Review

on the procedure for defense of a dissertation thesis entitled:

„Instruments for management and evaluation applying a user-centered approach for the design of video games for education“

for obtaining the scientific degree “Doctor” (educational and scientific)

by Yavor Ivanov Dankov

In the Scientific field: **4. Natural Sciences, Mathematics and Informatic**

Professional field: **4.6. Informatics and Computer Sciences**

Doctoral program: **„Computer Sciences“,** Department of Computing Systems (Temporary joined to Mechatronics, Robotics and Mechanics)

Faculty of Mathematics and Informatics (FMI),

Sofia University “St. Kliment Ohridski” (SU)

The review has been prepared by: **prof. Dessislava Georgieva Petrova-Antonova** in my capacity as a member of the scientific jury for the defence of this dissertation according to Order № RD-38-170 / 30.3.2022 of the Rector of the Sofia University.

1. General characteristics of the dissertation thesis and the presented materials

The dissertation thesis includes introduction, **four chapters**, conclusion, summary of the main scientific contributions and list of authors’ publications, bibliography, directions for future work, an appendix with sections from an XML document, which is used for development of educational video games, and glossary, presented in **134 pages**. It contains **24 figures and 17 tables**. Declaration of originality is also presented. Its content and structuring are determined by the set tasks and following the chosen methodology.

The **object** of the thesis is the study of software instruments for the management of the design and evaluation of video games for education. The **subject** of the thesis is the study of the analysis, design, integration into software architecture and the practical validation of specific software instruments for the management of the design and evaluation of maze video games for education. The **aim** of the thesis is the design and validation of tools for management and evaluation applying a user-centered approach for the design of maze video games for education using a specially designed and created a taxonomy for this purpose.

In order to achieve the goal set in the dissertation, 10 tasks are defined, which are summarized in 4 main groups: (1) Research and analysis; (2) Creating of a common and a specialized taxonomy; и (3) Design of the tools’ functionality and the software architecture that integrates them as well as description and analysis of the business processes for management and assessment of the design, and (4) validation of the proposed tools through experiments and analysis of the obtained results.

The development of the thesis follows a systematic approach that correspond to the defined tasks. Chapter 1 presents a systematic literature review on video games and their role in the modern education. It analyses the tools for design management of educational video games

as well as the tools for analytical assessment. Chapter 2 outlines the challenges and principles in taxonomy development. A common taxonomy of software instruments for managing and evaluating the design of video games for education is designed. Based on that taxonomy, a specialized TIMED-VGE taxonomy of software tools for managing and evaluating the design of video games for education has been developed which can be used for all kinds of educational maze video games. Chapter 3 is devoted on the design of tools for management and evaluation of maze video games for education in the APOGEE platform. The architecture of the APOGEE platform is described and the business processes for design of the platform are explained. Chapter 4 presents the validation of the tools through experiments using the educational video game „Let's save Venice". The obtained results are analyzed from in terms of user experience. In addition, the experimental video games "Assenevtsi" and "Valchan Voyvoda" are described.

The work outlined in the thesis is clearly presented, easy to follow and cited promptly. the questions are presented in logical sequence and coherence, the style of the presentation is scientific. The text is well structured, with the main emphases, conclusions and results highlighted, which helps to summarize the research contributions.

2. Biographical data and personal impressions

Yavor Dankov has a master's degree from the University в of National and World Economy (UNWE) in 2016. He is a part-time PhD student in Doctoral Program "Algebra, topology and applications" from 2016. Yavor Dankov is an assistant professor in the Department of Software technologies, FMI since 2020. He conducts exercises in the compulsory disciplines "Introduction to Software Engineering", "XML technologies for the Semantic Web" and "Quality Assurance" in the bachelor's program "Software Engineering", as well as in the disciplines "Object-Oriented Analysis and Design", "Object-Oriented Analysis and Design of Software Systems", "Architectures of Software Systems" and "Research Methodology" in the master's programs "Software technologies", "Distributed systems and mobile technologies", "Information retrieval and knowledge processing" and "Technologies for knowledge and innovations". As a lecturer in the discipline „Quality Assurance", I have personal observation of the teaching work of Yavor Dankov, which is characterized by professionalism and striving to upgrade the curriculum. In addition, he is a principled and correct colleague.

Yavor Dankov is member of the teams of **10 scientific projects**. As a member of the APOGEE project, I would like to point out that Yavor Dankov is a creative and productive researcher. Proof for this are his scientific publications and **h-index 4 in Scopus**, which is a significant achievement at the beginning of his research career.

3. Content analysis of the scientific and scientific-applied achievements of the candidate, contained in the presented dissertation thesis and the publications to it, included in the procedure

The main contributions of the thesis can be summarized as follows:

- A **systematic research and analysis** of the tools for design management and assessment of educational video games is conducted (scientifically applied contribution);

- A **common taxonomy** of software instruments for management and evaluation of the design of video games for education is designed. Based on it, a **specialized taxonomy** for management and evaluation applying a user-centered approach for the design of maze educational video games is elaborated (scientific contribution);

- **Tools for management and evaluation of the design** of maze educational video games are designed together with a description of the functional requirements and business processes. A software architecture of the APOGEE platform is proposed, which integrated the designed tools (scientifically applied contribution);

- The proposed tools are **experimentally validated** following a preliminary defined methodology (scientifically applied contribution) as well as development and practical application of maze educational video games (applied contribution). The obtained results are used for assessment of the designed tools (scientifically applied contribution).

As a results from the exploration ana analysis of the current state in the domain, a research problem on the need for tools for management and evaluation of the design of educational video games is identified. The obtained scientific and scientifically applied results correspond to the defined goal and tasks of the thesis. The methodology for the development of the thesis includes the application of a method for analysis and synthesis and a modelling approach, as well as conducting an experiment and evaluation analysis of the adequacy of the proposed solution.

The significant volume of the reviewed literature and its precise interpretation deserves a positive assessment. Yavor Dankov studied the multimillion-dollar market for video games, their impact on users and their potential for educational applications. The challenges for the design, creation and management of educational video games have been identified, with a view to making them popular, effective and financially successful. As a result of the study, the user experience is pointed out as a key factor in the design of educational video games.

An essential result of the thesis is the development of taxonomy for management and evaluation applying a user-centered approach for the design of educational video games (Evaluation of the Design of Video Games for Education). taxonomy offers two basic subcategories on the second level of – "Assistive tools" and "Analytical tools". It is a base for the development of a specialized taxonomy for management and evaluation of the design of maze video games for education. The two basic subcategories are kept. The category "Design Management" includes 3 basic and 2 additional tools. The category „Analytical tools" includes 14 tools, which are split in 3 categories (Analytical tools for education, Game analytical tools and User analytical tools). It should be noted the possibility for application of the specialized taxonomy for all kind of maze educational video games, and with the exception of the "Manager of the educational content" for the entertainment games.

The proposed specialized taxonomy is applied in the design of the educational tools and their integration in the APOGEE platform. A process for creation, analysis and evaluation of the design of educational video games is elaborated, including 3 stages – Game creation, implementing in 4 modules, Playing the designed game and exploration, implementing in 4 modules and Validation and improvement of the design of the video game, implementing in 3 modules. The functionalities provided by the software tools, as well as the groups of users (3 in number) who use them, are exhaustively described. A detailed view of the business process of the APOGEE platform is presented with a focus on the analysis and evaluation of the design of

educational video games. A multi-layered architecture of the APOGEE platform with the possibility for integration of tools has been proposed.

The feasibility of the proposed solution has been confirmed by practical experiments. Prerequisite for successful validation is the methodology developed for validation of the designed tools, including 4 stages. The user experience is assessed on the basis of several factors – playability, learnability and usability, including efficiency, effectiveness and satisfaction. The learnability is assessed by a special questionnaire with 16 questions, covering 6 attributes: Ease of Learning, Familiarity, Consistency, Predictability, Informative Feedback and Error Handling. The assessment of the playability is also realized on the basis of a questionnaire, in which 7 components of the gaming experience are evaluated by applying a five-point Likert scale. The practical validation is made using the maze educational video game "Let's save Venice". The tools have been successfully validated and a strong correlation has been established between all attributes of the learnability, as well as between all components of the gaming experience. The results of the survey, related to the assessment of the playability, show high values of four of the components – immersion in the game, positive affect, competence, flow of the game. This in turn proves that the video game provides a rich gaming experience for users.

4. Approbation of the results

The results of the thesis are published in **six articles**, one of which is a journal paper and 5 of which are papers in conference proceedings. All articles are **referenced in Scopus**. They are co-authored and in 5 of them Yavor Dankov is the **first author**. The article published in the proceeding of the international conference Computer systems and technologies is awarded as best paper.

The numerical indicators of the articles on the topic of the thesis are as follows:

Reference	**Publisher**	**Year**	**SJR**	**Citations in Scopus**
[1]	ACM	2020	0.182 (2020)	2
[2]	Springer*	2021	-	-
[3]	Springer*	2021	-	-
[4]	Springer	2022	0.151 (2021)	-
[5]	J. of Diff. Eq. and App.	2021	0.214 (2021)	-
[6]	SciTePress, ACM	2019	0.200 (2019)	1
		Number	**4**	**3**
***Last index 0.184 (2019)**				

It should be noted that in addition to the articles presented in the thesis, Yavor Dankov is a co-author of 8 more publications, indexed in Scopus. Thus, the **total number of publications is 21**. This confirms the high publishing activity, the good quality and significance of the achieved results.

The scientific works categorically **meet and repeatedly exceed the minimum national requirements** (under Art. 2b, para. 2 and 3 of the according to the Act on Development of the Academic Staff in the Republic of Bulgaria) as well as the Regulations for the conditions and rules for acquiring Ph.D. degree of the Sofia University "St. Kliment Ohridski" for acquiring the educational and scientific degree "Doctor" in Professional field 4.6. Informatics and Computer Sciences.

The **obtained results are original and there is no proven plagiarism**, as it was confirmed on the basis of the received report for similarity of the text of the presented thesis in the system for prevention against plagiarism of the Sofia University.

5. Qualities of the abstract

The abstract is 38 pages long and includes 15 figures and 9 tables. It is prepared according to all requirements and correctly reflects the content of the dissertation and the scientific contributions of the doctoral student. The abstract presents a common characteristic of the thesis, its content and structure, main topics, results, and conclusions as well as a summary of the research contributions. It includes a list of articles on the topic of the thesis and a bibliography.

6. Critical notes and recommendations

I have no critical remarks. The notes and recommendations that I pointed out as an internal reviewer during the discussion of the thesis in the department of Computing Systems (Temporary joined to Mechatronics, Robotics and Mechanics) were reflected by Yavor Dankov.

I recommend Yavor Dankov to continue his scientific work through participation in the implementation of the planned for future realization tools as well as, if possible, to conduct research related to the implementation.

7. Conclusion

Having become acquainted with the thesis presented in the procedure and the accompanying research articles and on the basis of the analysis of their importance and the scientific and applied contributions contained therein, I **confirm** that the thesis presented and the research articles to it, as well as the quality and originality of the results and achievements presented in them, meet the requirements of the Act on Development of the Academic Staff in the Republic of Bulgaria as well as the Regulations for the conditions and rules for acquiring Ph.D. degree of the Sofia University "St. Kliment Ohridski" for acquisition by the candidate of the scientific degree "Doctor" in the Scientific field: 4. Natural Sciences, Mathematics and Informatics, Professional field: 4.6. Informatics and Computer Sciences. In particular, the candidate meets the minimal national requirements in the professional field and no plagiarism has been detected in the scientific papers submitted for the competition.

Based on the above, I **strongly recommend** the scientific jury to award Yavor Ivanov Dankov the scientific degree „Doctor" (educational and scientific) in the Scientific field 4. Natural Sciences, Mathematics and Informatics, Professional field: 4.6. Informatics and Computer Sciences.

30.05.2022 Reviewer: .....

(prof. Dessislava Georgieva Petrova-Antonova)