



Title: Wind turbine functionality

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Subject title: Renewable Energy Sources

Grade: 3rd or 4th grade

Level of performance complexity: medium

Research method: problem-based

Stages of the research method:

determining the initial and known state, asking problem questions, choosing the way to solve the problem, finding the necessary data, presentation of research results

Key words:

renewable energy sources, wind energy, wind potential, types / parts of turbines

Correlations, interdisciplinarity and cross-curricular topics (CCT):

Power Electronics, Power Engineering, Technical Mechanics, Machine Elements, CCT: Learning to Learn, Personal and Social Development, Use of ICT and Sustainable Development

Learning outcomes:

- recognize the potential of wind as an energy source **(A, B, C, D)**
- explore and collect data on the concepts, sizes and parameters for a given problem task - the functionality of wind turbines **(A, B, C)**
- process data obtained by research **(B, C)**
- interpret issues and research results **(C, D)**

Cross-Curricular topics expectations:

Learn how to learn:

- Information management; The student independently seeks new information from various sources, transforms it into new knowledge and successfully applies it in solving problems.
- Precisely defines the problem and all its elements, 2. Applies and tests different strategies and selects those that will effectively lead to a quality solution, 3. Critically analyses the problem-solving process and identifies opportunities to use newly acquired knowledge and skills in other situations.
- Planning; The student independently determines the learning goals, chooses the approach to learning and plans the learning.
- Self-evaluation / self-assessment; The student self-evaluates the learning process and its results, assesses the progress made and plans future learning based on that.

Personal and social development:

- He manages his educational and professional path.
- Collaborative learns and works in a team.
- Collaborates, organizes, performs its task, sets hypotheses, develops its role in the team, makes decisions.

Use of ICT:

- The student analytically decides on the selection of the appropriate digital technology.
- The student takes responsibility for their own security in the digital environment and the construction of a digital identity.
- The student independently conducts complex research with the help of ICT.
- The student independently and responsibly manages the collected information.
- The student independently or in collaboration with colleagues presents, creates and shares new ones.
- The student independently or in collaboration with others creates new content and ideas or reshapes existing digital solutions by applying different ways to encourage creativity.
- The student presents, creates and shares ideas and works on a complex topic with the help of ICT.

Sustainable development:

- He critically considers the connection between his own way of life and the impact on the environment and people.
- He thinks critically about the impact of our actions on Earth and humanity.
- It designs and uses innovative and creative forms of action with the aim of sustainability.
- It suggests ways to improve personal and general well-being.

Evaluations:

For learning:

- input and output card **(A, D)**
- supervision of students by professors during work **(A, B, C, D)**
- presentation of research by students **(C)**

As learning:

- comparing other students problem solutions with one's own **(B, C, D)**
- assessment of one's own and others' work and team work (peer evaluation and self-evaluation) **(B, C)**
- discussion of students with other students and the teacher **(A, B, C, D)**

Learned:

- analysis of students' research work **(C, D)**
- presentation skills of students **(C)**

Activity description:

A Introductory lecture, discussion and defining the problem situation

The teacher begins the lecture by distributing a short questionnaire entitled 'True or False?', in order to interest the student in the teaching unit 'Wind Potential' and, accordingly, the problem task.

'True or False?'

Answer to the statements made with a tick below the appropriate letter; T (True) if you agree with the statement or F (False) if you do not agree with the statement.

Numb.	Statements	T (True)	F (False)
1.	Wind energy is a new way of using energy.		
2.	Wind turbines look simple but are complex devices.		
3.	Some of the wind turbines reach higher heights than the Sydney Opera House (65m), which is located in Australia.		
4.	Wind turbines are becoming ever taller devices.		
5.	Wind turbines do not create new business opportunities.		
6.	Wind as a source of energy can power the whole world.		
7.	Wind energy is becoming more expensive.		
8.	Wind turbines do not function in accordance with the ecological environment in which they are located (they destroy nature and harm animals).		
9.	Wind turbines are loud devices.		
10.	Wind turbines are the fastest growing renewable energy technology in the world.		

With this introduction, students are encouraged to think about the potential of wind as a renewable energy source. They think about what they have learned and what is not yet clear to them, and the teacher's task is to discuss with them each of the above statements and why it would be considered true or false.

After the introductory discussion and the students' interest in the unit, the teacher gives a short lecture entitled 'Wind potential', which can be found at the following link:

<https://windeurope.org/about-wind/>

The aim of the lecture is to further inform students about the topic of problem-based teaching: maintenance of wind turbines with which the potential of wind can be used in the activities of everyday life. Students are encouraged to ask as many questions as possible during the lecture in order to clarify possible unclear facts.

After independent learning activity, the problem scenario (task) is presented as:

'You have been placed in the position of shift manager of wind turbine maintainers at a remote location. Your superiors want a complete check of the functionality of the wind turbine to prevent a breakdown due to sudden gusts of wind. How will you determine the course of implementation of the functionality check in terms of financial, material and human resources? What steps will you take to ensure that the functionality check is secure? What problems do you expect?'

As the last stage of the introductory lecture, students are given a table to summarize the knowledge gained and previously learned, which is presented as follows:

What did I learn?	
What did I know before?	
What do I have to repeat?	
What is unclear to me?	

In this way, the teacher has the opportunity to act in a timely manner in the event that there are significant deficiencies in knowledge, which would be an obstacle to the implementation of problem-based teaching.

B Collection and exchange of information - individual and group work

After the introductory lecture, students were encouraged to solve the problem scenario, first through independent and later through group work.

Students' independent work consists of conscientious preparation for group work and will be carried out in two stages: reading a scientific article detailing all components of wind turbines and their maintenance, which can be found at the following links:

- https://www.uniper.energy/services/sectors/renewables/wind?gclid=EAIaIQobChMIzdeRwMba7wIV4wyLCh3vRAwcEAAAYASAAEgJF1vD_BwE (Wind Farm Solutions)
- <https://www.power-eng.com/renewables/wind-turbine-lubrication-and-maintenance-protecting-investments/#gref> (Wind Turbine Lubrication and Maintenance: Protecting Investments in Renewable Energy).

Students are also encouraged to find their own sources, which need to be pre-checked with the teacher to avoid the use of unverified or inaccurate information.

During the reading, students fill in the tables to make it easier to summarize the information found, which will help them come up with a solution to the problem situation.

Base	
Construction components	Maintenance method
Tower	
Construction components	Maintenance method

Blades	
Construction components	Maintenance method

In this part of the class, students are encouraged to 'storm the ideas' in order to better and more fully respond to the required problem situation. At the same time, the teacher is encouraged to continuously guide students and review the following:

- **Are learning outcomes clear to students?**
- **Are there pitfalls that students need to be warned about?**
- **What confuses them?**
- **Should something be explained to all students?**
- **What are the key questions of the students?**

After independent work, students present their ideas within selected groups. It should be emphasized that this type of teaching is more demanding on students with difficulties in learning and mastering the material, since it requires more significant autonomy compared to regular or research teaching. The must strive towards the proper distribution of students in groups according to their level of knowledge, which will be carried out with the intention of matching students with disabilities with gifted students. Students are divided into three groups, and after the division, they have the opportunity to change them in case they strongly disagree with the assigned group. Then the teacher adjusts the group dynamics, taking into account the talent / willingness of different students to work all the time.

Group work consists of combining possible solutions of all members of the group until a consensus is reached: students have decided on one of the solutions to the problem that they consider sufficient and which they will present to the rest of the class, or other groups.

C Preparation of presentations and presentation of solutions - peer and teacher evaluation

Prior to presenting the solutions of the groups, the teacher draws the students' attention to the basic criteria by which they will evaluate the presentation of their work, which are shown in the following table:

Evaluation table for teachers

Evaluation criteria	Poor (0 points)	Average (1 point)	Excelled (2 points)	Score by group				
				1.	2.	3.	4.	5.
PPP length:	<i>less than 10 slides</i>	<i>more than 10 slides</i>	<i>10 slides</i>					
Title slide:	<i>No title or author names.</i>	<i>It contains the title, name and surname of the authors.</i>	<i>It contains the title, name and surname of the authors, name of the institution, place and date of the presentation.</i>					
Introduction:	<i>The student did not introduce himself and the topic at the beginning of the presentation..</i>	<i>The student presented the topic, but not himself.</i>	<i>The student clearly presented himself and the topic of the presentation.</i>					
Content display:	<i>Too much text on slides, too many different fonts, too many different animations. Dark or crowded background.</i>	<i>Some slides are readable, but some are difficult because the font size is small, the paragraphs are too long, or there is a lack of contrast with the background.</i>	<i>The text on each slide is of appropriate length, clues are used. Fonts are easy to read and the size is different for titles and text. The background and colour of the text enhance the readability of the text.</i>					
Images:	<i>No pictures.</i>	<i>Images are not intended to clarify text.</i>	<i>The images are well chosen and support the basic message.</i>					
Content knowledge:	<i>The content is presented in an uncertain and confusing way. The presenter looked at the notes, monitor, or canvas most of the time.</i>	<i>The content is presented in an understandable way, but a lack of self-confidence is seen in some parts of the presentation. Occasionally looks at notes, monitor, or canvas.</i>	<i>The presentation was easy to follow, the content was presented with certainty, in a clear and understandable way. He rarely uses notes, monitor or canvas.</i>					
Voice, volume:	<i>Quiet voice and / or insufficient emphasis, monotonous and boring.</i>	<i>The presenter is well heard in class. Some words and information are highlighted as important.</i>	<i>The presenter is well heard, tries to emphasize everything that is important for understanding the presentation, uses different volume.</i>					
Communicating with the audience:	<i>No class involvement.</i>	<i>Limited class involvement, 1-2 questions asked.</i>	<i>The class asks appropriate questions and actively participates.</i>					
			Total points: X / 16					

After group discussions and reaching a uniform group solution, students are encouraged to share them with the rest of the class in order to open a discussion, which will be guided by the teacher. Given that within the presentation 'Instructions for students', which was conducted by the teacher as part of the introductory lecture, it was clearly emphasized that there are no wrong solutions to the problem situation, students have the freedom to present their thoughts at their own discretion. Each group has enough time to present, after which the other groups must ask at least one question per member and comment on the presented solution as a whole. The groups choose their representative who represents the same solution, but during the class discussion and answering the questions the whole group participates. To facilitate the discussion, the students were presented with an evaluation table as follows:

Evaluation table for students

Research group:		
Scoring elements	Points range	Points awarded
<i>The research information is presented in an understandable and interesting way.</i>	1-5	
<i>The research information is relevant.</i>	1-5	
<i>The group answered a research question.</i>	1-5	
<i>Overall impression of the research group.</i>	1-5	
Total number of points of the research group:		

D**Exchange of experience and reflection**

The exchange of students' experiences is based on their comprehensive impression of the problem type of teaching and the amount of material adopted within the given deadline. Students are encouraged to take a short online survey via the 'Survey Legends' digital platform (<https://www.surveylegend.com>), which contains the following:

Survey Questions	
How is wind created?	
How is wind energy used?	
Write the equation of wind energy and power!	
List at least 5 wind turbines in Europe!	

Self-evaluation:

Rate your independent work!	1.	2.	3.	4.	5.
Evaluate your preparation for group work!					
Evaluate the work of your group!					
Do you think your group worked well together?					
Do you think that the opinions of all members of the group were taken into account?					
Would you change your group's solutions?					
Do you think you have adopted the teaching unit?					
Which you especially liked about the problem-based teaching?					
What did you not like about the problem-based teaching?					

The results of the survey give a direct picture to the teacher about the quality of teaching and student satisfaction with group and individual work.

The teacher completes the problem-based teaching by showing a YouTube video of a young engineer engaged in the maintenance of wind turbines on the high seas. The video can be found at the following link:

<https://www.youtube.com/watch?v=vfUhBKZR4sU&t=1s>

The goal of the video is to awaken additional motivation of students to improve in only seemingly complicated concepts.

Additional literature, content and links:

Students can be introduced to relevant sources of information, which include the following links:

- „International Energy Agency – Wind“, <https://www.iea.org/fuels-and-technologies/wind>
- „Britannica - Wind“, <https://www.britannica.com/science/wind>
- YouTube channel: DTU Wind Energy, <https://www.youtube.com/watch?v=P9SyZvHrJvc&t=17s>

Students are also encouraged to independently find sources they deem relevant, including books, articles, videos, etc. Each source of information must be listed and used under teacher supervision.

Also, students can be introduced to links with which they can learn more about how to successfully present their presentation, which include the following links:

- „Top Tips for Effective Presentations“, <https://www.skillsyouneed.com/present/presentation-tips.html>
- „How to Give a Killer presentation“, Harvard Business School, <https://hbr.org/2013/06/how-to-give-a-killer-presentation>
- „Easy 3 Step Method To Awesome Presentation Content“, <https://www.youtube.com/watch?v=jOYH8aWB-6Q>

Support procedures

Before performing activities, students with disabilities need to be explained in detail how to work and check their understanding of the same. By agreement, students are provided with sufficient time and are in no way limited in time. The teacher selects the groups in such a way as to provide students with disabilities with a friendly and pleasant environment within which they work with more gifted peers who continuously guide and help them.

All gifted students who express interest in the topic of research teaching are provided with independent work, ie additional research on the following concepts: additional economic analysis of the implementation of wind turbine maintenance and differences in wind turbine maintenance on land and offshore (analysis of the difference between wind speeds and directions, the impact of waves and environmental aspects).