

**OF VISUAL TECHNOLOGIES IN DEVELOPING STUDENTS' SPATIAL THINKING
IN PHYSICS TEACHING**

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Abstract: this in the article physics science in education visual technologies of application training in the process place and importance analysis Students spatial his/her thinking in development visual tools, interactive simulations and 3D modeling technologies efficiency illuminated. Research results visual technologies study to the process systematic current to grow the necessity shows.

Keywords: visual technology, physics education, spatial thinking, interactive simulation, 3D model, didactics.

Introduction. Modern education in the process information and communication and visual technologies effective application of teaching quality increase, students independent thinking, analysis to do and problematic situations solution skills in development important to the factor Globalization and digital transformation under the circumstances education system in front of standing main from tasks one — education process innovative approaches based on organization This point of view visually technologies study material further clear, understandable and interesting in the form to students to deliver opportunity gives.

Physics science complicated theoretical concepts, abstract modeling and many measurable processes own inside received because of it effective in teaching visual perception and imagination role is incomparable. Students for spatial imagination and spatial thinking formation physicist laws, events and their each other dependence deep to understand service Visual technologies — 3D models, interactive simulations, animations, virtual laboratories — these the process simplifying, the student active perception strengthens them study of activity subject as shapes.

Didactics science modern in development education technologies new Types — multimedia, interactive education, digital exhibition, AR/VR systems — education efficiency in increasing wide is being used. This technologies study process demonstrative, communicative based, mutual collaborative active study environment as organization to grow opportunity Especially physics in science this tools using abstract realistic models of concepts in appearance expression, events spatial image analysis to do opportunity is created.

This of the subject relevance from that consists of physics in education visual technologies systematic current to grow not only of the students perception makes it easier, but them analytical and creative to think, complex spatial models understanding and them practical in activity to apply Therefore, this direction according to take to go research modern didactics important from issues one is considered.

Home part. Visual technologies modern didactics inseparable structural part they are training in the process information visual, figurative and systematic in a way perception to grow opportunity gives. Pedagogical theory point from the point of view of visualization human of thought main from mechanisms one is imagination and spatial perception to the processes Therefore, visual technologies student (or student) in mind new of knowledge formation simplifies them previously mastered knowledge and experience with to integrate help gives.

Visual education principle own historical roots classic didactics representatives — YA Comensky, KD Ushinsky, J. Piaget and others' in his works finds. Especially Comenius by previously pushed exhibitionism principle (" everyone thing intuition through perception "to be done ") today on the day digital technologies using new in stages manifestation is happening. If before this principle mainly pictures, tables or from models use through done increased However, currently multimedia visualization, 3D models, interactive simulations and virtual labs through training process further dynamic, communicative directed and individual characteristics flexible to form has it has been.

Didactic point visually technologies study in the process following **main functions** does :

- 1. Exhibitionism function** — complex processes and theoretical concepts simplified, view through understandable in the form expression. This is especially physics, mathematics, biology such as abstract sciences for extremely important.
- 2. Motivational function** — students (or students) in science relatively internal interest, cognitive activity and passion increase. Colorful, moving and interactive visual materials the student to study attraction does.
- 3. Cognitive function** — new knowledge perception analysis to do and reinforcement process makes it easier. Visual materials brain imagination and analysis centers together activates.
- 4. Reflexive function** — student own knowledge evaluation, errors determination and thinking process analysis to do skills develops.

Modern didactic concepts (e.g. constructivism) and multimodal teaching theory) visual technologies not only assistant tool, maybe knowledge formative active component as sees. R. Mayer cognitive multimedia teaching to the theory according to the person brain information two main channel through — visual (seeing) and in the auditory (hearing) direction again works. That's why for study in the process visual from materials reasonable use, verbal explanation with together when used, learning efficiency noticeable at the level increases.

this respect, visual technologies education process didactic mechanism as following advantages provides :

- study of activity cognitive processes activates;
- complicated abstract concepts clear, demonstrative images through expression opportunity gives;
- students spatial thinking and logical analysis to do ability develops;
- information remembering stay and again work process strengthens;
- student and teacher between interactive communication provides.

Physics education in the context of visual technologies to oneself typical didactic transformer role does. Because physics often theoretical abstractions, formulas and to complex model concepts is based on. Visualization tools this complicated theoretical content concrete in the form expressing it as “see” through “understanding” opportunity This gives not only knowledge to master relieves, but in students spatial contemplation, observation and scientific thought culture shapes.

Visual technologies modern didactic in the system education process visual, cognitive and interactive components harmonizing integrative pedagogical tool as This is applicable.

technologies study content figurative analysis based on to understand providing, students thinking activity deepening and scientific concepts logically consistent in the form to master service does.

Physical processes theoretical models visual expression student's in mind of knowledge systematic, spatial and logically based in the form to the formation help gives. As a result study in the process of perception activity, mastery depth and training of activity general efficiency increases.

Physics education own to the essence according to complicated theoretical concepts, abstract models and natural of processes laws is a science that requires mastery. Therefore education in the process visual technologies application — didactic efficiency increase, abstract knowledge through real experience with tie and students spatial and logical his/her thinking in development important factor as Visual technologies to the teacher knowledge various information in forms – graphic, video, animation or modeled in appearance presented to grow opportunity They are the student's perception, remembering stay, analysis and application stages makes it easier, that's it through education process effective management opportunity creates.

Didactic approach point from the point of view of physics in science applicable visual technologies following main to groups separation possible:

1). Multimedia technologies modern education in the process wide applicable from tools one which include PowerPoint presentations, video tutorials, animations exhibitions, graphics images, electronic slides and infographics in the form of manifestation This will be of technologies main advantage — education information text, image and sound by means of complex in a way to deliver at the opportunity manifestation This approach will of the students attention attraction will, the subject consistent to understand help gives and training motivation increases.

Pedagogical point in terms of multimedia tools education process exhibitionism and emotional impressionability principles in practice to come true They are in the students to the topic relatively positive relationship shapes, educates material deeper perception to grow and remembering stay process activates. Thus, multimedia technologies use education process further effective, interactive and didactic in terms of based to form brings.

2). Interactive simulations modern physics real experience in education instead clicker virtual environment create opportunity giver effective digital from tools is one For example, PhET Interactive Simulations, Crocodile Physics, Algodoo such as platforms to the students various physicist processes experience based on study for interactive conditions creates. Student such in the environment variables independent manages, results observes and analysis does this and the sequence " experiment - observation - conclusion " shapes and physics laws personal experience through understanding opportunity gives.

Pedagogical point visually, interactively simulations study process activates, students to know was interest increases and their cognitive independence develops. These tools of teaching constructivist approach suitable without, knowledge ready in the form from giving according to him own experience based on discovery to grow opportunity creates. With this together, interactive models of the students analytical thinking, observation and logical links determination ability strengthens.

As a result, interactive simulations not only technician tool, maybe students active study activity organization experience based on to study directed didactic mechanism as education efficiency increases.

3). 3D modeling technologies physics in education complicated objects and processes spatial analysis based on study opportunity giver advanced digital These are tools. technologies using atomic structure, electromagnetic fields, waves spread, mechanical systems dynamics or heat exchange such as physicist events three dimensional models in the form of visual in a way

manifestation Such models to students of objects internal structure, their each other impact mechanisms and in space happened to be changes clear and realistic in the form imagination to do opportunity creates.

Pedagogical point from the perspective of 3D modeling technologies spatial thinking in formation, abstract concepts concrete in appearance in understanding and theoretical knowledge visual basically in strengthening separately importance They have to study. in the process student's to know activity activate, complex physicist processes analysis to do and they between logical links determination opportunity gives.

3D models using student in real experiments observation difficult was or in practice again create opportunity limited processes learns. This technologies physicist laws systematic perception development, research to the activity preparation and theoretical knowledge practical in context application opportunity gives.

3D modeling technologies physics in education spatial imagination deepening, studying material demonstrative and interactive in the form to master organization to be able to, as well as to students cognitive activity upon activation didactic in terms of effective tool as is applied.

4). AR (Augmented Reality) and VR (Virtual Reality) technologies physics in education immersive study environment create through study process new to the stage take comes out. Extended and virtual reality technologies using student physicist events not only theoretical in terms of, perhaps directly perception to grow based on study as much as possible has For example, VR glasses through electricity chain work process spatial in appearance analysis to do, AR app using and magnet field lines in real space observation possible.

This technologies the student complete interactive and demonstrative study environment with provides, in which student not only observer, maybe of experience active to the participant As a result, the student own to know activity practical experience, visual perception and emotional analysis with harmonized without organization This is study process only information acceptance to do not, maybe him/her active again working, modeling and analysis to do directs.

Pedagogical point from the perspective of AR and VR technologies of the students cognitive activity, spatial his/her thinking and scientific imagination in development important factor is considered. Immersive study environment in students complicated physicist events whole system as understanding, cause and effect connections to determine and theoretical knowledge in real conditions from the test transfer skills Thus, the use of AR and VR technologies education to the process integration physics science in education not only innovative technician approach, maybe modern didactics effective conceptual mechanism as manifestation will be.

5).Digital laboratories physics education experimental component digital technologies based on organization to reach opportunity giver innovative study They are touch - sensitive. measurement devices, digital oscilloscopes, data automatic record provider systems and online measurement using platforms (e.g. Vernier or PASCO) students for virtual or hybrid laboratory environment creates. In such an environment student experiments independent accordingly design, results measure them analysis to do and scientific conclusions release to the possibility has will be.

Digital laboratories study process practical direction strengthens, theoretical knowledge experience with tie opportunity gives and being studied physicist Real measurement of laws results based on to confirm service does. Pedagogical point in view of this laboratories experimental thinking develops in students problematic in situations fast and logical decision acceptance to do, data analytical again work and the results consistent justification skills shapes.

Digital laboratories education process individualization, each to the student his/ her own training pace and to the strategy suitable experience activity organization to grow opportunity This

gives technologies theoretical knowledge in practice application, experimental thinking develop and research competencies to form service does.

Digital laboratories physics in education modern didactics important structural element as theory and of practice integral integration provides and study process systematicity, interactivity and consequentialism principles done in increasing effective methodical tool become service does.

This technologies study to the process systematic integration to do of teaching visual, interactive and experience based on components harmonizes. As a result physics education only theoretical knowledge with limited not, maybe **perception, observation, analysis and to modeling based active study activity** in the form of organization This is the same as the in turn, digital education in the environment physics science training efficiency noticeable at the level increases and pedagogical the process to the person focused, creative and independent thinking developer to the system turns.

Spatial thinking is human objects between spatial relationships perception imagination to do and analysis to do Physics science in learning this thought type separately importance profession will, because many events (trajectory of motion, force direction, waves distribution, areas) in space It's going to happen.

Visual technologies spatial thinking in development following mechanisms through impact shows:

- **Imagination process activation** — 3D animations and models through the event eye in front of revive opportunity gives;
- **Analytical thinking development** — virtual experience through cause and effect their connections independent to determine help gives;
- **Spatial perception deepening** — objects rotate, zoom or various from the corners observation through many measurable imagination shapes.

Experience based on as defined, visual technologies application as a result students physicist events imagination to do them modeling and in space analysis to grow skills noticeable at the level increases. This is spatial of thought to develop directly positive impact shows.

From this outside, visual technologies using education in the process students own of activity the result eye with sees this and studied of the material solid to master, creative thinking and problematic in situations solution find skills to develop ground creates.

Visual technologies physics education in the system information only transmission tool as not, maybe students spatial his/her thinking formation, scientific imagination deepening and theoretical knowledge practical models with integration opportunity giver didactic mechanism as manifestation will be. This technologies education in the process abstract physicist of laws visual expression provides them with real processes with tie through training of activity logical consistency, conscious participation and efficiency increases.

Conclusion and recommendations. Taken analysis and observations result this physics shows that science in teaching visual technologies application education process efficiency increasing, students active knowledge to occupy instigator important tool Visual technologies using abstract and complicated physicist processes clear, demonstrative and logical in consistency to students This is delivered. their spatial his/her thinking development, physics events modeling, analysis to do and practical application skills The above from the conclusions come came out without following offer and recommendations working output:

1. Physics in their classes visual technologies regular and systematic accordingly current to teach, to teach for methodical manuals working exit necessary.
2. High education virtual laboratories in institutions, 3D modeling programs and AR/VR platforms wide current to grow through practical experience environment create necessary.

3. Students spatial his/her thinking assessment criteria working exit and education monitoring the results practice on the road to put to the goal according to.
4. Physics of the teachers digital and visual pedagogical competencies increase for special qualification increase courses organization to grow recommendation is being done.
5. Education in the process visual technologies not only education tool, maybe students creative thinking and problematic situations solution to grow ability developer didactic mechanism as application necessary.

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