OPINION
by Prof. Dr. Radoslav Yoshinov
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of a dissertation on the award of the educational and scientific degree "**Doctor**" in the doctoral program "**Informatics**", professional field **4.6. Informatics and Computer Science**

with author: Plamen Dimitrov Petrov

on the topic: Models and methods for application of virtual and augmented reality in education

Scientific supervisor: Assoc. Prof. Tatyana Atanasova, PhD

By Order No 304 of 27.10.2022 of the Director of the Institute of Information and Communication Technologies, Bulgarian Academy of Sciences (IICT-BAS) I was appointed as a member of the scientific jury in a procedure for the defense of a dissertation on "Models and methods for the application of virtual and augmented reality in education" for awarding the educational and scientific degree "Doctor" doctoral program "Informatics", professional field 4.6. Informatics and Computer Science by Plamen Dimitrov Petrov.

As a member of the scientific jury, I have received:

1. Dissertation for awarding the educational and scientific degree "Doctor";
2. Dissertation autoreferate;
3. Copies of the articles included in the dissertation;
4. Reference for the implementation of the minimum requirements of IICT-BAS for acquiring the educational and scientific degree "Doctor".
5. Other documents supporting the procedure.

Plamen Dimitrov Petrov was born on 12.03.1974. In 1997 he acquired "Master" degree with professional qualification "Teacher of Mathematics and Informatics" at Sofia University "St. Kliment Ohridski"..

1. Actuality of the dissertation

The context-dependent learning use of digital resources provides additional opportunities including processes such as search, exploration, identification, documentation, registration, conservation, restoration, adaptation and presentation of educational objects and resources incorporating elements of virtual reality.

The main objective of the dissertation study is to propose, explore and test tools (models, methods and tools) suitable for the application of virtual and augmented reality in learning. Objectives, opportunities, areas of application, models, challenges and risks of using virtual and augmented reality in e-learning are presented

The implementation of the set goal implies the solution of the following tasks:

Task 1. To develop a model for the use of augmented and virtual reality in STEM learning taking into account the different educational goals and specifics of the individual subjects.

Task 2. To propose a model for the combination of augmented and virtual reality with a physical learning environment.

Task 3. To develop a model for combining augmented and virtual reality with project-based learning in a single teaching scenario.

Task 4. To propose methods for assessing the effect of combining a learning environment, augmented with augmented reality, implemented to improve the learning process and understand the learning material for certain learning objectives.

I find that the set goal and the tasks thus formulated are up to date, and the content proves the significance of the dissertation presented. I appreciate the topic and the research done in the dissertation.

2. Degree of knowledge of the state of the problem and general characteristics of the work

It is evident from the presented materials that the PhD student has a solid theoretical background and extensive insight into modern information technologies and in particular in the field of virtual reality, types, tools, application techniques, effect on the pedagogical and content aspect of e-learning.

The dissertation work has a volume of 114 pages, presented through a table of contents, a glossary of terms and abbreviations used in the dissertation, an introduction, the structure of the dissertation, four chapters, a conclusion constituting a summary of the results obtained. 7 publications of the author related to the dissertation presented

In the bibliography of the dissertation are cited 121 literary sources: books, scientific articles and Internet publications.

In Chapter 1. An analytical overview of modern directions and technologies in e-learning is made. The goal and objectives for achieving it are formulated.

In Chapter 2. the developed models for the application of augmented and virtual reality in different STEAM disciplines with different educational objectives are presented.

In Chapter 3. methods for estimating the effect of the application of the developed models are described.

Chapter 4. provides an overview of software environments for creating and hardware tools for using AR/VR educational materials. A SWOT analysis has been made for the application of AR/VR technologies in education.

The Conclusion summarizes the results obtained on the tasks. The main scientific, applied and scientific-applied contributions of the dissertation are indicated. Prospects for future development are formulated

All this proves that the doctoral student has in-depth knowledge in the subject of the conducted research.

3. Compliance of the proposed methodology of research and the set objective and tasks of the dissertation

Models, software components and an online environment for introducing virtual reality elements in e-learning are presented.

The chosen methods and means correspond to the main goal and tasks set for solution by the doctoral student.

4. Characterization of the nature and assessment of the credibility of the material on which the contributions of the dissertation are built

The methods and models that are created and used correspond to the target task.

I have not noticed any errors in either the specific or conceptual models. I also find that the strategies proposed are well founded.

5. Contributions of the dissertation

The more significant results obtained in the dissertation work are summarized in author's claims for 4 scientific and applied contributions as follows:

1. A model for the use of augmented reality in STEM training has been developed. The model allows easy adaptation to the specifics of different STEM disciplines, encouraging creativity and teamwork.

2. A model for the use of augmented reality in mathematics education has been developed. The model allows the use of various augmented reality technologies, making it suitable for application both inside and outside the classroom. It allows for the use of different educational approaches.

3. A model for the use of augmented reality in arts education is proposed. The model allows the use of both augmented and virtual reality. This makes it flexible and applicable to a very wide range of activities in fine arts education. It enables the use of different educational approaches, encourages creativity, discovery and teamwork.

4. A model for combining project-based learning with augmented and virtual reality has been developed. The model is practically oriented and allows the use of a multidisciplinary approach in working with students. Working on a real problem with the help of both types of realities creates a real sense of experience and successfully addresses an important but difficult to solve problem such as that of student motivation.

The reviewer accepts the contributions thus described

6. Extent of the dissertant's personal involvement in contributions

The personal participation of the doctoral student is judged by the publication activity of the doctoral student reflected in the materials published on the dissertation. The PhD student convincingly presents the achieved results with a very good and thorough argumentation, as well as uses professional graphic design of the materials. I haven't noticed plagiarism at work.

I believe that the PhD student has done well and I do not question his personal participation in the development of the dissertation material.

7. Evaluation of publications on the dissertation

The attached list of publications contains 7 titles, 2 of which are currently indexed in Scopus and/or Web of Science. Three publications are in international refereed scientific journals and 4 - in works at international conferences. One publication is in a scientific journal with SJR. The publications are co-authored with the supervisor.

This shows the ability of the doctoral student to conduct research in a team.

The publications reflect the more substantial results achieved in the dissertation. 41 of their citations were spotted, which proves the valuable nature of the publications. They are reported at reputable scientific forums, which I take as approbation in the scientific community.

8. Compliance of the autoreferate with the requirements for its preparation and adequacy of reflection of the main points and contributions of the dissertation

The presented draft autoreferate is in accordance with the rules for the preparation of the dissertation papers at IICT-BAS. The autoreferate reflects the essence and results achieved, as well as the contributions of the author. It is graphically shaped very well and includes the necessary information describing in summary the dissertation.

9. Opinions, recommendations and remarks

The dissertation discusses a very complex, dynamically developing and promising field - development of methods and models for introducing elements of virtual reality in e-learning.

I recommend the PhD student to continue publishing in indexed scientific journals with an impact factor.

I have made some of the non-essential (linguistic) remarks on the copy that has been submitted to me.

10. CONCLUSION

The content and contributions of the dissertation of Mag. Plamen Dimitrov Petrov fully meets the requirements of the Law on the Development of the Academic Staff of the Republic of Bulgaria, the Regulations for its application and the Regulations on the terms and conditions for acquiring academic degrees at IICT-BAS. Considerable in volume and content research work has been carried out. There is a sufficient number of scientific and applied contributions. A sufficient number of publications on the dissertation published at prestigious scientific forums have been presented. The educational doctoral minimum set in the individual plan is covered. Undoubtedly is the personal participation of the doctoral student in the development and contributions received. This gives me reason to strongly recommend to the Honorable Scientific Jury to award **to Plamen Dimitrov Petrov** the educational and scientific degree "Doctor" in professional field 4.6 "Informatics and Computer Science", specialty "Informatics"

Prepared the opinion: На основание ЗЗЛД

Sofia, 30.11. 2022 year