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Sindh Agriculture University
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A systematic Review of Learning Object Oriented Programming through Serious Games and Programming Approaches

Suhni Abbasi, Hameedullah Kazi, Kamran Khowaja

Department of Computer Science [1]
Isra University, Hyderabad
Hyderabad, Sindh, Pakistan

{suhni.abbasi, hkazi}@isra.edu.pk, kamran.khowaja@gmail.com

Abstract - **In this review paper, the studies dedicated to identifying the learning of Object Oriented Programming through Serious Games(SGs) and applying different programming approached applied were investigated. This systematic review attempts to gather all evidence that helps answer three specific research questions: identification of SGs developed or incorporated for learning OOP, OOP concepts covered in those games, and programming approaches applied. Three different ways were found as result of the learning through SGs: learning by playing games, learning by creating games and learning by using game related tools. Majority of studies covered all basic OOP concepts. The programming approaches applied includes object first, concept first, GUI first and code first programming approaches. Result indicates learning by playing games is most frequently used and effective strategy followed by learning by using game related tools. The most common programming approach applied is Game as first approach.**

Index Terms – Systematic Literature Review, Object-Oriented Programming, Learning Outcomes Programming Approaches, Serious Game

I. INTRODUCTION

Game-Based Learning (GBL) is the branch of SGs deals with games that have defined learning outcomes[1], [2]. Using the games in curricular terms means translating an element of a subject (such as a law of physics or the law of supply and demand) into the mechanics of a game, which operates within a self-contained system based on choices and consequences[3].

In addition, it is reported that GBL methods may provide a good opportunity to stimulate learners' abstract thinking in cognitive development and further develop their high-level thinking skills[4]. Therefore, if teachers can apply computer games to teaching in any subject discipline, students can not only get better learning outcomes, but also through these games they learn happily because of their engaging, immersive as well as interactive features[5]–[7].

Programming involves the design of the algorithm, code writing, debugging, testing and implementation. Computer programming is quite related to problem-solving but at the foundation level, students are not expected to solve complex problems rather they need to start by the acquisition of basic concepts to build higher cognitive understanding and possibly for better grasping of advanced programming concepts. The problem for mastering the students in programming concepts includes the identification of different ways the pogroming problems can be presented and to be solved. Transitioning from one programming paradigm to another, such as from procedural programming to OOP is also challenging task as it contains many overlapping concepts[8].

OO paradigm is considered more natural domain to work with, as the problem domain of OOP constitutes from objects which are interrelated to the real-life objects[9]. Nevertheless, it is quite difficult and challenging for students to understand and map the basic concepts of OOP (e.g. class, object, attributes, methods, method passing, inheritance, polymorphism and Encapsulation) with real-life scenarios[10]. SGs could cope with this difficulty by providing close to real life scenarios in the immersive and engaging way to be interacting without any fear of failure. Positive learning outcomes can be achieved by proper mapping of the concepts over the game elements[5], [11].

Since the principal aim of using the educational games was to achieve learning outcomes[12], but little discussion has been done to identify the learning achieved through SGs and the different ways by which the games are incorporated in the learning environment.

II. RELATED WORK

As part of, identification of the need for this review, we carried out a search to find a systematic review of SGs for learning OOP. During the search, we did not find any significantly related review study. However, we found generalized review based studies which were helpful to provide empirical evidence about the positive impact of SGs on students. Few of closely related review based studies are described below;

Malliarakis et al. [13] conducted the comparative study of commonly used techniques i.e. Programming Environment(PE), Microworld and SG for OOP education. The result indicates, PE and micro-world learning are an impressive tool for learning OOP but deficient to motivate students to learn actively, in contrast, SG facilitates the development of skills and personal characteristics through collaboration in a highly interactive and motivating environment. It is concluded that expanding existing SGs or creating new ones are essential to not only motivate and attract students but also helps to foster their skills and knowledge of OOP.

Boyle et al. [14] performed a review for analyzing the impact and outcomes of using Computer and SGs. Most

obtrusive outcomes from games for learning was knowledge acquisition, followed by Skill acquisition whereas entertainment games concluded the wide range of affective, behaviour change, perceptual and cognitive, and physiological outcomes. The conclusion drawn from this study implies that learning outcomes such as Knowledge and skill acquisition could be achieved by implementing games for learning in any subject discipline.

Battistella & Wangenheim [15] conducted the systematic review to help in adoption and/or creation of educational games for teaching computing. Most of the reviews games were aims to achieve the learning outcomes of cognitive level's lower part, few were focused on skills and affective level. The evidence from this study suggests that instructional method should be well-founded and incorporated by identifying the specific learning needs and should be designed properly based on learning/game theory to achieve the intended learning outcome.

III. METHODS

To performing the systematic literature review, the review process proposed by the[16], comprising the following stages;

Stage 1: planning the review
>   Activity 1.1. Identification of the need for a review
>   Activity 1.2: Commissioning a review
>   Activity 1.3: Specifying the research question(s)
>   Activity 1.4: Developing a review protocol
>   Activity 1.5: Evaluating the review protocol

Stage 2: conducting the review
>   Activity 2.1: Identification of research
>   Activity 2.2: Selection of primary studies
>   Activity 2.3: Study quality assessment
>   Activity 2.4: Data extraction and monitoring
>   Activity 2.5: Data synthesis

Stage 3: reporting the review
>   Activity 3.1: Specifying dissemination mechanisms
>   Activity 3.2: Formatting the main report
>   Activity 3.3: Evaluating the report

To conduct this review Stage 1 and 2 are covered in this paper for analysing the SGs and programming approached used for learning the OOP based on the following research questions.

RQ1. Which SGs have been developed or incorporated for learning OOP?
RQ2. Which OOP concepts are covered?
RQ3. Which programming approaches have been applied for learning OOP?

The identification of the research as part of Activity 2.1 of Stage 2, the following electronic databases were searched; a. Springer Link; b. IEEE XPLORE; c. ERA(Educational Research Association); d. ScienceDirect; e. ERIC(Education Resources Information Center); f. ACM Digital Library; g. ISP(Informing Science Press); h. INASP(International Network for the Availability of Scientific Publications)

A. Inclusion and Exclusion criteria

The focus of the search was to access full-text documents using various combinations of search keywords. The following keywords were subjected as searching criterion from the above-mentioned databases

- ("serious games" OR "game based learning" OR "game-based learning" OR "GBL" OR "educational games") AND ("Object Oriented Programming" OR "Object-Oriented Programming" OR "Object Oriented Paradigm" OR "Object-Oriented Paradigm" OR "OOP")

The review was conducted to identify the empirical evidence about the SGs and programming approached for learning OOP. The review was restricted to peer-reviewed articles, high-quality journal articles, book chapters and 'other' (e.g. research reports) written in English and published from 2005 to 2016. The plethora of studies was found in the initial screening, then after a subsequent screening, we ended up with fifteen studies that met our inclusion criteria (i.e. relevance to the topic, have implemented or developed a game for learning OOP).

The studies do not incorporate any game or other game related tool for improvement of OOP were excluded in the review process
The summaries of the articles included in this systematic review are provided in Table 1.

IV. ANALYSIS AND FINDINGS

The analysis of the results of reviews studies are described below;

A. SGs created or used

The year wise distribution of the studies is shown in Figure 1. Learning by playing games were published in 2005([17]), one in 2010([21]), one in 2011([22]), four in 2014([9], [24]–[26]), one in 2015([27]) and one in 2016([29]). Learning by creating the games were published in 2007([18]), 2009([19]), 2010([21]) and in 2011([23]). Learning by other game related tools were published in 2007([18]), 2009([10]), two in 2010([20], [21]), two in 2011([22], [23]), and one s in 2016. Some studies used mix strategies of learning via creating and playing the game[21], learning via playing games and using other game related tools[21], [22], learning by creating games and using other game related tools[18], [21], [23] and learning by playing, creating games and using other game related tools is used by [21].

B. OOP concepts covered

Most of the studies mentioned all basic OOP and procedural concepts to be covered, however they were lack in providing the evidence for all the OOP competencies. Results shows that eleven([9], [17]–[19], [22]–[27], [29]) out of fifteen studies incorporated all the basic concepts, whereas three studies ([10], [21], [28]) only includes the Object, Class and Inheritance concepts. One study [20] were limited to imparted about the inheritance concept.

C. Programming approaches applied

Among the various programming approaches studied in the related work it has been observed that few studies explicitly mentioned the programming approaches they followed whereas, in other studies, we have analyzed their approaches by looking the steps they were following in the

TABLE 1
INVESTIGATED ARTICLES INCLUDED IN SYSTEMIC REVIEW

	Author & year	Programming Approach	OOP CONCEPTS	Unit of Analysis		Games/Tools Incorporated	Results
				No.	Level of education		
[17]	A. M. Phelps et al. (2005)	Object First	Encapsulation, Inheritance, Polymorphism	N= 2 or 4	Final Year Project	Game/Tool Name: MUPPETS Game Genre: Not Available	Results were not significantly validated due to lower number of participants.
[18]	W.-K. Chen and Y. C. Chen (2007)	Mix of the imperative-first and objects-first	OOP principles and Design patterns	N=38 (19 Teams)	Fall 2005 OOP Laboratory Undergraduates students	Game/Tool Name: Game Framework Game Genre: Not Applicable	Results were significate for 16 teams, but insignificant for 2 teams. 1 team dropped out in starting of the course.
[19]	C. Xu(2009)	Game First	Basic OOP concepts, Graphics, Animation, JavaBeans, and Event handling,	-	Special Topics(Game Programming)	Game/Tool Name: WormChase, Breakout, Othello Game Genre: Puzzle	Results were not significantly validated because participants information was not provided.
[10]	L. Yan(2009)	Object First, Programming second	Class and object	-	1st year CS/IT	Game/Tool Name: GreenFoot and BlueJ Game Genre: Not Applicable	Results were not significantly validated because participants information was not provided.
[20]	A. Al-Linjawi and H. Al-Nuaim(2010)	GUI First	Inheritance	N=45(Treatment Group: 24 Control Group: 21)	3rd year females	Game/Tool Name: Alice Game Genre: Not Applicable	Results were statistically significant.
[21]	R. Adipranata(2010)	GUI First	Class, Object, Inheritance	N=125 Divided in 5 heterogenous groups.	2nd semester	Game/Tool Name: GameMaker, MinimUML and WARCRAFT Game Genre: Not Applicable	Statistically significant results observed when comparing with previous semester results.
[22]	A. E. Rais et al. 2011)	Concept First	Basic OOP concepts	N=10 Treatment(GAPS and Alice) and Control	2nd Year CS	Game/Tool Name: Traditional learning, GAPS 1.0 and Alice 2.0 Game Genre: Not Applicable	The results were statistically significant.

Ref	Author (Year)	Approach	Topics	Sample size group (Traditional learning)	Student level	Game/Tool	Results
[23]	C. A. Depradine(2011)	Code First	Basic OOP Concepts	N=54	Advanced level II (second year)	Game/Tool Name: SIMOO Game Genre: Arcade	Statistical significance of the results was limited because of preliminary sort of study.
[9]	J. Livovský and J. Porubän (2014)	Object First	Basic OOP concepts	N=14	1st Phase: teacher and PhD Student 2nd Phase: 2nd year students 3rd Phase: 14 students	Game/Tool Name: Amiga action-adventure game Game Genre: RPG	Results were significant for learning performance.
[24]	J. M. Rodriguez Corraet al.(2014)	Code First	Basic OOP concepts and Events	N=30(Experimental Group: 15 Control Group:15)	1st students (Industrial Technology Engineering)	Game/Tool Name: TUI Sifteo cubes Game Genre: Not Applicable	Results were statistically significant.
[25]	W. Y. Seng &M. H. M. Yatim(2014)	Game as supporting tool	Basic OOP concepts, Control and Repetition Statements, Array	N=40	BS(CS)and BS(SE) 1st Year 3 semester	Game/Tool Name: Ztech de Game Genre: RPG	Results were significant.
[26]	Y. S. Wonget al. (2014)						
[27]	Y. S. Wonget al. (2015)						
[28]	B. Poolsawas(2016)	Game First	Object Classes inheritance	N=40	3rd year, majoring IS and ID&GD	Game/Tool Name: Unity 3D Game Genre: Not Applicable	Results were statistically significant.
[29]	Y. S. Wonget al. (2016)	Game as supporting tool	Basic OOP concepts, Control and Repetition Statements, Array	N=60	1st year BS(GD)	Game/Tool Name: Ztech de Game Genre: RPG	Results were significant.

MUPPETS : Multi-User Programming Pedagogy for Enhancing Traditional Study, SCRUMBAM: combination of agile methodologies Scrum and Kanban, SIMOO: Simulator for Teaching Object-Oriented Programming, RDGC: Rapid Digital Game Creation, IS: Information System , ID &GD: Interactive Design and Game Development, GDP: Game Development Platform; RPG: Role Playing. TUI: Tangible User Interface; GAPS: Game-Based Approach to Support Programming Skills

learning process. The investigated studies applied different programming approaches for OOP learning shown in Fig. 2. The result indicates that, out of fifteen studies, four([9], [10], [17], [18]) applied object first, six as game first([19], [25]–[29]), two as GUI first([20], [21]), two as code first approach([23], [24]) and one as concept first([22]). Game as first programming approach has been observed in most of the studies followed by Object, GUI, code and concept first approach. Among these studies one study[18] used the mix of imperative (Programming) and Object as first programming approaches, we considered it as Object first approach. four studies([25]–[27], [29]) used games as supporting tool which is considered as the game first approach in this study.

V. CONCLUSION AND FUTURE WORK

This review was conducted to identify the learning the OOP programming through SGs and programming approaches applied. The finding contributes to identify the games played or created for learning OOP, the concepts of OOP as curriculum covered in the studies and programming approached applied for learning. The learning of OOP drawn in the light of incorporation of the SGs and programming approaches applied is discussed as follow:

A. Learning based on Incorporation of SGs

• Majority of the review studies employed the learning by playing SGs to gain positive learning outcomes. Effective and cognitive level outcomes such as apply, evaluate, synthesis, active participation in task completion and willingness to learn were main effects observed on students for learning by playing games. Final examination grading and passing ratio of the students were also improved.

• Learning by creating the games showed the significant effects for deeply understating the concepts and improve the problem-solving skills by continuously engaging the student in enjoyable and entertaining environment.

• Learning by other game related tools were useful to increase the knowledge about the OOP concepts.

B. Learning based on programming approaches applied

• In majority of the studies learning by complying the game as first programming approach includes cognitive types of learning occurs.

• Using object first approach shows cognitive and affective level outcomes and deeper- understanding of the concepts. Peer-to-Peer collaboration among students, with upper division students and with teachers improved.

• GUI first approach were fruitful to increase content specific knowledge if the GUI truly depict the curriculum contents.

• Concept first approach were helpful to improve examination score and grads; however, the insignificant results were achieved for mastering basic concepts of OOP.

• The code first approach proved improved grading and students could understand the OOP concepts easily in took less time in task completion, on other hand students feel difficult to start learning by writing coding as first thing in programming subjects.

Despite of above results observed on learning OOP, no study compares the results of analysis among these approaches specifically for effect on learning performance for SGs. Hence it provides the opportunity to the researcher to identify the effects of using different approaches in Game-based environment.
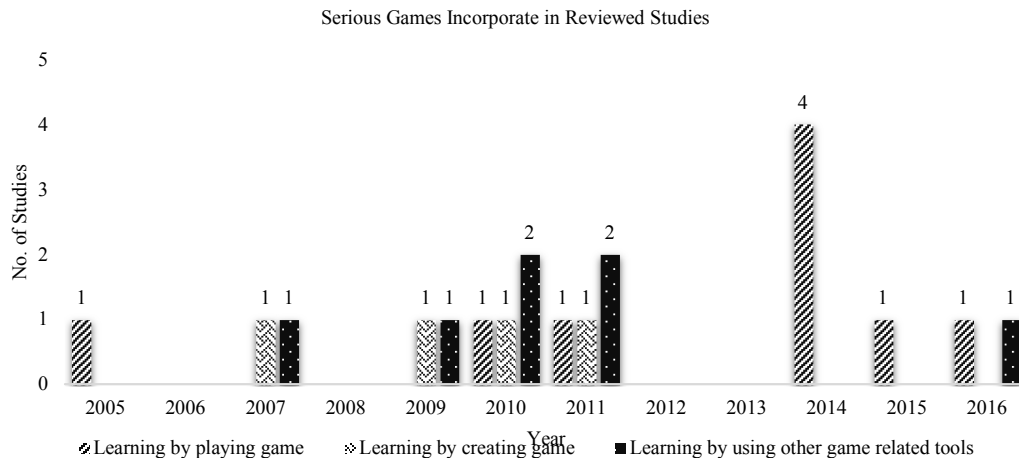
Serious Games Incorporate in Reviewed Studies

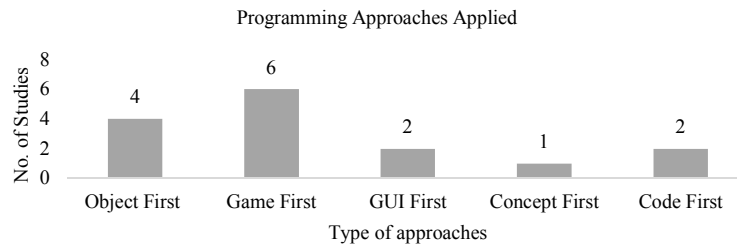Fig 1: SGs and Other game related tools used in review studies

Fig 2: Programming approaches investigated in review studies

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