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D1.4

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Abstract

The current document is an update of D1.2 – Data structure and functional requirements and as such it has a similar scope and structure. It aims to present an updated compilation of requirements and prioritized recommendations in response to the first evaluations of the authoring tool, the analytics and visualization services, and the 3D virtual labs. First the updated list of metrics which will be incorporated in the shallow and deep analytics services and related visualization tools are presented. Then the update of functional requirements of the various components (authoring tool, analytics and visualization services) in light of the evaluation results from the piloting tests the functional requirements for the combination of Chemistry labs and for an elaborated version of a multi-stage 3D virtual lab/game based on

the Wind Energy Lab Finally are presented.

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History

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Executive Summary

The current document is an update of D1.2 – Data structure and functional requirements and as such it has a similar scope and structure. It aims to present an updated compilation of requirements and prioritized recommendations in response of the first evaluations of the authoring tool, the analytics and visualization services, and the 3D virtual labs.

With respect to proposed metrics, we first presented and proposed an initial list of them, their definition and rationale of use in D1.2. In this document we list only the ones that are of particular interest and focus of teachers and educators. According to their feedback and insight, these are easily comprehensible and are directly supporting and facilitating the monitoring and assessment of the teaching and learning process. These are the following metrics: a. time-on-task, b. time-to-completion, c. class categorisation profile, d. Levels of proficiency and e. travel-path. These metrics are proposed to be incorporated in the updated versions of the analytics and visualization tools offered by the project.

In D1.2 we proposed the structure of the analytics data and its aggregation level to permit analysis and interpretation similar to the one that is conventionally done in the actual school environment. This is already accommodated in the analytics back-end system. Therefore in this update we do not foresee any alteration to be necessary.

The functional requirements that the virtual lab authoring tool and accompanying analytics and visualization service of ENVISAGE will accommodate are updated and discussed in detail. In general the potential and value of the virtual lab authoring tool was clearly identified by end-users. Although its functionality was well received they highlighted some areas where improvements can be made or expected and which will facilitate its wider use. Overall the difficulties encountered are related to the user interface, help functionality and 3D navigation. These can be greatly overcome or even completely eliminated if the suggested requirements discussed in the document can be technically accommodated. The analytics and visualization services offered were well-received by the teachers during the piloting tests since they are anticipated to assist them in refining or adjusting the teaching and learning process using virtual labs. Possible improvements in their initial design were suggested addressing the main functional difficulties like visibility or users' preference to have more commonly used visualization types.

Regarding the enhancement of the existing Chemistry labs we also proposed a series of functional and general design requirements in order to guide and assist the development team. An elaborated version of a 3D virtual lab based on the Wind Energy lab was also presented. Its overall design is proposed to be enriched with multiple stages, to have a game-like multi-event flow, and thus to be possible to incorporate a large spectrum of educational objectives. The complete blueprint/design document is given in detail in the document.

Abbreviations and Acronyms

GUI	Graphical User Interface
WYSIWYG	What You See Is What You Get
PISA	Programme for International Student Assessment

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1 Introduction

The current document is an update of D1.2 – Data structure and functional requirements and as such it has a similar scope and structure [1]. It aims to present an updated compilation of requirements and prioritized recommendations in response of the first evaluations of the authoring tool, the analytics and visualization services, and the 3D virtual lab which are reported in detail in D5.2 – Implementation of the educational scenarios and evaluation report (first phase) [2].

The document is structured as follows: in Section 2, first we present the updated list of metrics which will be incorporated in the shallow and deep analytics services and related visualization tools. We then briefly mention the expected data structure and aggregation level, this is only for the sake of completeness as there are not any changes proposed for these. Then we discuss the update of functional requirements of the various components (authoring tool, analytics and visualization services) in light of the evaluation results from the piloting tests. We finally present the functional requirements of an elaborated version of a multi-staged 3D virtual lab/game based on the Wind Energy Lab. The main points of the document are summarized in Section 3.

2 Metrics, data structure and functional requirements

2.1 Proposed metrics

We first presented and proposed a list of metrics, their definition and rationale of use in D1.2. In this section, we list only ones that are of particular interest and focus of teachers and educators. According to their feedback and insight, these are easily comprehensible and are directly supporting and facilitating the monitoring and assessment of the teaching and learning process. These are the following metrics: a. time-on-task, b. time-to-completion, c. class categorisation profile, d. Levels of proficiency and e. travel-path. Their definitions are briefly mentioned below, more complete information and references therein can be found also in the particular section of D1.2. These metrics are proposed to be incorporated in the updated versions of the analytics and visualization tools offered by the project. Other metrics, like "perceived, expected and actual general class or group profiles" and "mastery index", are considered relatively more complex and may be only of interest of educational researchers or designers. As such and due to the fact that may be a source of distraction or disorientation for the main target group of teachers and educators we propose that these will be omitted.

2.1.1 Time-on-task

Definition: Time-on-task is defined as the total time that students spend engaging in a task that is related to outcome measures of learning or achievement. For example, in a lesson plan or educational activity that follows a structured inquiry-based model the time-on-task refers to the time that is spent within the specific phase of the inquiry activity. Based on the time-on-task paradigm, which is a simple but powerful framework to explain students` achievements, it may be possible to draw conclusions about the effectiveness of the educational process.

2.1.2 Time-to-completion

Definition: This metric is similar to the time-on-task metric, the main difference is that the emphasis is on measuring the overall time students spent from a starting point until they complete the whole sequence of tasks that compose the learning activity. In this respect, it is more useful reference metric in case of circular activities or where students are assigned with tasks that can be repeated several times until a satisfactory outcome is reached. It offers also valuable information of the learning behaviour of students in case of homework assignments. In this case it is useful for teachers to monitor and know whether their students do their work in one step or in multiple steps or iterations.

2.1.3 Class categorisation profile

Definition: In this metric, students are categorised in three categories according to a well-defined categorisation scheme, e.g., PISA 2012. The metric is calculated by considering the lowest level task per phase for the completed task. For example, students in the context of an educational activity have to solve two specific tasks that are connected with the specific partial ability. If a student completes successfully the two assigned tasks, he/she gets on a high level. In case the student is not able to solve neither of the tasks, then his/her profile value will be on the low level in that phase. However, if the student's answers were high or moderate, then his/her profile value will be moderate. By this procedure the specific study underestimates the real performance but such a process will minimize the risk for interpretations when comparisons are included.

2.1.4 Levels of proficiency

Definition: This metric could offer an opportunity to teachers for direct comparisons with country average or other standardized scores, e.g., OECD average scores. Additionally, the continuous use of such assessments from the teachers for the same class could act as a very effective method to monitor students' skills development. The level of each task is added for every problem-solving question in each phase of the inquiry activity and is then divided by the number of tasks. This method is offering the opportunity to have a clear view of the students' performance as there is no need to select among the task level when the student performance is not the same in the task of each phase. Then the percentage is calculated. The example of the average of high, moderate and low levels of proficiency calculation are compared with OECD Average or other reference data.

2.1.5 Travel-path related metrics

Definition: The travel-path is defined as the sequence of actions that a student follows within a learning activity. Metrics related to that can be the overall length in time, critical path to completion, loop time, transition density, etc. The measurement and monitoring of such metrics are more important in learning activities which are action-oriented rather than results-oriented. In this context, the visualization of travel-path related metrics will help teachers to identify students that have difficulties or cases of possible disorientation where intervention and guidance is needed.

2.2 Data structure and aggregation level

In D1.2 we proposed the structure of the analytics data and its aggregation level to permit analysis and interpretation similar to the one that is conventionally done in the actual school environment. This is already accommodated in the analytics back-end system. Therefore in this update we do not foresee any alteration to be necessary.

2.3 Functional requirements

In this section, we present and discuss an update focused on the functional requirements that the virtual lab authoring tool and accompanying analytics and visualization service of ENVISAGE will accommodate. These are in-line with the various feedback collected from end-users during the piloting tests as described in D5.2 [2]. In the following we are listing the main requirements which basically are derived from suggested recommendations and are related to possible enhancement of existing functionalities or to the design or development of new features. These will be addressed with higher priority by the development team.

Afterwards we are discussing the functional requirements specification for the Chemistry and Wind Energy 3D virtual labs/games. The development of these took place in collaboration with teachers and educational designers initially without the use of the authoring tool in order to test them and then design their templates that will be used with the authoring tool. These templates will be used later in the authoring tool so that teachers or educators can make variations of these virtual labs/games.

2.3.1 Authoring tool

In general the potential and value of the virtual lab authoring tool was clearly identified by end-users. Although its functionality was well received they highlighted some areas where improvements can be made or expected and which will facilitate its wider use. Overall the difficulties encountered are related to the user interface, help functionality and 3D navigation. These can be greatly overcome or even completely eliminated if the following requirements can be technically accommodated.

- The graphical user interface of the authoring tool can be substantially improved with a better arrangement of existed action buttons which are in context and in consistency with the flow of actions that a user has to follow to complete a task.

- Unnecessary or irrelevant buttons (e.g. RSS feed) or non-functioning fields (e.g. Comment field, Search field) that can distract or frustrate users can be removed or omitted.

- Help section and documentation can be improved with more simplified and concise step-by-step instructions or how-to tips or other explanatory texts and features, especially for the novice and inexperienced users.

- In this context, technical language or abbreviations in guides and menus should be avoided. An overall improvement will be also the consistency in terminology of various key terms and concepts.

- Error prevention or avoidance can be facilitated with a better placed Save button or reminder/warning hint or even Auto-save feature if that is technically feasible.

- Along this line an Undo/Redo functionality would be a highly facilitating feature.

- Aforementioned possible improvements are of particular importance regarding the 3D navigation and related actions as most targeted end-users, i.e. teachers and educators, are not familiar with them.

- Accompanying or linking the authoring tool with a repository or samples of ready-made 3D objects and scenes for the users to edit and adapt should also be considered for future enhanced versions of the authoring tool. Similarly, the ability to drag and drop objects into the 3D scenes and the option to clone or make multiple copies of a whole lab are also desired features.

2.3.2 Analytics and visualization services

The analytics and visualization services offered were well-received by the teachers during the piloting tests since they are anticipated to assist them in refining or adjusting the teaching and learning process using virtual labs. Possible improvements in their initial design were suggested addressing the main functional difficulties like visibility. In general teachers preferred to have more commonly used visualization types such as bar charts and timelines instead of information-rich but difficult to interpret types as for example chord diagrams or force-directed graphs. In response to feedback from the first evaluation of phase the analytics and visualization services we propose the following requirements:

- Two separate categories of visualizations of analytics as standard and advanced options may be provided. The former category will include commonly used types (bar charts, timelines, simple histograms, matrix of actions etc.). The latter will contain less commonly used types (chord diagrams, force-directed graphs) with which end-users are not familiar.

- Overall visibility of the dashboard of graphs and their contents can be easily improved aesthetically (e.g. larger fonts in text and titles, arrangement of colors) in order to assist users to clearly comprehend the displayed information.

- Overall design may be more responsive in order to accommodate different screen resolutions without loss of content.

- Help and documentation can be provided as a separate tab or frame as part of the visualizations dashboard so that users, especially the novice or inexperienced ones, can easily get explanatory definitions, short clarifications and exemplified description of the displayed information.

- A basic graphical interface, which is appropriately and functionally arranged in separate frames or subtabs or menus, can be provided so that teachers could perform further analysis of the collected data, visualize historical data, change aggregation level, etc.

2.3.3 Virtual 3D Chemistry lab

ENVISAGE has included three virtual labs (entitled Building Inorganic Molecules, Naming Organic Molecules and Building Organic Molecules, respectively) which are related to the educational domain of Chemistry [3, 4]. They all were in 2D and currently are being further developed and transferred in 3D. In general, the labs were primarily designed as test and practice assignments for exams, preparation for thematic contest, progressive memory test/quiz for high-school students (ages 15-18). More frequent users may be students with inclination towards following chemistry, biology, medical studies or during preparation for university entry exams. All labs have fixed procedural sequence that students have to follow.

In order to guide and assist the development team in transferring to 3D and in further enhancing the existing Chemistry labs we propose the following functional and general design requirements:

- In general, possible improvements are expected mostly in aesthetics, and not in the content of the virtual labs, in order to make them more appealing and engaging for students.

- Also improvements may be in terms of available maximum trial attempts allowed per section, addition of help or guidance pop-up windows to assist students to progress.

- All labs have fixed and clear procedural sequence of user actions and consequently most appropriate metrics to implement are: time-on-task and time-to-completion (of the complete sequence or its subsections), percentage ratio of correct/incorrect answers, number of attempts to achieve correct answer.

- In this respect, the final score or marks are expected to be related to total number of molecules processed (positive marks), number or percentage of correct answers (positive marks), number of attempts before correct answer is reached (negative marks) and total time spent.

- The overall design of the lab and the game playing flow should accommodate various possible scenarios or use cases. For example, fixed time and predefined list of molecules (e.g. teacher preselects molecules to be in progressive difficulty and complexity), fixed time and whole list of available molecules same as above but without time constrains (perhaps as homework assignment), final exam test (e.g. in 45min to go through all labs and process a preselected list of molecules).

- We propose that two or more pre-existing labs, provided they are thematically related, can be combined in one virtual 3D environment in a form of a multi-staged game. In this way overall user progress through the various distinct stages may be more easily tracked and monitored.

- The main user actions can be inside a realistic 3D virtual environment that resembles the appearance of a physical lab. An example is depicted in Fig.2.1. This could better attract the interest and achieve the engagement of students and will motivate them to explore all aspects and actions requested. Besides they get familiarized with the procedures that they have to follow just like being in a real lab (e.g. safety and precaution measures, safe handling, storage and disposal of chemicals, safe operation of instruments etc).

- Emphasis should be given to avoid creating misconceptions to students, in general to end-users, in relation to operation of fictional instruments, handling of chemical substances etc. For example a virtual microscope that users can operate to investigate the structure of atoms or to build them is an attractive game-like feature, however this is only a fictional instrument than can create the misconception that atoms are visible microscopic objects. This can be avoided with properly placed explanatory notes or guidance material.

- In order to assist teachers in designing, developing or customizing their own chemistry virtual lab with the authoring tool we suggest that various preloaded 3D objects/assets can be provided such as test tubes, storage boxes, safety signs, protective clothing like eyeglasses, gloves etc.

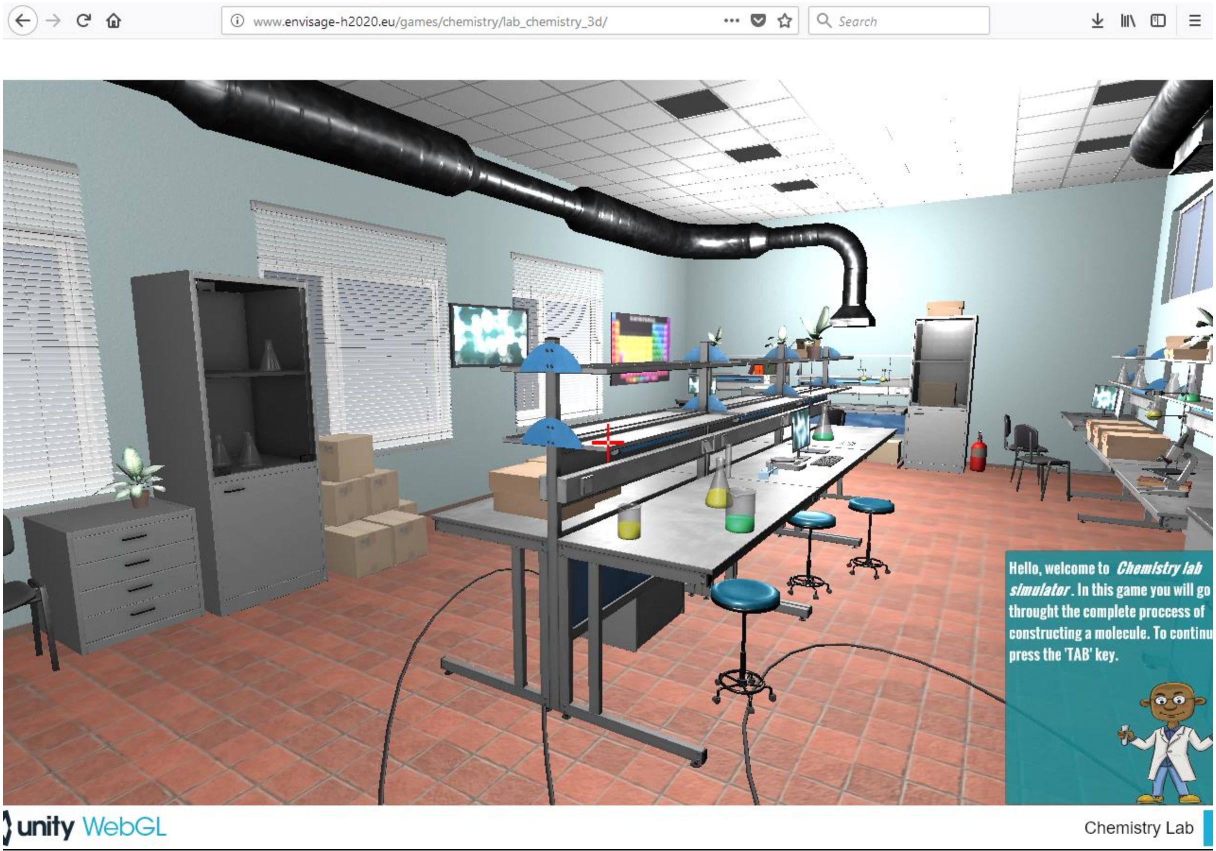

Figure 2.1 Example of initial design for the 3D environment of the Chemistry virtual lab of ENVISAGE.

2.3.4 Virtual 3D Wind Energy lab

Initially ENVISAGE worked also with the 2D version of the Wind Energy lab which was actually implemented in real classroom environment. A 3D version was then developed with which feedback from teachers was collected during the first piloting phase. In response to the evaluation results and also in light of the exploitation plan of the project, documented in D6.3 [5], EA and CERTH formed a development team that in close collaboration with teachers are designing an enhanced and elaborated version of the lab. This is planned to be piloted with teachers and students in classrooms during the second phase of evaluation. The overall design of the virtual lab is enriched with multiple stages, has a game-like multi-event flow, incorporates a wider spectrum of educational objectives in order to guide and motivate students to acquire concept and content knowledge about green and renewable energies in general, and wind energy farming in particular, sustainable development, cost effectiveness etc. The complete blueprint/design document is given in detail in the Appendix. This document is used to facilitate the communication and collaboration between the end-user, teacher or educational designer and the developers on all technical or not aspects of the game or virtual lab under development. It contains the subsections: Story – flow of events, Marks and performance calculation, Mechanics, Gameplay features, Aesthetics, Educational Purposes.

In the following we briefly list its main functional requirements:

- The main educational purpose of the virtual lab is students to familiarize themselves with the concepts of green and renewable energies in general, and wind energy farming in particular. To practically understand the notions of sustainable development, the related challenges and opportunities, the cost effectiveness of various decisions that should be made, etc.

- In this context, a virtual lab with a game-like structure of multiple stages with a flow of various events or decision steps is requested in order to provide a rich variety of different pathways that students can follow. Through the gameplay activity students learn and practice project preparation, planning, management and operation of a wind farm following a procedure that resembles the actions that engineers and scientists do in reality to find solutions in real-life problems or challenges. They also develop key competencies and skills such as critical innovative thinking and problem solving.

- The general concept of the game/virtual lab is that the student player selects the most appropriate area where he/she plans to install the wind farm taking into account all pros and cons (e.g. wind speed, proximity to area of archaeological site, proximity to area of natural reserve, proximity to high voltage power lines, proximity to main highway or port, available types of wind turbines). Then she has to operate the wind farm as efficiently as possible to satisfy the electrical power demand of a nearby city. She has also to respond to surprise future change of conditions.

- We propose the virtual lab to guide the users through the following flow of events or/and steps of decisions to be made: 1. Main instructions, 2. Selection of main area where a wind farm can be installed, e.g., mountains or plain-land or seashore with high, medium or low wind speeds respectively, 3. Selection of a subarea with most appropriate characteristics, e.g., cost, proximity to sites of interest, 4. Selection of wind turbine type with appropriate characteristics, 5. Operation of installed wind farm, 6. Initial score of performance, 7. Surprise scenarios.

- The 3D scenes and interactions therein should be laid out in a way that they can realistically depict real-life situations or challenges. They may contain various elements to enhance the user experience and engagement. The main elements are: 1. City or village, 2. Area of archaeological site, 3. Area of natural reserve, e.g. forest or lake, 4. High voltage power lines and pylons, 5. Main highway, 6. Sea port, 7. Free area close to mountains (with high wind speed) where the wind farm may be installed, 8. Free area close to e.g. city (with medium wind speed), 9. Free area-C close to e.g. sea shore (with low wind speed). The detailed proposed layouts are shown in the Appendix.

- In each selected area, the user can have the option to choose from a list of wind turbines with realistic specification parameters. A table with the proposed list is shown in the Appendix.

- After the main tasks of installation and operation of the wind farm, students are challenged to respond accordingly to a surprise phase that resembles possible future change of conditions or parameters that can affect their initial decisions (e.g., one case may be that in the future the power consumption of the village is much lower or higher than initially planned).

- With respect to the overall score, we propose that this will be related to the various economical costs of installation, operation of the wind farm given the selected area, the performance of energy generation in balance with the consumption and finally the extra positive or negative points the players gets during the surprise phases. A detailed score matrix following a PISA/OECD problem-solving competency scale is shown in the Appendix.

- The elaborated version of the Wind Energy lab is proposed to follow technically the templated structure that is compatible with the authoring tool, in order to assist teachers in designing, developing or customizing their own wind energy virtual lab.

Figure 2.2 Example of initial design for the entry page of the Wind Energy virtual lab of ENVISAGE.

3 Summary

We presented an updated compilation of requirements and prioritized recommendations in response of the first evaluations of the authoring tool, the analytics and visualization services, and the Wind Energy virtual lab. The reader is also reminded that the current document is an update of D1.2 – Data structure and functional requirements and so it followed a similar scope and structure. We first discussed the updated list of metrics which will be incorporated in the shallow and deep analytics services and related visualization tools. For the sake of completeness we then briefly mentioned the expected data structure and aggregation level for which there are not any changes proposed. Then we discussed the update of functional requirements of the various components (authoring tool, analytics and visualization services) in light of the evaluation results from the piloting tests. We finally presented the functional requirements for the combination of Chemistry labs and the details of an elaborated version of a multi-staged 3D virtual lab/game based on the Wind Energy Lab.

4 References

[1] ENVISAGE Deliverable D1.2 – Data structure and functional requirements http://mklab.iti.gr/envisage/lib/exe/fetch.php?media=d1.2_datastructurefunctionalrequirements_final_v5.0.pdf

[2] ENVISAGE Deliverable D5.2 – Implementation of the educational scenarios and evaluation report (first phase) http://mklab.iti.gr/envisage/lib/exe/fetch.php?media=d5.2_implementation_of_the_educational_scenarios_and_evaluation_report_final_version_v3.pdf

[3] ENVISAGE Deliverable D1.1 – Educational scenarios and stakeholder analysis http://mklab.iti.gr/envisage/lib/exe/fetch.php?media=d1.1-educational_scenarios_and_stakeholder_analysis-final.pdf

[4] ENVISAGE Deliverable D1.3 – Educational scenarios and stakeholder analysis (Update)

[5] ENVISAGE Deliverable D6.3 – Exploitation plan http://mklab.iti.gr/envisage/lib/exe/fetch.php?media=d6.3-exploitationplan-final.pdf

5 Appendix

Wind Energy Farm (elaborated version)

Virtual Lab/Game Design Document

What this document is about: *This document will be used so the player/end-user/teacher and the developer can communicate, and also gives the player the ability to express his ideas of how he wants the game to improve. This is only used to give you some guidelines of how to describe your game idea in paper.*

Story – flow of events: *Although the game does not have any specific story concerning characters or scenario, you can describe the events that happen in the game. More specifically I would give an example.*

1) *The player reaches for the first time the scene where he can control the wind farm.*
2) *The speed of the wind initially is 10 m/s and he must add turbines to match the required amounts of power needed.*
3) *After 2 minutes the speed of the wind drops and he must turn down some turbines to produce the desired amount of power.*

So try to follow this example and write extensively from the beginning to end how you would like the game story to flow. In case you find yourself stuck and unable to produce an idea about the story, remember that there is no problem at all and we will fill this gap and add ideas. After all, this section is about listing all your ideas about the story of the game.

Write the story (flow of events) here:

Event 1

The player launches the game and is asked to read carefully the instructions (Fig.5.1).

Event 2

The player explores the scene in order to identify the elements that are present. The main elements are:

1. City or village
2. Area of archaeological site
3. Area of natural reserve, e.g. forest or lake
4. High voltage power lines and pylons
5. Main highway
6. Sea port

7. Free area-A close to mountains (with high wind speed) where the wind farm may be installed

8. Free area-B close to e.g. city (with medium wind speed)

9. Free area-C close to e.g. sea shore (with low wind speed)

Event 3

The player selects an area (A or B or C) where he/she plans to install the wind farm taking into account all pros and cons (e.g. wind speed, proximity to area of archaeological site, proximity to area of natural reserve, proximity to high voltage power lines, proximity to main highway or port)

Event 4

The player starts installing wind turbines (he/she may have the option to choose from a list of 3 available types of wind turbines with fixed specifications as shown in Tab.5.1).

Event 5

The player starts the simulation (the simulation runs for a fixed time, say 3-5min, and corresponds to a typical day of power required by the village, and to a typical wind speed profile for the chosen area). During this event the player has to turn on/off turbines accordingly in order to be as much time as possible in "correctly-powered" state. The player may have the option to Replay the simulation (perhaps up to a fixed max number of iterations, e.g. 3 or 5)

Event 6

The player sees the overall score

Event 7 (this may be a new game or a continuation of the same game)

A surprise appears. For example, say after 5 years, in scenario 1 the power consumption of the village is much lower than initially planned because most of its residents left. The player is asked to consider what to do with the wind farm.

Option 1 Turn off completely the excess of wind turbines

Option 2 Keep the wind farm and sell the excess of power generated by connecting the wind farm with the main electricity grid/high voltage lines

Option 3 Do nothing. Keep everything as it is

Each option gives the player negative or positive score points

In scenario 2 the power consumption of the village area has been increased e.g. because of a large hotel resort near the sea shore or near the natural reserve.

The player is asked to consider what to do with the wind farm.

Option 1 Try to install more wind turbines in the same area

Option 2 Keep the wind farm as is and install a new wind farm (or even solar panels) in a new area.

Option 3 Do nothing. Keep everything as is

Each option gives the player negative or positive score points

Event 8

The player gets the overall score. The game is over

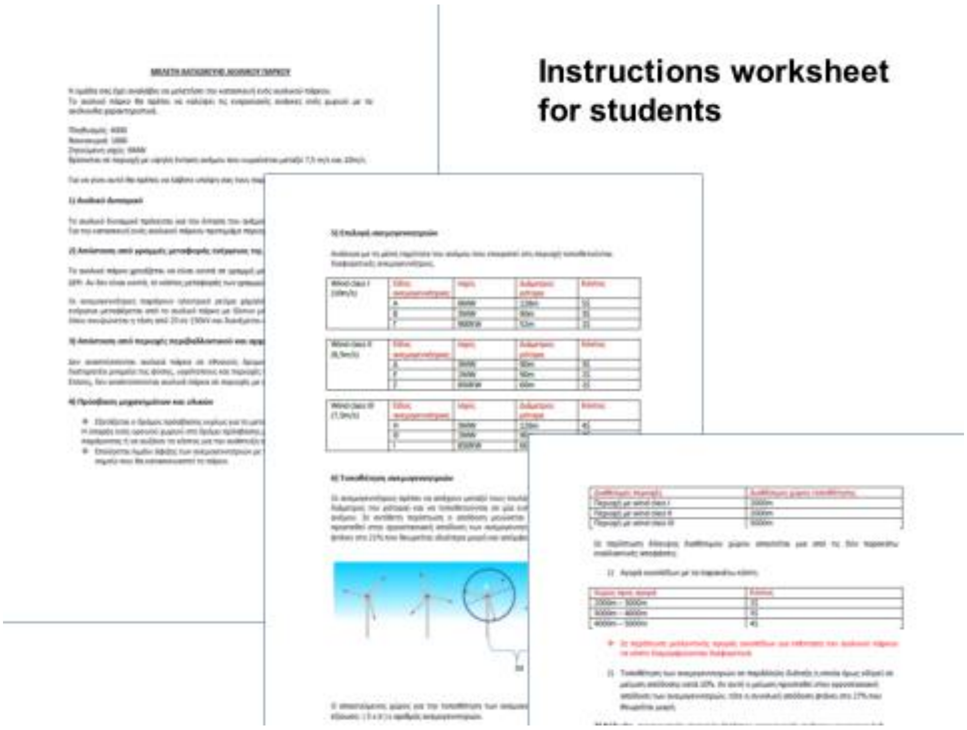

Figure 5.1 Sample of instructions worksheet for students.

Table 5.1 Depending on the average wind speed prevailing in the area and the available space, different wind turbines can be installed with the following specifications.

Wind class I (10m/s)	Type of wind turbine	Power	Rotor diameter	Cost
	A	6MW	128m	5$
	B	3MW	90m	3$

	C	900KW	52m	1$

Wind class II (8,5m/s)	Type of wind turbine	Power	Rotor diameter	Cost
	D	3MW	90m	3$
	E	2MW	90m	2$
	G	850KW	60m	1$

Wind class III (7,5m/s)	Type of wind turbine	Power	Rotor diameter	Cost
	G	3MW	126m	4$
	H	2MW	90m	2$
	I	850KW	60m	1$

Available areas	Available installation space
wind class I	2000m
wind class II	2000m
wind class III	3000m

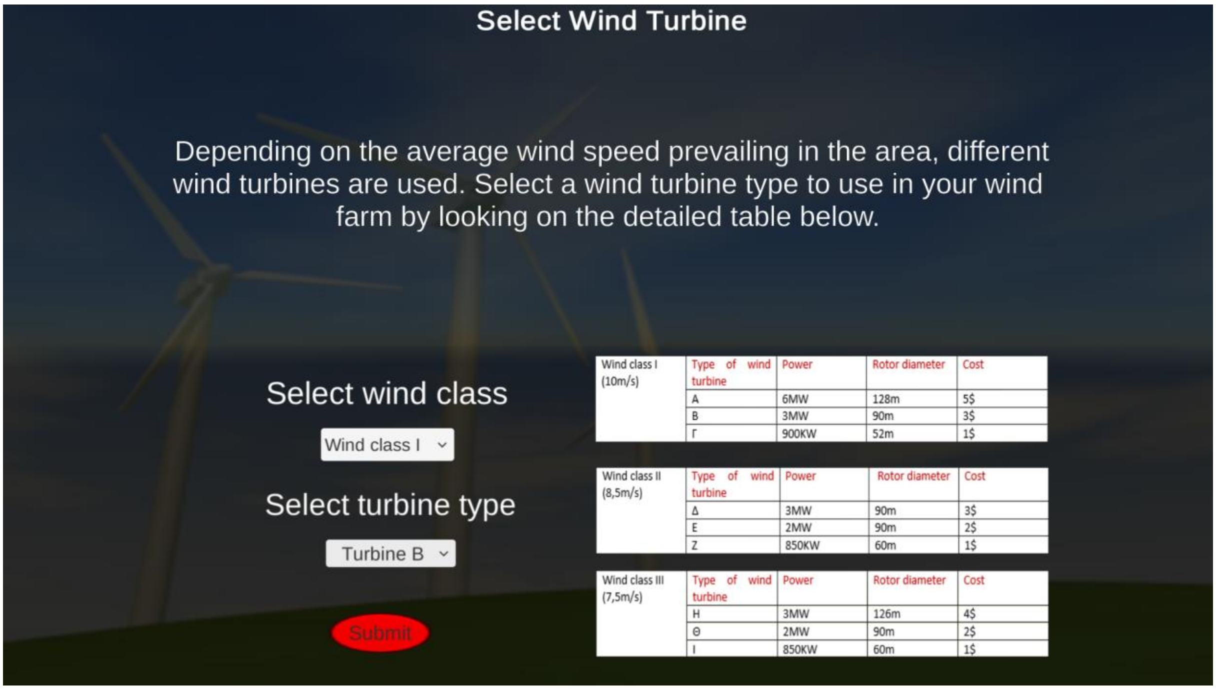

Figure 5.2 Example of initial design of graphical user interface for the selection of wind turbines.

Marks and performance calculation: *In case you would like the game to validate the player while playing based on his actions, try to describe this process in this section. Have in mind that will be very helpful if you could match this section with the story events of the game that you mentioned above. For example, in story event no.5 let's say where the player adds a new turbine to increase the general output you can describe the validation of the player that could take place.*

Describe the player validation and marks in the game:

The general idea is that the score will be related to the various economical costs of installation, operation of the wind farm given the selected area, the performance of energy generation in balance with the consumption and finally the extra positive or negative points the players gets during the surprise phase.

Figure 5.3 depicts the proposed matrix of the different costs for the various combination of possible main areas and subareas that the user can choose to install a wind energy farm. This is to be taken into account to calculate the overall performance score according to an overall marking scheme which is shown in Tab.5.2. In more detail, user can accumulate mark points (0, 1 or 2), depending on the selected option in each of the five different decision events (area selection, subarea selection, turbine type selection, response to first surprise, response to second surprise). The final total score is in the range from 0 up to 10 points. This is then mapped accordingly to a standard PISA/OECD scale of problem-solving competency level as follows: Low level for scores of 0 to 4, Medium/moderate level for scores of 5 to 8, High level for scores of 9 and 10. Depending on the resulting level at the end of the game the user receives a positive motivation message that encourages improvement.

Main area	Subarea	Cost due to access	Penalty cost due to proximity to archaelogical site	Penalty cost due to proximity to natural reserve	Cost due to distance from HV lines	Total	Comments
1	1	3	0	0	0	3	Area-1 is near mountains. It has dificult access. Its windclass is High (windspeeds 10m/sec)
1	2	3	0	0	2	5	
1	3	3	2	0	0	5	
1	4	3	2	0	2	7	
1	5	3	0	2	2	7	
2	1	2	0	0	0	2	Area-2 is near plain land. It has not difficult access. Its windclass is Medium (windspeeds 8.5m/sec)
2	2	2	0	0	2	4	
2	3	2	2	0	2	6	
2	4	2	0	2	0	4	
2	5	2	0	2	2	6	
3	1	1	0	0	0	1	Area-3 is near seashore. It has easy access due to port Its windclass is Low (windspeeds 7.5m/sec)
3	2	1	0	0	2	3	
3	3	1	2	0	0	3	
3	4	1	2	0	2	5	
3	5	1	0	2	0	3	
3	6	1	0	2	2	5	
3	7	1	2	2	0	5	
3	8	1	2	2	2	7	

Figure 5.3 Matrix showing the different costs for the various combination of possible main areas and subareas that the user can choose to install a wind energy farm. This is to be taken into account to calculate the overall performance score.

Table 5.2 Marking scheme depending on the user's selection in each of the different decision events (area selection, subarea selection, turbine type selection, response to first surprise, response surprise). The total is in the range from 0 up to 10 points.

SCORE1 – AREA SELECTION	SCORE2 – SUBAREA SELECTION	SCORE3 – TURBINE SELECTION	SCORE4 – SURPRISE1	SCORE5 – SURPRISE2
AREA1	SUBAREAS 1.1, 2.1, 3.1, 3.2, 3.3, 3.5	TURBINES A, D, G	ANSWER1	ANSWER1
AREA2	SUBAREAS 1.2, 1.3, 2.2, 2.4, 3.4, 3.6, 3.7	TURBINES B, E, H	ANSWER2	ANSWER2
AREA3	SUBAREAS 1.4, 1.5, 2.3, 2.5, 3.8	TURBINES C, F, I	ANSWER3	ANSWER3

= 2 points (blue)
= 1 points (green)
= 0 points (red)

Total = Score1+Score2+Score3+Score4+Score5

Mechanics: *When talking about mechanics in the wind energy lab we mean all the actions that the player can achieve. In other words, the current mechanics that are important are:*

- *Interaction with the turbine: The player can turn on/ off the turbine and repair it in case it breaks.*
- *Configuration of the physics of the game (wind, power requirements, simulation speed): The player can change the mentioned values through slides from the user interface of the game.*
- *Camera: The player can only rotate the camera around and is unable to move around.*
- *Added turbines to the scene: The player can add new turbines in the scene, and is unable to remove them.*

The above are the core mechanics of the game. To help us understand greater your perspective of how the game you want to improve you can describe what types of mechanics you want the game to have. Remember to mention all mechanics, even the ones that already exist.

Describe the mechanics of the game here:

- Interaction with the turbine: The player can turn on/ off the turbine and repair it in case it breaks.
- Configuration of the physics of the game: (wind speed, power requirements, simulation speed may be fixed to run up to 3-5min before it can be repeated if needed). The master player/teacher may change the starting configuration of parameters or main settings through the authoring tool.
- Camera: The player can rotate the camera and to move around the scene
- Added turbines to the scene: The player can add/turn on turbines in the scene, and is unable to remove them. The master player/teacher may change the arrangement of positions through the authoring tool.

Gameplay features

Installing a wind farm: *In our last communication we concluded that we should add a new element in the game and that's installing a wind farm to a location that matches some criteria.*

So because the "installation of the wind farm" will be the first part of the game, we would like you to describe how you want this new feature in the game to be developed.

Please describe extensively the process that a player must follow to install a wind farm:

For more details consult story section – event flow mentioned above

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Controlling the wind farm: *Although this gameplay feature is already developed, the insertion of the wind farm installation feature may change how the wind farm will be controlled.*

Describe any changes that may need to be applied in how the player controls the wind farm:

At this moment of development of the game story and events we do not foresee any further control features

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Aesthetics: *By Aesthetics we mean everything that you see in the game. Because how the game "looks" is a very important factor. To make the player dive greater in the experience of the game, we would like you to give us your thoughts about this issue. More specifically, the game already has its own look and feel, however this can easily be changed to match your criteria.*

Describe how you would like the game to look (e.g. an onshore wind farm, with hills and a small city in the background):

In the scene we consider to have the following main elements:

1. City or village
2. Area of archaeological site
3. Area of natural reserve, e.g. forest or lake
4. High voltage power lines and pylons
5. Main highway
6. Sea port
7. Free area-A close to mountains (with high wind speed) where the wind farm may be installed
8. Free area-B close to e.g. city (with medium wind speed)
9. Free area-C close to e.g. sea shore (with low wind speed)

A position distribution of these elements in each 3d scene is shown in Fig.5.4, 5.5 and 5.6 for the three corresponding main areas of high, medium and low wind-speed respectively. Figs.5.7, 5.8 and 5.9 depict initial designs of the 3D virtual scenes of the three main areas and wherein the user can select predefined subareas.

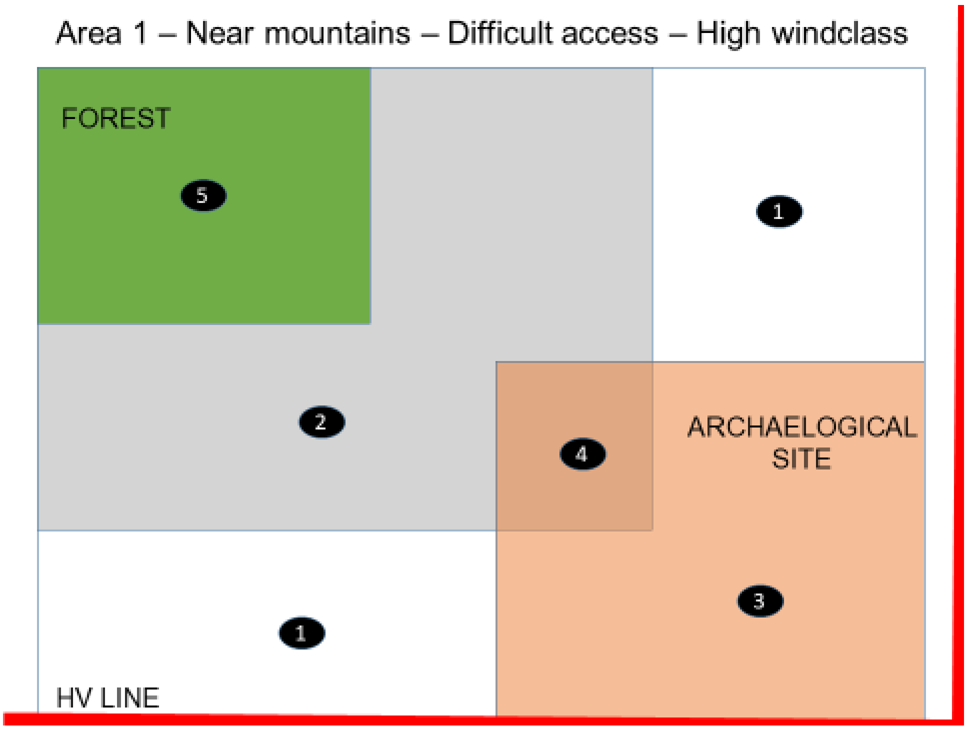

Figure 5.4 Proposed layout of the first main area of wind-class-I and position of the five possible subareas that the user can choose to install a wind energy farm.

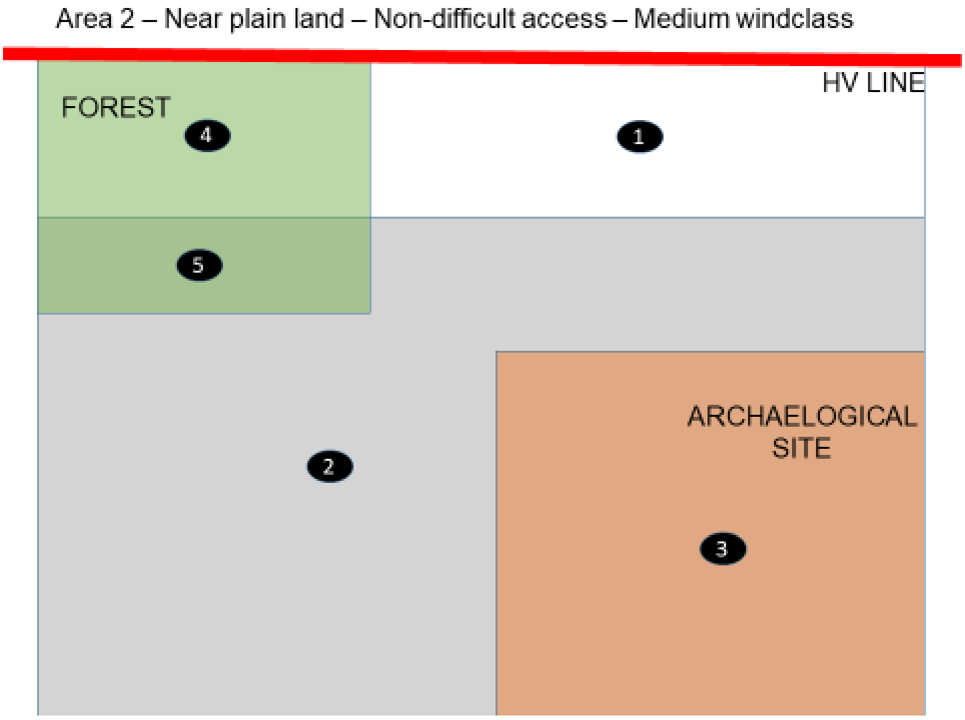

Figure 5.5 Proposed layout of the second main area of wind-class-II and position of the five possible subareas that the user can choose to install a wind energy farm.

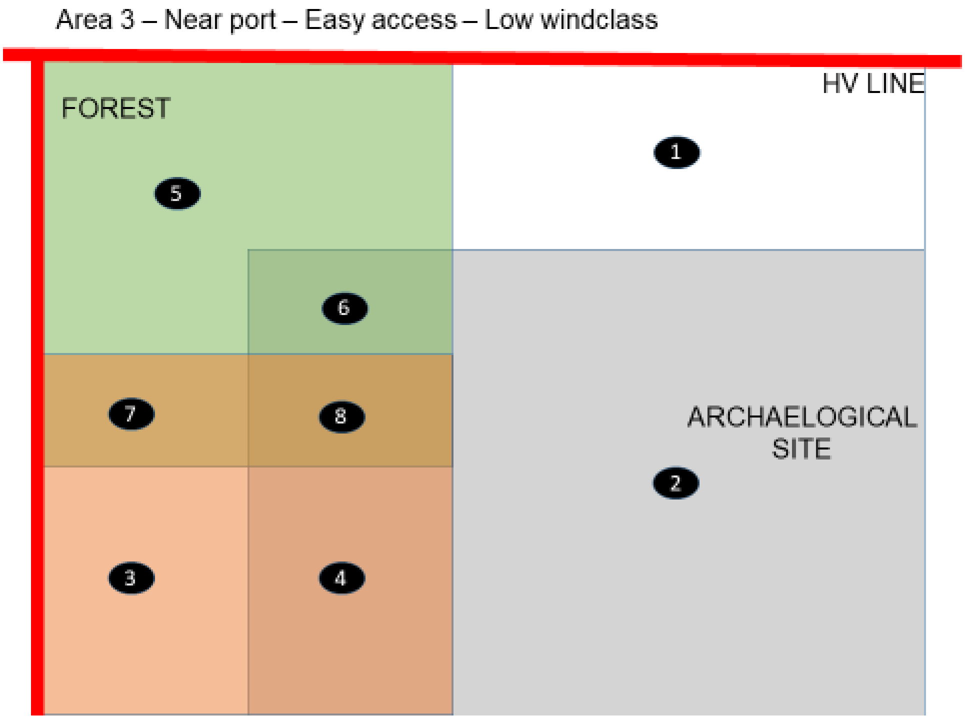

Figure 5.6 Proposed layout of the third main area of wind-class-III and position of the eight possible subareas that the user can choose to install a wind energy farm.

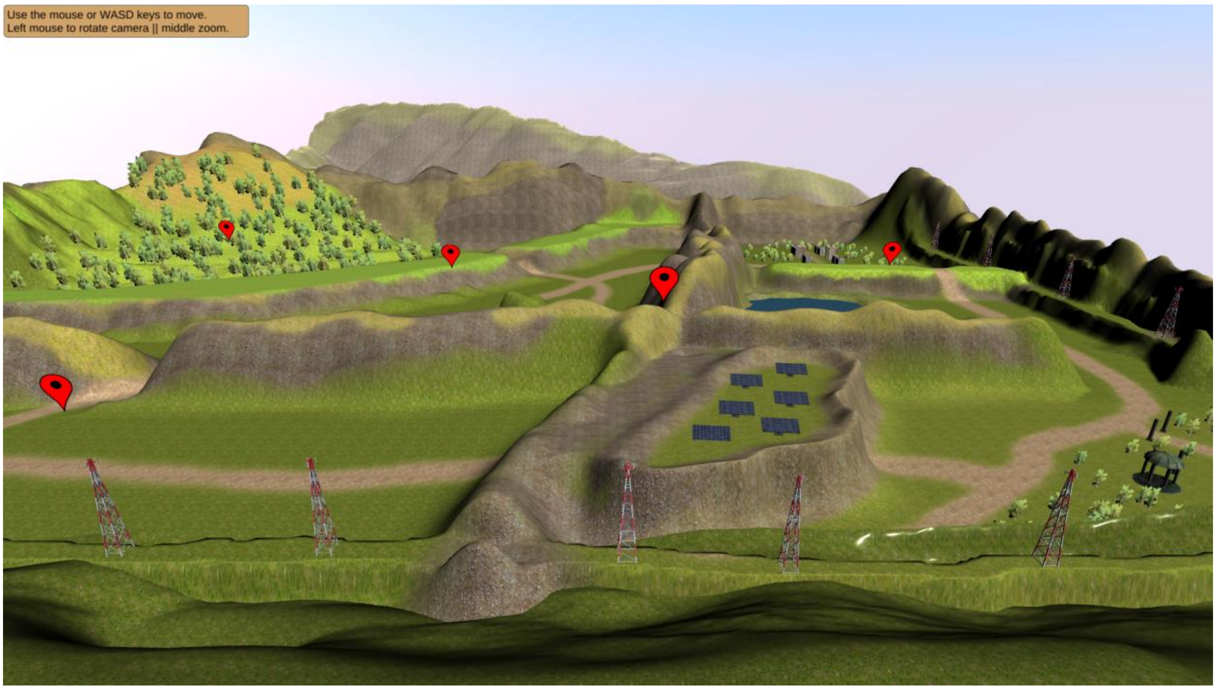

Figure 5.7 Initial design in 3D of the first main area of wind-class-I and position of the possible subareas that the user can choose to install a wind energy farm.

Figure 5.8 Initial design in 3D of the second main area of wind-class-II and position of the possible subareas that the user can choose to install a wind energy farm.

Figure 5.9 Initial designs in 3D of a subarea of the first main area of wind-class-I (left) and of third main area of wind-class-III (right).

Educational Purpose

Describe how and where the game will be used.

Concerning "where" we mean inside class or as an exercise game in home
Concerning "How" we may mean, students will use the game in team on one computer, or every student individually. And also if students will use the game itself or any other extra tools (e.g. an assignments given by the teacher).

Describe the "how" and "where" elements of the game:

Concerning "where", the game will be used primarily in school classes by students. It may also be used by teachers during training workshops.

Concerning "how", the game will be used primarily by students individually. In cases that this is not possible due to constraints in available access devices then the game may be used by small group of players, of about 2-3 persons max.

The game will be used as part of assignment given by the teacher.

Mention all the scientific and general knowledge upon the field of wind energy and wind farms that the student you would like to acquire by finishing the game:

The main educational purpose of the game is students to acquire concept and content knowledge about green and renewable energies in general, and wind energy farming in particular, sustainable development, cost effectiveness etc.

Through this gameplay activity students learn the basic notions of project preparation, planning, management and operation of a wind farm following a procedure that resembles the actions that engineers and scientists do in reality to find solutions in real-life problems or challenges.

The students also develop and practice key competencies and skills such as critical thinking, creativity, innovative thinking, problem solving.

Also as they may work in groups to perform the assigned mission as part of a wider project assignment they practice and develop their skills of collaboration, communication, presentation during or at the end of the game.

Surprise feature

According to Event 7 in the event flow mentioned above we consider this feature that may be a new game or a continuation of the same game or a new phase or stage incorporated in the same game.