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3D Visualization Trends in Science Learning: Content Analysis

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Abstract: In the current digital era, the development of science and technology is growing rapidly in the world of education. In learning the use of technology in the form of using smartphones and the internet which can be accessed by both teachers and students. Trends in learning by incorporating elements of technology in science learning. Science is a family of biology, physics, chemistry which has material characteristics that can be seen or observed by the senses and are not visible to the five senses and cannot be displayed in class. The natural aspect of science is quite broad because it relates to phenomena and natural phenomena, therefore 3D visualization is needed in learning so that abstract material can be more concrete in the meaning of learning. The purpose of this study is to analyze the content or content analysis of 20 articles related to 3D visualization in science learning. The results obtained are 3D visualization in learning used from elementary to high school levels. The 3D visualization is in the form of AR-based learning media and AR-based modules that affect the learning outcomes that teachers and students want to achieve. In making objects in the form of 3D visualization using several software, namely blender, unity, vuforia, AR, uniteAR.

Keywords: Media; Science learning; 3-D Visualization

Introduction

The development of science and technology (IPTEK) has progressed very rapidly so that it has affected aspects of life such as government agencies, business and education (Azizah et al., 2022). In the world of education, the development of science and technology (IPTEK) fills an important role. This can be seen from the creation of new technologies that are entering the digital stage (Mulyani & Haliza, 2021). Theoretically and practically, science and technology have a reciprocal relationship where science provides supporting material for technological progress in the form of theories while technology as an expansion of scientific research horizons is in the form of technology-based research tools (Wahyu Winarni, 2021). Technology in the world of education is a system that can used as a learning support so that learning objectives can be achieved (Lestari, 2018; Maritsa et al., 2021).

Learning is an interaction activity between teachers and students. Learning as a form of process in exploring knowledge by the teacher as a facilitator and students as parties to achieve learning goals so that it can lead to a high level of knowledge (Maritsa et al., 2021). The role of the teacher in learning is not only transferring knowledge to students but there are several things that must be considered and prepared by the teacher before learning. Some planning in learning includes preparing lesson plans as learning guidelines so that learning is more directed and learning objectives can be achieved properly (Anggraeni & Akbar, 2018), class management by creating classroom conditions as an effective environment for learning (Hidayat et al., 2020), and provide reinforcement in presenting learning materials (Hasyim, 2014).

In general, Natural Sciences (IPA) is a science group that has 3 aspects, namely chemistry, biology, physics. Basically this science studies natural phenomena and symptoms that are built based on products, processes, and scientific attitudes (Trianto, 2010; Wisudawati & Sulistyowati, 2014). Science learning has begun to experience a paradigm shift, where so far science

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learning has only been to know science concepts through rote memorization, currently it is necessary to experience an increase in students' abilities in higher-order thinking skills (Sumintono et al., 2021). In addition to high-level thinking skills, 3 skills are also needed as a complement, namely collaboration, communication, and creativity skills (Mardhiyah, 2021). This achievement is also inseparable from the suitability of the science material taught with the media and learning models that are in accordance with the characteristics of the science material.

The dimensions of knowledge in science learning include factual, conceptual, and metacognitive (Novika Pertiwi, 2021). However, in learning there are still many misconceptions and students find it difficult to understand the material being taught. In static electricity material, the average percentage of students' misconceptions from the 15 questions tested was 47% of students' misconceptions, 7% of students understood the concept, and 36% of students did not understand the concept and 10% of students had errors (Islami et al., 2018). Apart from that, in material characteristics of living things and life organizations with good factors from the teacher's teaching method, students who are less active, and students who do not understand abstract concepts (Samiha et al., 2017).

Science teachers are required to continue learning to update their knowledge in accordance with science that continues to experience development. But in fact, the teacher still has difficulty in teaching science concepts. Factors that hinder teachers are the lack of mastery of science concepts so that it becomes an obstacle to meaningfulness in the learning process (Insani, 2016), the background of science teachers and the design of lesson plans (Indrawati & Nurpatri, 2022). To overcome these obstacles, science teachers do not need to spend a lot of time explaining lessons in front of the class by utilizing technology in learning. The technology in question is in the form of learning media.

Media in learning aids or communication media that teachers use in learning. Through the use of media in learning, it is expected to be able to improve communication relationships so that learning can run effectively (Rahman et al., 2017). In the current digital era, the use of learning media is very diverse, such as the use of interactive multimedia to attract students' interest in learning (Dwiqi et al., 2020), the use of power points to motivate students to learn (Irfan et al., 2019) , and the use of smartphones and computers for concrete experiences and motivation for student learning (Rahman et al., 2017).

Utilization of media that is currently being used in learning is 3-dimensional (3D) media. 3D media, namely 3-dimensional objects which according to shape and physique have length, width, thickness which can be observed from various points of view based on sensory perception (Arifudin et al., 2019). Visual-based media plays an important role in learning. 3D visualization media in learning can display images with actual models of real objects (Priyo Nur Cahyanto & Handayani, 2018). There is a lot of software that can be used to develop 3-dimensional objects, namely augmented reality, Unity, Blender, Vuforia, assembler edu, and virtual reality. Utilization of 3D visualization in learning can concretely display abstract material concepts. The application of virtual reality-based 3D media can increase interest and learning outcomes (Dewi, 2020).

Based on the description that has been presented, the formulation of the problem in the content of this analysis includes (1) What materials are used in 3D visualization media in learning? (2) Is there any effect of using 3D visualization media in learning? (3) What software is used in developing 3D objects?

Method

This type of research is descriptive research. The method used in this research is qualitative content analysis. Data obtained from reviewing journal articles related to research are then concluded. Data processing and analysis was carried out qualitatively and cumulatively with descriptive elaboration. Article search for content analysis; the author provides categories as requirements for articles to be reviewed. The categories are identified based on 1) type of publication, 2) specification of the journal, 3) year of publication of the journal, 4) independent variable, 5) field of research, 6) type of study study. Articles that already meet these categories can be used as a basis for carrying out content analysis.

Table 1. Article Criteria

Category	Article Criteria
Type of Publication	Scientific Articles Published in Journals
Journal Specifications	National Journal with ISSN index (International Standard Serial Number)
Journal Publication Year	2016-2022
Independent Variable	3D Visualization
Field of Research	Learning and Education
Study Type	Empirical and Theoretical

From the article criteria in table 1, it can be seen that the distribution of articles in this study is specifically described in table 2.

Table 2. Article Distribution

Type Journal	Status	Journal Name	Quantity
Nasional	Accredicate Sinta 1 and Scopus Q3	Cakrawala Pendidikan	1
	Accredicate Sinta 2	Jurnal Penelitian dan Pengembangan Pendidikan Fisika (JPPPF)	2
		Jurnal Pendidikan : Teori, Penelitian, dan Pengembangan	1
		Jurnal Penelitian Pendidikan IPA (JPPIPA)	3
		Journal of Educational Science and Technology (EST)	1
		BIOSFER : Jurnal Pendidikan Biologi	2
		Jurnal Pendidikan Biologi (JPB)	3
		Unnes Physics Education Journal (UPEJ)	1
		Jurnal Pendidikan Matematika dan Sains (JPMS)	1
	Terakreditasi Sinta 3	Jurnal Inovasi Teknologi Pendidikan	1
		Unnes Science Education Journal	1
		Journal of Biology Education	1
		Prisma Sains : Jurnal Pengkajian Ilmu dan Pembelajaran Matematika dan IPA IKIP Mataram	2
Amount			20

Result and Discussion

The 20 articles that were selected based on the journal selection criteria that had been set by the researcher were then analyzed for content with the following results:

3D Visualization in Learning

Based on the 20 articles that have been analyzed, they are grouped into learning, materials, and levels that utilize 3D in learning as described in table 3.

Effect of 3D Visualization in Learning

After grouping in table 3. Then it is analyzed whether there is an effect after using 3D media in learning which is specifically described in table 4.

Table 3. 3D Visualization in Learning

Learning	Material	Level	Quantity	%
Sciece	Bloodstream system	SD	1	10
	Alternative Energy Sources		1	
Science	Solar system		2	
	Human Transportation System	SMP	1	20
	Particle		1	
Biology	Excretion System		2	
	Endocrine System		1	
	Animalia		1	
	Nervous system		1	
	Respiratory system		2	
Chemistry	Atomic Structure	SMA	2	70
	Electron Configuration		1	
	Acid-Base		1	
	Chemical Bonds		1	
	Hydrocarbons		1	
Physics	Fluid		1	
		Amount	20	100

Table 4. Effect of 3D Visualization in Learning

3D visualization	Effect	Quantity
	Multi-representation capability	1
	Concept Mastery	4
	Science Process Skills (KPS)	1
	Analysis and Evaluation Ability	1
	Motivation to learn	6
	Learning outcomes	3
	Mastery of Concepts and Creative Thinking	
	KPS and Learning Outcomes	1

3D visualization	Effect	Quantity
AR-Based Learning Media		
AR Based Module	Interest and Learning Motivation	1
	Concept Mastery	2
Amount		20

3D Visualization Developer Software

The results of the analysis of using software in visualizing 3D in learning are in table 5.

Table 5. 3D Visualization Software

Software	Percentage (%)
Unity, Vuforia, Android Studio	30
Unity, Blender, Vuforia	40
Augmented Reality	20
UniteAR	10
Amount	100

This research is a content analysis with descriptive qualitative elaboration. The data obtained based on this analysis are from 20 selected journals based on criteria that are adjusted to the scope of the theme taken. Based on table 1, it can be seen the mapping of the use of 3D visualization at 3 levels of education, namely elementary, middle, and high school levels. Elementary school level with a percentage of 10% on the circulatory system material and alternative energy sources. Circulatory system material is difficult to learn directly so students are unable to absorb the material properly, therefore augmented reality technology-based media is needed to absorb information (Suryaning Astutik et al., 2020), whereas in alternative energy sources material on students class V, because at elementary level students. Students who are in elementary school are generally aged 7 to 11 years. Thus students are in the concrete operational phase, where at this stage students have the ability to do various jobs starting from something tangible with a form that can be seen directly (Listiyani et al., 2021).

At the junior high school level, with a percentage of 20%, there are 4 materials, namely solar system material, human transportation systems, and particles. Solar system material is one of the materials taught in class VII even semester. This material is abstract because it relates to celestial bodies which cannot be presented in class (Pratama et al., 2020). During junior high school students enter their teens where they enter the formal operational stage, namely students build, and construct knowledge based on experiences experienced and related to the objects observed.

At the high school level with a percentage of 70% by solving 3 science clusters, namely chemistry, physics, biology. In biological material, there is more material that is abstract in the human body related to systems that cannot be directly observed by the five senses. In chemistry related to chemical bonds, atomic structures, hydrocarbons, electron configurations, and acids-bases. Chemical material that studies matter, properties, reactions, structures and accompanying energy so that chemical material is difficult to understand because chemical substances are related to one another and are microscopic, so visualization is needed. Fluid material in physics learning is material about molecules that are governed by forces and are classified as liquids (Permana et al., 2021).

After mapping the material that utilizes technology in learning, then it is analyzed whether there is an effect of its use in learning which is explained in table 4. In the table it is explained that there are 2 forms of 3D visualization used in learning in the form of augmented reality-based learning media and augmented reality-based modules. The use of AR-based learning media has an effect on students' multipresentation abilities which can be seen by increasing the posttest scores of multipresentation questions which include macroscopic, submicroscopic, and symbolic aspects (Ningrum et al., 2021).

In mastering students' concepts, it can be seen from the results of learning evaluations of students who meet the minimum standards (KKM) (Aris et al., 2020; Emawati & Haka, 2022; Pratama et al., 2020; Rohmah & Anggraito, 2021; Zsalsabilla et al., 2022). The influence on students' science process skills (KPS) by looking at the value of the increase in KPS from 3 classes, namely 1 control class, and 2 experimental classes (Paembonan & Ikhsan, 2021). The analysis and evaluation skills of students can be seen from the results of the average value of analysis and evaluation skills which have a value of 0.58 ± 0.21 in the experimental class and 0.29 ± 0.14 in the control class (Jalmo et al., 2022). Students' mastery of concepts and creative thinking can be seen from the pretest and posttest scores on the description of students' mastery of concepts and creative thinking skills which include 4 aspects, namely fluency, flexibility, originality, and elaboration (Wulandari et al., 2020).

The increase in science process skills and learning outcomes is seen from its value which has a simultaneous difference between the MAR-assisted PBL model and students who do it conventionally (Wahyu et al., 2021). Student learning motivation can be seen from the value of student responses and the attractiveness of students in learning (Ambarwulan & Muliyati, 2016; Fajriani et al., 2021; Rini et al., 2022). 3D visualization in

the form of AR-based modules influences interest and motivation to learn in learning chemical bonds before and after learning simultaneously and individually. The effectiveness value is 18.8% for interest and motivation to learn simultaneously, 17.2% for interest in learning and 9.7% for learning motivation (Whatoni & Sutrisno, 2022), while for mastery with AR-based modules, that is with an average score mastery of the concept of 81.3% (Riyanti et al., 2022).

Based on table 5, there are several softwares that are used to develop objects or 3D visualization in learning. The most used percentages are Blender, Unity, vuforia. The process of making 3D visualization in learning begins with design objects made in blender, then changing the fbx format to be imported into unity software for object coloring and then making markers with easy AR (Rini et al., 2022).

Unity editor as the main developer software and vuforia unity package as supporting software that can run on smartphones (Permana et al., 2021; Pratama et al., 2020). Based on the markers contained in the module or already in apk form, you can view 3D objects via uniteAR (Emawati & Haka, 2022). The trend of 3D visualization in learning is also called the use of augmented reality in learning. Augmented reality is a combination of the virtual world and the real world that creates interactions between humans and computers or smartphones that are presented in an environment that feels real (Irwansyah et al., 2019; Priyono et al., 2018).

Conclusion

For researchers who want to develop 3D-based learning media or teaching materials, they can use some of the software that has been described in this study, according to their needs.

Author Contribution

Nuri Vina Mawadah: writing original draft introduction, method, result and discussion, and conclusion Jaslin Ikhsan, Suyanta, Sabar Nurrohman, and Sri Rejeki: review and editing.

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Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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