sufficient quality. Also, this will help new authors to learn the tool faster and more easily.
6. The procedure of creating global assets is based on the existing by default "joker games", i.e., projects created prior to any other and that are not meant to be used for lab production but only for creation of new assets.
   Thus, there is no need to create a joker game; instead, go to the main menu and select an existing "joker game" project of such type that is the same with that of the projects to use the assets in the future. There are three types of assets that one can create in the joker games. These are:
   a) Room, which consists of three files, a 3D model (.obj) an .mtl and a texture file (.jpg)
   b) Molecule, consisting of three files as above, but with a .pdb file (3D model) instead of an .obj, which a 3D model representing the chemical formula of the molecule
   c) Gate, consisting of a 3D model (.obj) an .mtl and a texture file (.jpg), (practically, a special point in the 3D lab where the player can have access to another lab or to chemistry exercises), which can be either:
      a. A laptop, which serves as a "gate" to a molecule construction or naming exercises
      b. A door, which serves as a "gate" to another chemistry lab.
      c. A safety sign board, acting as a "gate", similarly to the door.

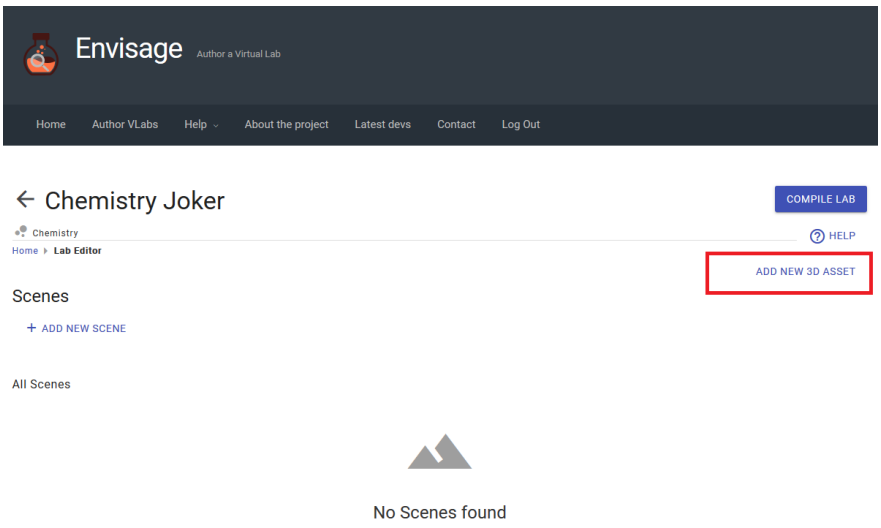


Figure 63: Adding new assets in the Chemistry joker game (red rectangle).

Steps for creating 5 specific assets:

- To create a molecule asset, go to the main menu, click again on the “Add new asset” button, as previously. Then, in the new screen that will appear, select the type of the asset to be “Molecule”, see Figure 64. After that, you can name the molecule and enter a description, as shown in Figure 65, for the example of the ammonia molecule. The most crucial part of the creation of this asset (as with any other type of asset) is the uploading of three graphics files, i.e., the .obj, .mtl and the texture (.jpg) files, where the latter, the texture file, is optional. You must have these files in order to create the room asset. You can browse your file system by clicking on the browse button, i.e., click the relevant button shown in Figure 65, and then select the three aforementioned files. Another crucial part of the creation is the molecule chemical formula, which is needed in order to check whether the student taking the molecule naming exams has given the correct formula. Thus, you must add the molecule formula to the respective field, i.e., the “Chemical Type text field” residing below the “Molecule Options” text. In the example of Figure 65, the formula of the molecule is set to be NH3 (that of ammonia) and the description has been automatically been fetched by Wikipedia, by pressing the “Fetch description from Wikipedia” button. Thus, after entering the formula, press the aforementioned button. Ammonia is colourless, so, in this example, the color is set very close to white. Set also the viscosity property to a value. Lastly, clicking on the “take screenshot” button will produce a snapshot of the 3D model of the molecule that will be used as a thumbnail.

- The creation of a room asset is much simpler than that of the molecule, since there is no need for a formula, viscosity, or for color. To create a room asset, go to the main menu, enter the chemistry joker game and click on the “Add new 3D asset” button, see red rectangle in Figure 63. The, in the new screen that will appear, select the type of the asset to be “Room”, see Figure 64. After that, you can name the room and enter a description. The most important part of the creation of this asset (as with any other type of asset) is the uploading of three graphics files, i.e., the .obj, .mtl and the texture (.jpg) files, where the latter is optional. You must have these files in order to create the room asset. You can browse your file system by clicking on the browse button and then select the three aforementioned files. Lastly, don’t forget to take a screenshot. For this particular scenario, add three molecules: ammonia (NH3), methane (CH4), water (H2O).

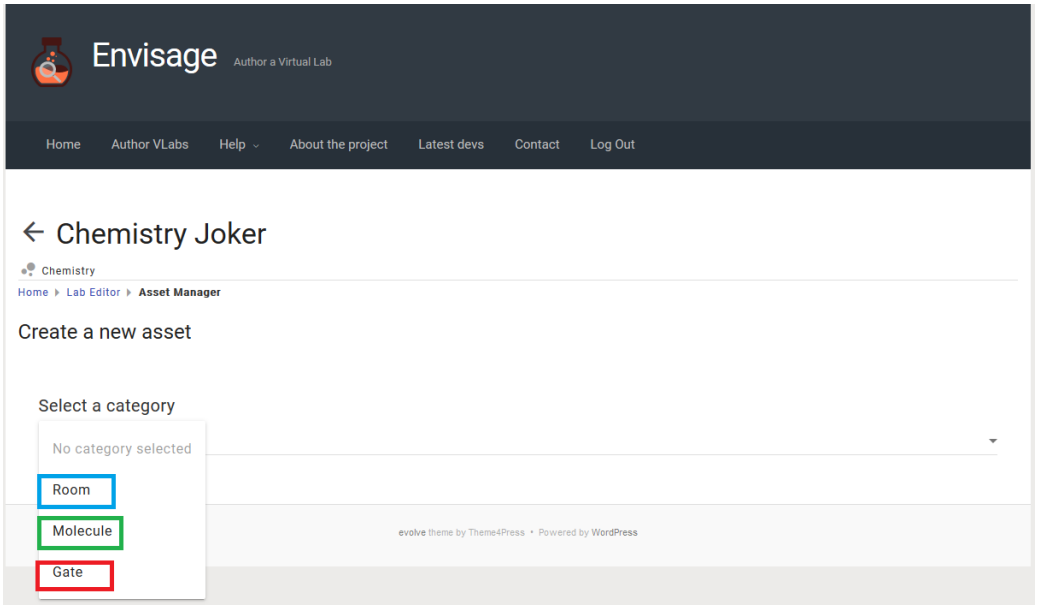


Figure 64: Selection of the asset category. Blue rectangle: room, green: molecule and red: gate.

- The creation of a laptop asset is much simpler than that of the molecule case. To create a laptop asset, go to the main menu, click again on the “Add new Asset” button. Then, in the new screen that will appear, select the type of the asset to be “Gate”, see Figure 64. After that, you can name the laptop and enter a description. Then, you must complete the next important step, which is the uploading of three graphics files, i.e., the .obj, .mtl and the texture (.jpg) files, where the latter is optional. Lastly, don’t forget to take a screenshot.
- Similarly to the laptop case, the creation of a door asset and a safety sign board is also straightforward. To create such an asset (door or board), go to the main menu, click again on the “Add new Asset” button. Then, in the new screen that will appear, select the type of the asset to be “Gate”. After that, you can name the door or board and enter a description. Then, you must complete the next important step, which is the uploading of three graphics files, i.e., the .obj, .mtl and the texture (.jpg) files, where the latter is optional. Lastly, don’t forget to take a screenshot.

  Overall, for this particular scenario, you have to create the following assets:

  a) A door,
  b) Three molecules: ammonia (NH3), methane (CH4), water (H2O), and/or any other you prefer,
  c) Two laptops,
  d) A safety sign board.

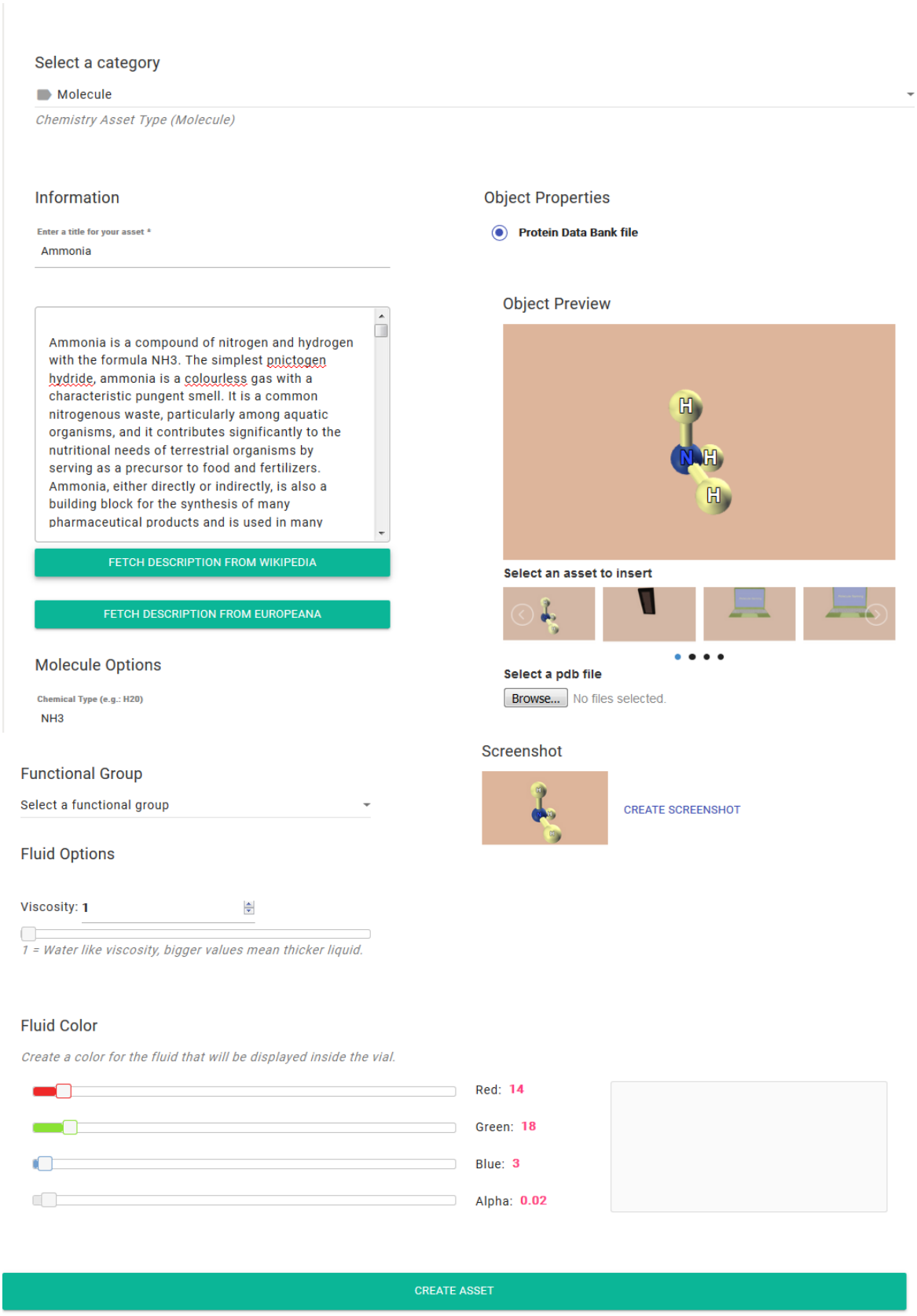


Figure 65: Adding a molecule asset.