A Framework for Game Engine Selection for Gamification and Serious Games

Zulfiqar Ali
Department of Computer Science
Shaheed Zulfikar Ali Bhutto Institute of Science and Technology
Islamabad, Pakistan
mzulfiqar32@hotmail.com

Muhammad Usman
Department of Computer Science
Shaheed Zulfikar Ali Bhutto Institute of Science and Technology
Islamabad, Pakistan
dr.usman@szabist-isb.edu.pk

***Abstract*—In the last decade, the gaming industry has grown greatly in scale, and many companies around the globe are now developing games. The development of these games uses some common functionality, including the implementation of graphics rendering, artificial intelligence, sound, video, physics and network capability. Implementation of these functionalities requires high levels of skill, resources and time. To overcome these issues, such core functions are built and bundled together in the form of a game engine. A game engine provides the basic framework for developing games. All engines include the aforementioned common functions, but each engine has pros and cons. So, to choose a suitable engine, a thorough study of the attributes of the various engines is required. Choosing the appropriate engine for a specific gaming application is not straightforward. The games being developed today have big budgets, and the selection of the wrong gaming engine can lead to big financial loses, as the product developed may not be up to standards due to lack of features in the selected engine. It is therefore necessary to have a framework to help pick the right engine. In recent years, a number of game engine selection methodology paradigms have been proposed, but these have certain limitations and weaknesses.**

The purpose of this paper is to propose a more robust framework to help game analysts and developers identify the best available game engine for serious games and gamified applications.

Keywords—games; game engines; gamification; serious game engines; selection framework

I. INTRODUCTION

Games were never as popular in past, as they are in the current era. Since the revolution of handheld devices, games are now being used everywhere. People of all age groups and genders play games. The trend of gaming is quite similar throughout the globe, and is not restricted to a specific region or country. The game industry has become one of the top industries due to the size of its consumer base.

In the last few years gaming has emerged as a growth industry, and many games with huge budgets are now being developed [15]. Due to the intense competition in the industry, investors are eager to invest in making a product that stands out from the crowd. Due to the potential for high profitability, a lot of investors globally are now investing in this industry.

There are certain challenges to achieving success in the field of game development, specifically: 1) to develop better games and applications, 2) with less budget and resources and 3) in a timely manner. This is why already developed gaming engines [12,13,14] are so important, as these help to cope with the aforementioned challenges. Gaming engines are not only being used for games, but also for gamification, i.e. when game design elements are used in industry applications [7]. This trend is increasing, and many big organizations have already adopted gamification for business applications [7].

A game engine is a set of software modules combined together to form the basis for the development of computer games and applications based on virtual environments. It hides the complexity of low-level development and provides the API functions to use and build new games. There are numerous gaming engines [12,13,14] on the market, and it has become a difficult task to choose the best engine to suit project requirements. All engines have a few common features and modules, along with some distinctive features. Once an engine is selected, the game features possible may be restricted by that engine's functionality. A modern computer game budget may range up to 50 million dollars or more [11,15]. With such budgets, if a game is started using a particular engine, it is not feasible to go back and choose a different one halfway through the project, as this is a huge waste of resources and time.

Due to these factors, suitable engine selection is very important for the success of the end product. But choosing an engine for a specific application is tricky because of the differences in functionalities of the existing game engines. Many researchers have attempted to provide a solution for this issue by evaluating [2,4] and comparing certain attributes [1,3,5-10] of the various engines considered important for games and applications.

However, these attempts at providing a better selection methodology [1-10] have offered solutions for some specific needs without offering insight into the selection process for the wide range of games and applications that are being built on gaming engines. For instance, Marks, S., et al. [1] gives a selection methodology for simulated clinical training, while the authors of [2] have done the same for developing first-person virtual environments. Anderson, E. F., et al. [4] have

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provided a solution for choosing a gaming engine for entertainment and serious computer games, while others have proposed solutions for different domains, such as serious games and mobile platforms [8,9].

This research was conducted while keeping in view the above issues, weaknesses and limitations in the previous research. It proposes a framework for the selection of a gaming engine for gamification and serious games, which resolves the limitations of the previous work.

A brief summary of selected prior studies is given in the Section II literature review, followed in Section III with a critical evaluation of selection methodologies for all the literature reviewed. In Section III the relationships among the selected literature are evaluated along with strengths, weaknesses, methods and outcomes. In Section IV, a new selection framework is presented for the selection of a game engine for gamification and serious games. Finally, in Section V, the conclusions and findings of the research are summarized along with discussion of areas for future work.

II. Literature Review

Marks, S., et al., evaluated different game engines for their suitability for simulations of clinical training [1]. Only three engines (Unreal Engine 2, id Tech 4 and Source Engine) were chosen for comparison. The authors compared the selected engines for editing, content creation and game play, using a case study of a different game for each engine. They found that Source Engine surpassed the other two.

In a second study, Trenhelme and Smith chose to evaluate CRYENGINE, id Tech 3, id Tech 4, Jupiter Extended, Source Engine and Unreal Engine 2 for the development of first person virtual environments [2]. The authors selected these engines on the basis of being the ones used in the development of most recent available commercial computer games. According to the authors, all of the selected engines were suitable for the development of first person virtual environments.

Xie presented a framework and requirements for developing a new mobile game engine [3]. The author discussed the key elements of mobile game engines, the features of some of the existing mobile game engines, and finally presented a solution for developing a mobile game engine. The key technologies described as requirements for mobile game engines are scene management, rendering, collision detection, and a physics engine. The engines selected for comparison included Cocos2d, SIO2, Unity 3D and Shiva 3D.

Anderson, et al., [4] proposed a new approach to engine selection using a 'white room'. This is a test level created by the authors for the purpose of evaluating the selected engines, Source Engine, Unity 3D, UDK and CRYENGINE. They evaluated the chosen engines for their implementation of capabilities including 3D rendering, interior geometry, artificial intelligence, collision detection, physics, sound, and scripting.

Munro, Boldyreff, et al. in [5] analyzed the architecture of engines. The authors chose all the open source engines of the Quake family, including id Tech 1, id Tech World, id Tech 2, id Tech 3 and id Quake.

Weiss compared gaming engines to select for game development [6]. The author selected five engines for comparison: Unity, Corona, Cocos2d-JS, Appcelerator Titanium and Rapid Game Pro. The author first discussed the engine features along with licensing types and costs, and finally recommended different engines for different scenarios.

Uskov and Sekar analyzed how serious games, serious gamified applications and gaming engines support activities in engineering and computer science [7]. The analysis included the use cases of games in the business processes of industry along with the types and attributes of serious games. The authors chose four engines for detailed study: Unity Pro, GameSalad Creator, DX Studio and V-Play. By comparing these engines authors presented the results.

Petridis, Dunwell et al. in [8] proposed an engine selection methodology for high fidelity serious games. The engines selected were Quest 3D, Blender, Unity 3D and the Unreal 3 Engine. A model of the Coliseum was used as a test case for evaluation. Per the authors' results, the Unreal 3 engine outperformed the rest.

Pattrasitidecha compared different engines and proposed a methodology for the selection of a gaming engine for mobile platforms [9]. The list of selected engines included UDK, Unity 3D iOS Pro, Shiva 3D Advance, Marmalade, DX Studio, Esenthel Engine, SIO2, Ogre 3D, Unigine, SunBurn, Raydium, Oolong Engine, and JPCT. The results were presented in a selection matrix and a case study was conducted to prove the results correct. In that case study, the requirements of a project were given in a selection matrix based on those requirements, which was used to find the best suitable engine. The chosen engine thus conformed to requirements, proving the matrix correct.

The main findings and outcomes of a serious gaming engines research project were presented in [10]. Vasudevamurt and Uskov analyzed 100+ serious games and developed a comparative analysis of serious gaming engines. The engines were classified into groups on the basis of features, and the features were then ranked for quality. Finally the authors presented their recommendations for the selection of a specific serious gaming engine.

The authors divided serious gaming engines into three groups, A, B and C. The engines in group 'A' were Unreal Engine 3, CRYENGINE 3, Unity SIM, Game Maker Studio, Adobe Flash Professional CC, NeoAxis Engine, GameSalad, Cocos2d, Torque, and Unigine SIM; in 'B' were Quake 4, Construct 2, Shiva 3D, Delta 3D and Source Engine; and group 'C' included CRYENGINE 4, Unreal Engine 4, FrostBite, SnowDrop, Dunia 2, Fox, Chrome Engine, ID tech 5, and ID Tech 6. The parameters for comparison included graphics, the work flow editor, the world (level) editor, the character model editor, the texture editor, cinematic support, physics, artificial intelligence, networking, creation of online game, programming experience required, scripting, platforms

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supported, and licensing. Finally, the authors presented results and specified the engines surpassing others for different scenarios.

III. Critical Evaluation of Selection Methodologies

All selected literature is critically evaluated and ratings are assigned, demonstrating the importance of research on the selection methodology for game engines. All the research under review is evaluated for three main parameters: 1) Selection of game engines for comparison, 2) Comparison criteria for game engines and 3) Result presentation and validation.

The results of this review are presented in Table III, which evaluates the articles based on the engines selected, the number of engines reviewed, and the selection and comparison criteria. It also highlights the weaknesses of the existing research under review.

A. Game Engines Selected for Comparison

The authors of [1-8] selected less than six game engines for comparison, which is quite a low number considering the large number of available game engines [12-14]. However, the authors of [9] selected 13, and 23 are compared in [10]. From the trend of choosing game engines based on selection methodology, it can be concluded that a good selection methodology should include the greatest possible number [10] of engines, which could be a number greater than 20, as only this number could encompass most of the game engines actively being used. The greater the number of engines under comparison, the better the insight and selection choice for game analysts and developers.

The engine selection criteria is not mentioned in [3-7], whereas the authors in [1,2,8-10] stated their engine selection criteria for comparison. Although [1,2,8] set a criteria for choosing engines, they did not fully apply their criteria, or otherwise the number of engines selected would be larger in number. For instance, the engines selected in [8] were based on the criteria of being popular. But Source Engine and CRYENGINE are not in the list, despite the fact that these were clearly among the most popular game engines. Similarly [1] compares only three game engines, even though applying the stated criteria should have called for a larger number of game engines. Most of the famous engines all have the features called for by the criteria the authors [1] were looking for. The number of engines selected is better in [9-10], as they have fully implemented their stated criteria for choosing the engines for comparison. The authors selected all the available mobile supporting gaming engines which were actively being used [9]. On the other hand, all the engines with richer features are selected in [10], resulting in a much larger number as compared to all of the rest under review.

B. Comparison Criteria for Game Engines

No comparison criteria are mentioned in [3,5]. The comparison criteria set by [1,2,4,6] is not significant, as it does not include many of the necessary parameters for a game engine listed in Table I. On the other hand, [7,8] have chosen some meaningful criteria and included all of the necessary and common elements for a game engine. Likewise, [9,10] have good criteria for the selection of an engine. In [10], the criteria for comparison includes all the necessary components that are common in engines, along with other factors such as "programming experience required." The authors of [10] have given better insight and selection choice to developers and thus stand out from the rest [1-9] under review.

C. Results Presentation and Validation

The results of [1-6] are hard to use for the selection of a gaming engine, as they have described the engine features in lengthy texts. Conversely, the authors of [7,8,10] presented their results in a tabular format, which is easier to interpret and use. Similarly, Pattrasitidecha in [9] offers a matrix with the results of his findings, which is genuinely useful for engine selection. The authors of [8,10] presented results in multiple tables. However, [9] offers only one matrix for engine selection. Additionally, the results of [1-8, 10] either lack any case studies, or their case studies don't validate their results, in contrast with [9], which proves the final matrix and selection methodology using a case study.

D. Rating Criteria

A rating is assigned to each study under review. The factors considered for assigning rating values include 1) Number of engines selected, 2) Engine selection criteria selected by author, 3) Comparison criteria selected, and 4) Case study conducted to prove results. Table II includes the list of all these factors along with awarded points. For factor 3 (comparison criteria selected), the important criteria parameters are identified and are listed in Table I and the studies that included these parameters for comparison are identified. These parameters are selected from all the studies under review. For some of the listed parameters, different authors might have used a different name. For example, programming libraries is used as parameter in [9], which is then broken down to subparts (i.e. physics, artificial intelligence etc.) These subparts are included in the selected parameters list instead of programming libraries, since these are used by most [4,6,10] of the authors. Table III contains the summary of rating points for all of the studies and their earned points for all three factors mentioned above.

Table III shows that the ratings for [1-7] are all less than 20. They used fewer engines, did not have selection criteria to choose engines for comparison and did not include all the necessary factors mentioned in Table I for comparison criteria. They also did not base results on case studies, and did not present the results in a format which could be easily interpreted by game analysts and developers.

On the other hand, the rating value for [8] is a bit better, and would have been even better if they had chosen a larger number of engines for comparison. They even did not truly apply their engine selection criteria to select the engines to compare. However, they have better comparison criteria and better results representation, which made their rating values higher as compared to [1-7]. The rating values for [9, 10] are best among the selected literature for reasons including

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TABLE I. POINTS FOR USED COMPARISON PARAMETERS (PART 1)

Feature	Literature Under Review				
	[1]	*[2]*	*[3]*	*[4]*	*[5]*
2D/3D Support				a	
Deployment Platforms		a			
Development Platforms					
Graphics Rendering					
Artificial Intelligence				a	
Audio/Visual Fidelity				a	
Physics				a	
Networking					
World (Level) Editor	a	a			
Content Creation	a				
Accessibility		a			
Composability					
Learning Curve					
Scripting Languages				a	
Licensing Costs		a			
Total Points:	2	4	0	5	0

POINTS FOR COMPARISON PARAMETERS USED (PART 2)

Feature	Literature Under Review				
	[6]	*[7]*	*[8]*	*[9]*	*[10]*
2D/3D Support	✔			✔	✔
Deployment Platforms	✔	✔	✔	✔	✔
Development Platforms	✔	✔	✔	✔	✔
Graphics Rendering		✔	✔	✔	✔
Artificial Intelligence		✔	✔	✔	✔
Audio/Visual Fidelity		✔	✔	✔	✔
Physics	✔	✔	✔	✔	✔
Networking		✔	✔	✔	✔
World (Level) Editor				✔	✔
Content Creation				✔	✔
Accessibility		✔	✔	✔	✔
Composability		✔	✔	✔	✔
Learning Curve	✔	✔	✔	✔	✔
Scripting Languages	✔	✔	✔	✔	✔
Licensing Costs	✔	✔	✔	✔	✔
Total Points:	7	12	12	15	15

TABLE II. AWARD POINTS FOR EACH RATING CRITERIA

Criteria	Award Points
Engine Filter Criteria	5 Points
Comparison Criteria Selected	1 Point/Parameter
Case Study/Results Validation	5 Points
Number of Engines Used	1 Point/Engine

TABLE III. AWARD POINTS FOR RATING CRITERIA (PART 1)

Criteria	Literature Under Review				
	[1]	*[2]*	*[3]*	*[4]*	*[5]*
Engine Filter Criteria	5	5	0	0	0
Comparison Criteria Selected	2	4	0	5	0
Case Study/Results Validation	5	0	0	5	0
Number of Engines Used	3	6	4	4	5
Grand Total of Earned Points:	15	15	4	14	5

AWARD POINTS FOR RATING CRITERIA (PART 2)

Criteria	Literature Under Review				
	[6]	*[7]*	*[8]*	*[9]*	*[10]*
Engine Filter Criteria	0	0	5	5	5
Comparison Criteria Selected	7	12	12	15	15
Case Study/Results Validation	5	0	5	5	0
Number of Engines Used	5	4	4	13	23
Grand Total of Earned Points:	17	16	26	38	43

better selection criteria, better comparison criteria, nice representation of results, and validation of results on the basis of a case study.

The graph in Fig. 1 shows that Vasudevamurt, et al., [10] received the highest points (43) and emerged as the best of the studies chosen for review.

IV. PROPOSED FRAMEWORK FOR THE SELECTION OF A GAME ENGINE FOR GAMIFICATION AND SERIOUS GAMES

A new framework for the selection of game engines for gamification and serious games is proposed. Table V lists the selected game engines and their attributes. Table IV shows the scores assigned for each attribute. Fig. 2, Fig. 3 and Fig. 4 show the scores to be assigned along with a step-by-step approach for engine selection.

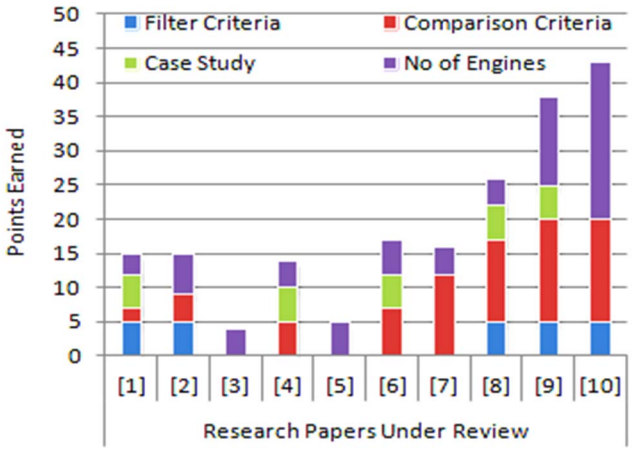

Fig. 1. Research award points for selected evaluation criteria

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TABLE IV. SCORES TO ASSIGN TO ENGINES IN PROPOSED FRAMEWORK

Attributes	Scores to Assign
2D/3D Support	25
Deployment Platforms	25
Development Platforms	25
Licensing Costs	25
Graphics Rendering	05
Audio/Visual Fidelity	05
Artificial Intelligence	05
Physics	05
Networking	05
CAD Platform Supported	01
Import/Export of Assets Available	01
Developer Toolkits Available	01
World (Level) Editor	01
Content Creation	01
Scripting Languages	01
Learning Curve	01
Accessibility	01

The attributes of the engines are divided into three groups with respect to their importance for gamification and serious games. These are then used in a step-by-step calculation for the final selection of the best available game engine. As shown in Fig. 2, the most important attributes are considered in the first stage. These selected attributes are 2D/3D support, deployment platforms, development platforms and licensing costs/terms. The points for each of these attributes is 25. If any attribute from this group is missing from the engines being compared, then that engine should be dropped from the group of engines under consideration. This group contains the attributes that are critical, and the absence of any of these cannot be tolerated.

Attributes in group 2 include graphics rendering, audio/visual fidelity, artificial intelligence, physics and networking. These are used for the calculation in Fig. 3. Each of these attributes is worth 5 points, which should be awarded if the attribute is a requirement and it exists in the engines being compared. These attributes are of lesser importance relative to group 1 attributes, however, these are more important than attributes in group 3.

Group 3 attributes include CAD platform support, availability of import/export of assets, world (level) editor availability, content creation, scripting languages, learning curve and accessibility. Each attribute has a score of 1 point, which is awarded if the attribute exists in the game engine under review, and if that attribute is a requirement for the project under development. These attributes are used for the calculation shown in Fig. 4.

Users can apply this framework to compare any engines they prefer to reach a final selection of the most appropriate engine for their gamified application or serious game. As per the proposed framework, once the initial set of engines is selected, the user would first need to look at Fig. 2. For instance, they should first check whether the selected engine supports the graphics required for the intended use (i.e. 2D or 3D graphics). If they are intending to make a 3D application or game, they should not proceed with an engine which only supports 2D graphics. Proceeding in the same way and then checking for other attributes like deployment platforms, development platforms and licensing, they assign the scores as per Table IV. If any of the attributes in Fig. 2 is missing, the user must choose a different engine, as the attributes in Fig. 2 are all mandatory for a successful engine selection.

After the steps in Fig. 2 are complete, users will need to proceed with the steps in Fig. 3 with the engines that passed the criteria in Fig. 2. The user should proceed in the same way as in Fig. 2, assigning points for the various attributes. The conditions in Fig. 3 are employed such that, if a functionality is not required, then the assigned points for that attribute would be 0, regardless of whether the attribute exists in the selected engine. This condition is imposed to reinforce the priority of the required attributes for the specific application. This ensures that the framework will work perfectly for diverse requirements. After the steps in Fig. 3, the user proceeds to the steps listed in Fig. 4 and assigns points in the same way as in Fig. 3. After completing all steps, the user will sum the scores earned in each step. The engine earning the highest total score should be selected, as it will best fulfill the requirements of the user's gamified application or serious game.

V. CONCLUSIONS AND FUTURE WORK

It is concluded that although there have been a number of efforts [1-10] to propose a solution for engine selection for various type of games and applications, the existing studies have many weaknesses (highlighted in Table IV) that must be taken care of to make the results worthy. The results of the above-mentioned literature are not always generalizable even though most of the features of the game engines are common. For instance if [1] had selected few more criteria parameters, its results would have been generalizable for other domains as well. As engine selection is an important step for the development of any kind of gaming engine-based application and has great impact on overall results like cost [11,15] and timeline to complete the application, a solution is required which addresses and considers the weaknesses of research in this area and proposes a solution which is more credible and trustworthy.

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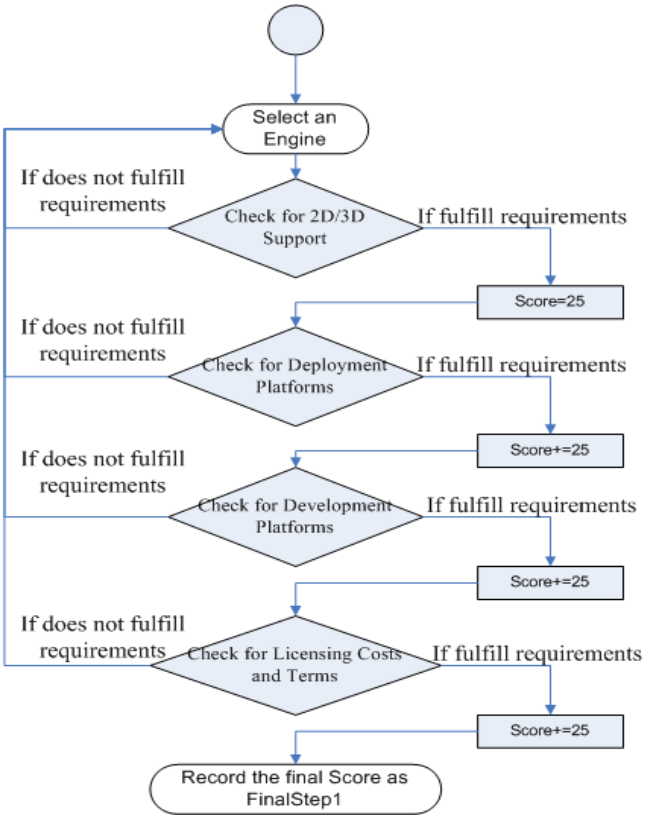

Fig. 2. First set of steps for engine selection

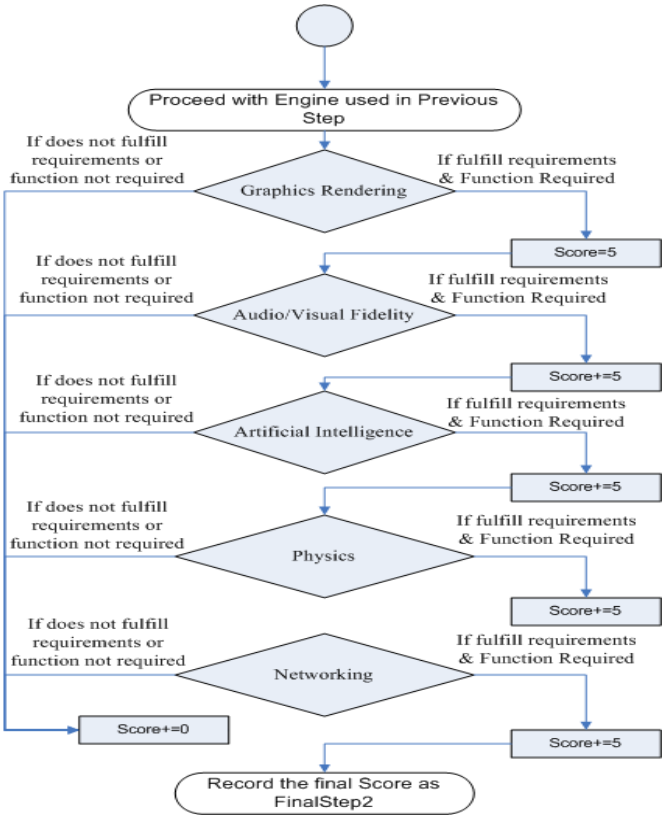

Fig. 3. Second set of steps for engine selection

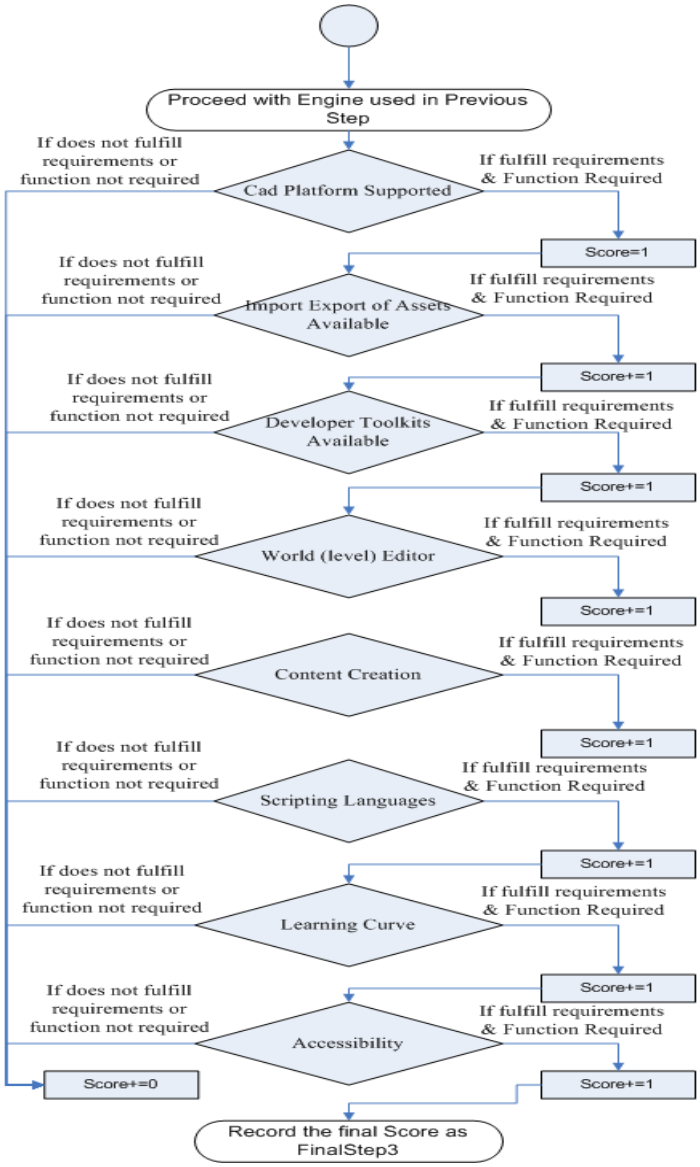

Fig. 4. Third set of steps for engine selection

Fig. 5. The new framework proposed in Section IV solves many of the limitations of the previous research. As it includes a greater number of engines, most of the famous engines can be selected for comparison and results are generalizable. The framework is developed in such a way that an engine can be selected for any kind of gamified application, serious game, or any other genre of game. Although the framework proposed solves many limitations in the area of selection methodology, a future study that includes more attributes could potentially make the framework even more worthy, as only the most important attributes are included in the current paper. A future work might include more attributes and apply the same framework to engine selection for a variety of game genres and gamified applications.

The Legend used in Table is as follows:

Y - Yes; N - No; H - High; M - Medium; L - Low;

CE4 - CRYENGINE 4;

UE3 - Unreal Engine 3;

UE4 - Unreal Engine 4;

GMS - Game Maker Studio;

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GS - GameSalad;
AFP - Adobe Flash Professional CC;
AT - Appcelerator Titanium;
Win - Microsoft Windows;
PS - PlayStation;
NM - Normal Mapping;
BM - Bump Mapping;
AO - Ambient Occlusion;
Prop – Proprietary

TABLE V. ATTRIBUTES MATRIX FOR SELECTED ENGINES

Engine/ Attribute	2D/3D Support	Deployment Platforms	Development Platforms	Graphics Rendering	Artificial Intelligence	Audio/Visual Fidelity	Physics	Networking	World (level) Editor	Content Creation	Accessibility	CAD Platforms	Import/Export of Assets	Developer Toolkits	Learning Curve	Scripting Languages	License Type
CE4	3D	Win, Linux, PS, Xbox , iOS, Android	Win,Linux, OSX	NM	Y	Y	Y	Y	Y	N	Y	3d Max	Y	Y	H	C++, Lua	FREE
id Tech5	3D	Win, PS, Xbox	Win, OSX		Y	Y	N	Y	N	Y	Y	3d Max	N	Y	M		Prop
Source	3D	OSX, Linux, Android	Win,Linux, OSX		Y	Y	Y	Y	Y	Y	Y	3d Max, Maya	Y	Y		C++	Prop
Unity 3D	2D/ 3D	Android, Black Berry, iOS, Linux, OSX, PS, tvOS, Win, Xbox	Win, Ubuntu, OSX	NM	Y	Y	Y	Y	Y	Y	Y	3d Max, Maya	Y	Y	L	C#, Java script	Prop
UE 3	3D	Win, Linux, OSX, Xbox, PS, Android, iOS, Win RT, HTML5	Win,Linux, OSX	AO	Y	Y	Y	Y	Y		Y	Max, Maya			H	C++, C#, Unreal Script	Prop
UE 4	2D	Win, Linux, OSX, XBox, PS4, iOS, Android, HTML5	Win,Linux, OSX	NM	Y	Y	Y	Y	Y		Y	3d Max, Maya			H	C++, C#, GLSL,Cg, HLSL,US	Free
Blender	2D/ 3D	Win, Max, Linux	Win, Linux, OSX, Solaries	BM	N	Y	Y	N	Y	Y	Y	3d Max, Maya	Y	Y	L	C, C++, Python	GPL
Cocos2d	2D/ 3D	Win, Mac, Linux, Web, iPhone, iPad, Android,	Corss Platform		Y	Y	Y	Y	Y	Y	Y	3d Max, Maya	Y	N	M	Java script, Java, Lua	MIT
Delta 3D	3D	PC	Cross Platform		Y	Y	Y	N	N	Y	Y	3d Max, Maya	Y	Y	H	C++	LGPL
GMS	2D	Win, XBox, PS, OSX, Ubunto, HTML5, Android, iOS	Win, Ubunto, OSX		Y	Y	Y	Y	Y	Y	Y	3d Max, Maya	Y	Y	L	Game Maker Language	Prop
GS	2D	iOS, Android	Win, OSX		N	Y	Y	Y	Y	N	Y	3d Max	Y	Y	H		Prop
id Tech4	3D	Win, OSX, Linux, PS, XBox	Win, Linux, OSX	BM	Y	Y	Y	Y	Y	Y	Y		Y	Y		C++	GNU
Quake 4	3D	Win, OSX, Linux, PS, Xbox	Win,Linux, OSX		N	Y	Y	Y	Y	Y	Y	3d Max, Maya	Y	Y		C++	GNU
AFP	3D	Win, Mac, Linux, Web, Flash, iPhone, iPad	Win, OSX		Y	Y	Y	Y	Y	Y	Y	3d Max	Y	Y	L	C++	Com m
AT	2D	iOS, Android, Blackberry, Win	Win,Linux, OSX		Y	Y	Y	Y	Y	Y	Y	3d Max	Y	Y	H	Java script	APL, Prop
Chrome	3D	Win, Linux, PS, Xbox	Win,Linux, OSX		Y	Y	Y	Y	Y	Y	Y		Y	Y	L	C++	Prop
Construc t 2	2D	Win, OSX, HTML5	Win		N	Y	Y	Y	Y	Y	Y		Y	Y	H	C++, Java script	Prop, GPL
Dunia 2	2D	Win, PS, Xbox	Win, OSX		Y	Y	N	Y	Y	Y	Y	3d Max, Maya	Y	N		C++	Prop
DX Studio	2D/ 3D	Android	Win		Y	Y	Y	Y	Y	Y	Y	3d Max	Y	Y		Java script	Prop

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Ogre 3D	3D	Linux, Win, OSX, iOS, Android	Cross Platform	N M	N	Y	Y	Y	Y	Y	Y	3d Max	Y	Y		C++	
SIO2	3D	Win,Web OS, iOS	Win, OSX		Y	Y	N	Y	Y	Y	Y	3d Max	Y	Y		C++, C#	GPL
Torque	3D	PC, Web	Win, Linux	B M	Y	Y	Y	Y	Y	Y	Y		Y	Y	H	Troque Script	MIT
Unigine	3D	Win, Linux, OSX, PS3, Android, iOS	Win,Linux, OSX		Y	Y	Y	N	Y	N	Y	3d Max, Maya	N	Y	L	C++	Prop
Frost Bite	3D	Win, PS, Xbox	Win, Linux		Y	N	Y	Y	N	Y	Y	3d Max, Maya	Y	Y		C++	Prop

TABLE VI. PARAMETERS AND EVALUATION TABLE

Reference/ Attribute	**Application Area**	**Engine Filter Criteria**	**Engines**	**Comparison Criteria**	**Weaknesses**
[1]	Simulated clinical training	Excluded due to being in early development, without sound and essential components. Included having features for creating game environment (maps) and editing tools.	3	Editing, Content creation and Game play	Weak engine selection criteria, Lower number of engines used, Missing important comparison criteria, Results are not interpretable
[2]	Developing first-person virtual environments	Being used in the development of recent commercial games	6	Level editor, Source code availability, SDK availability, Documentation availability and Others (license, community and tutorials availability)	Weak engine selection criteria, No comparison criteria, Results are not interpretable/usable
[3]	Research on mobile game engines	x	4	x	x
[4]	Entertainment and serious computer games	x	4	3D rendering, Interior geometry, AI, Collision detection, Physics, Sound and Scripting	No engine selection criteria, Low number of engines used to compare, Results are hard to interpret
[5]	Comparison of engines for analyzing the architecture of engines	x	5	x	Only one family of engines is used.
[6]	Comparison of gaming engines to select for game development	x	5	Features like Language, Physics, 2D/3D Support, Learning curve, Platforms supported, Destination platforms and Licensing costs	Lower number of engines used
[7]	Use cases of engines in industry processes and indentify/classify serious game engines	x	4	Audiovisual fidelity, Functional fidelity, Composability, Accessibility, Networking, and Heterogeneity	Lower number of engines used
[8]	High fidelity serious games	Popularity of selected gaming engines	4	Audiovisual fidelity, Functional fidelity, Composability, Availability and Accessibility, Networking, and Heterogeneity	Engine selection criteria is not truly applied, Low number of engines used
[9]	3D mobile game engines	Excluded 2D, Non mobile, without successful platform, Low quality and Tiny community game engines	13	Programming libraries, Usability, Development platforms, Deployment platforms and Price	GUI Editor used as selection criteria instead of Mobile GUI Editor

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[10]	Comparative analysis of serious game engines	Feature rich engines are included. Group 'A' has the ones used most frequently, 'B' the ones which are used rarely, and Group 'C' includes the Next Generation engine or Engines just released that are rich featured	23	Graphics, Work flow editor, World (level) editor, Character model editor, Texture editor, Cinematic support, Physics, AI, Networking, Creation of online game, Programming experience required, Scripting, Platforms supported and Licensing	For the engines selected in group 'C', they have not filled the values for most of the criteria and just filled the values for 2-3 of the parameters.

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