Physics Learning Tasks for Students with Special Educational Needs: Disabled and Gifted

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Abstract
The educational development of every individual student seems to be a future imperative also in physics education. Each student can be considered as a learner with special educational needs. A physics learning task is one of the most effective educational instruments in physics education. Disabled and gifted students are students with special educational needs. Disabled students with specific learning disabilities meet many problems when they solve physics learning tasks. That is why effectiveness of physics educational process decreases. The study presents research results of concrete symptoms of Specific Learning Disabilities during the solving of physics learning tasks. The research outcomes are presented in the form of the list of symptoms of these disabilities and examples of symptoms from a case study of a student with dyscalculia. Innovations of learning tasks for disabled students are presented as therapy including compensatory aids for the solving of physics learning tasks. Physics learning tasks for gifted students should be presented in a special form useful for a development of this giftedness. Cognitive motivation is an important part of the student’s giftedness. The study presents research results of physics learning tasks for gifted students based on the motivational factor analysis in physics education. Physics experiments strongly motivate ungifted and gifted students. A physics learning task based on an experiment has a strong motivational influence. This kind of learning tasks is unfortunately rare in physics education. Special forms of these learning tasks were created: problem physics learning tasks, play physics learning tasks and modification physics learning tasks. Learning tasks based on physics experiment can be widely used within all teaching phases. These physics learning tasks upgrade students’ motivation and should be used for development of giftedness.

1 Introduction
Many students have educational problems. A future imperative in education seems to be the individual educational development of every student. Each student can be considered as a learner with special educational needs. We should prepare an appropriate educational technology also in science and physics education. This study tries to open the problem of individual approach in development of every student in physics and in science education.

2 Physics learning tasks
Learning tasks are very important educational and also motivational tools in physics education. Not every learning task can be an effective educational stimulus. Talyzinova said: “...without problems, without tasks, neither skills nor knowledge can be acquired” (Talyzinova, 1988, p. 76). We define the learning task as a specific requirement set to students. Learning tasks have specific forms. Elementary tasks demand only memory reproduction of knowledge. Complicated tasks call for creative thinking. Learning tasks perform different roles in education. These roles are primarily linked to the teaching phase: motivation, exposition, fixation, diagnostics and application (Vaculová, Trna & Janík, 2008).

We can use more sorts criteria such as: the level of calculations during task solution (quantitative and qualitative learning tasks), the form of setting and solution (verbal,
numerical, graphic and experimental learning tasks), and the teaching phase (motivational, expository, fixation, diagnostics and application learning tasks). Tollingerova classified learning tasks on the basis of Bloom taxonomy into five categories. The sort criterion is difficulty of cognitive operations needed for learning task solution (Tollingerova, 1970):

- Learning tasks demanding memory reproduction of knowledge when students use memory operations
- Learning tasks demanding simple mental operations with knowledge such as analysis, synthesis, comparison, and categorization
- Learning tasks demanding complicated mental operations with knowledge such as induction, deduction, interpretation, transformation, and verification
- Learning tasks demanding knowledge interpretation when students interpret not only the results of their own solution but also its progress, conditions and phases
- Learning tasks demanding creative thinking based on the previous operations, ability to combine these operations into wider complexes and come to new solutions

Physics learning tasks play an important role in physics education, but also in teaching/learning of students with special educational needs: especially disabled and gifted.

3 Specific learning disabilities in physics education

Most frequent specific learning disabilities in physics education are:

- Dyslexia
- Dysgraphia
- Dyscalculia
- Combined disabilities - e.g. syndrome ADHD - Attention Deficit Hyperactivity Disorder which often co-exist of hyperactivity and attentional fatigue (Biederman, 1998)

We focus on dyscalculia in this study.

Dyscalculia is defined as a genetically-linked learning disability which affects a person's ability to understand, remember, or manipulate numbers or number facts (Dehaene, 1997). The term is often used to refer specifically to the inability to perform arithmetic operations, but it is also defined as a more fundamental inability to conceptualize numbers as abstract concepts of comparative quantities. Exteriorization of dyscalculia has these forms:

- Inability to read a sequence of numbers (e.g. turning 23 into 32)
- Difficulties with arithmetic (e.g. confusing the signs: +, -, / and x)
- Difficulty with tables and mental arithmetic
- Difficulty with measurement guessing (e.g. distance )
- Inability to acquire sequences, mathematical concepts and formulae
- A phobia of mathematics topics and coherences in extreme stage

Students with dyscalculia can be endowed with over-sensitivity to noise, light, and smell. On the other hand they are not able to filter and tune out unwanted impressions. They might have a well-developed sense of imagination, possibly as cognitive compensation to mathematical disability.

4 Physics learning tasks for students with specific learning disabilities

Students with specific learning disabilities meet a lot of problems when they solve learning tasks in physics education. That is why the effectiveness of the educational process dramatically decreases.

Our research outcomes are presented in the form of the list of symptoms of dyscalculia disability and examples of symptoms from case study of the student with dyscalculia.
Innovations of physics learning tasks for these students are demonstrated as therapy including compensatory aids for the solving of physics learning tasks.

We present three examples of the solving of physics learning task from one student. His name is Ondrej. We studied his development of his solving of physics learning task during three years. This case study covered his age from 13 to 15 years:

**Example 1 (eighth grade)**

Calculate the lifting force which upholds a body with a volume of 0.05 m³ in air. The air density is 1.3 kg/m³.

![Figure 1. Lifting force](image)

**Example 2 (early ninth grade)**

An iron body of mass 540 g and temperature of 15 °C was put into a heating furnace of 600 °C. Calculate the accumulated heat.

![Figure 2. Accumulation of heat](image)
Example 3 (late ninth grade)
What was the heat loss of 3 kg water, if the water temperature changed from 90 °C to 25 °C?
What work was done by a lift truck, if a box of mass 300 kg was taken up to the height of 2 m?

\[ Q = m \cdot \Delta T = (3 \cdot 10^{-3} \text{ kg}) \cdot (25 - 90) \]

\[ Q = 3 \cdot 10^{-3} \text{ kg} \cdot 90 \cdot \frac{\text{J}}{\text{kg} \cdot \text{°C}} \]

\[ Q = 270 \text{ J} \]

\[ W = m \cdot g \cdot h = (3 \cdot 10^{-3} \text{ kg}) \cdot 9.8 \cdot 2 \text{ m} \]

\[ W = 58.8 \text{ J} \]

Figure 3. Heat and work

The students’ main problems with dyscalculia when he solved physics learning tasks were:
- Difficulties with arithmetic
- Difficulties with conversion of physics units
- Difficulties with data processing
- Inability to remember and use of physics-mathematics concepts, rules and formulae
- Difficulties with self-reflection of the solving of a physics learning task
- Inability to explain the solution of a learning task

An open question is to find the “therapy” which leads to students’ success in the solving of physics learning tasks. No common therapy for dyscalculia has been properly verified to be effective (Henderson, Came & Brough, 2003). Our proposal of educational therapy in the form of teaching/learning methods/strategies is:
- To provide disabled students with the solution of a physics learning task as an example
- To provide disabled students with special aids such as a structured overview of formulae and units, aids for the conversion of physics units etc.
- To use a simple and transparent graphic form of given physics learning tasks
- To limit the time needed for solving of physics learning tasks
- To use more qualitative, verbal, graphic and experimental learning tasks

We identify a set of research questions for our future research and development activities:
- To discover typical and frequent problems of disabled students in process the solving of learning tasks
- To study cognitive structures of understanding of physics formula by disabled students
- To state rules for diagnosis and evaluation of knowledge/skills of disabled students
- To produce compensating aids for disabled students

5 Giftedness in physics education
Gifted students are also students with special educational needs in physics education (Amatrong, 1998). Cognitive motivation is an important part of the student’s giftedness.
Specific learning tasks suitable for development of giftedness should be created. We discovered that a physics learning task based on an experiment has a strong cognitive motivational influence for gifted students. That is why the educational application of this type of physics learning tasks is important for development of gifted students. Physics learning tasks based on an experiment are unfortunately rare in physics education.

6 Physics learning tasks for gifted students
Three specific kinds of learning tasks based on an experiment for gifted students were created: problem physics learning tasks, play physics learning tasks and modification physics learning tasks. These physics learning tasks combine together and upgrade students’ cognitive motivation and should be used for development of giftedness.

6.1 Physics learning tasks for gifted students - problem physics learning tasks
Problem based teaching is a significant innovation of science and physics education. Motivational effectiveness of problem learning tasks results from increasing students’ cognitive needs and their consequent satisfying by way of students’ active cognitive working (Trna & Trnova, 2006). Psychological base of increasing cognitive needs is “perception and conceptual conflict” (Berlyne, 1997). This conflict becomes an incentive which causes strong motivation and thus students become active which heads towards conflict elimination and satisfaction of the need. An induction of that conflict has several variants:
- Surprise
- Paradox
- Doubt
- Uncertainty
- Difficulty
An example of problem physics learning tasks follows (Trna, 2008):

**Problem cylinder**
We glue a coin on the base of a polystyrene cylinder. The coin has the same diameter as the cylinder. Height of the polystyrene cylinder will be adapted so that only the coin extends from the surface of the water. We turn the cylinder coin down and place it in the water again. How deep will the cylinder with the coin dip?
(a) the height of an extending polystyrene is the same as the height of the coin
(b) polystyrene will not extend from the surface since the coin pulls it to the bottom
(c) the higher part of polystyrene than the coin will extend from the surface

**Correct solution of physics learning task:** (a) This is about Archimedes’ principle application. Weight of the cylinder does not change during turning and therefore buoyant force and volume of the sunken part of the cylinder will be the same.

![Figure 4. Problem cylinder](image-url)
6.2 Physics learning tasks for gifted students - play physics learning tasks
We define a toy as an object which displays a feature that is remarkably emphasized (elasticity, colour, distinctive behaviour etc.). The toy in the role of hands-on activity stimulates the needs to have sense and muscle activities. The relaxation function of the play is also remarkable. There are many toys manufactured commercially but students can create their own. We can form the play learning task (to discover a principle of the toy etc.) and apply it to gifted students. An example of play physics learning tasks follows (Trna, 2007):

**Balance on a surface:** We put a high block of polystyrene on the water surface in a vessel with its big sidewall. The block in a stable position is lying on the surface. Then we sink a load (screw, nut etc.) into the centre of a small base of the second block, same as the first one. If we put the second block with its big sidewall down on the water surface, it surprisingly stands up on its small base. Explain the base of the demonstrated phenomenon.

**Correct solution of physics learning task:** Surprising behaviour of the second block is caused by lowering of the centre of block mass thanks to the load.

![Figure 5. Balance on a surface](image)

6.3 Physics learning tasks for gifted students - modification physics learning tasks
Strong motivation and support of creativity development is brought by physics learning tasks which contain creation of modifications. Students’ learning task is to create similar experiment or, on the contrary, an experiment with additional physics phenomenon. These learning tasks are appropriate especially for gifted students to develop their creativity. An example of modification physics learning tasks follows (Trna, 2005):

**Buoyant hydrostatic force:** Create experimental equipment for measuring of the buoyant hydrostatic force made from polystyrene.

**Correct solution of physics learning task:** The equipment is presented on the figure 6.

![Figure 6. Buoyant hydrostatic force](image)
7 Conclusions
Disabled and gifted students must be considered as learners with special educational needs in physics education. It is possible to assume that the individual educational development of every student will be a future imperative in physics education. Learning tasks are an important part of physics education also for students with special educational needs. Because of the quick increase of physics and science education efficiency, information about special educational needs must be inserted into both pre-service and in-service physics teacher training. Physics teacher has the crucial role in this innovation of educational technology. Physics teacher must be forearmed by wide professional spectrum of knowledge, methods, aids etc.

8 References

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