UNIVERSITY OF GLOUCESTERSHIRE

Paper Topic

Utilizing game analytics to enhance user performance in serious games

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1 Introduction

1.1 Abstract

This paper explores the practice behind creating serious games for the development of learning. It will also investigate game analytics and how they can be utilised to track and analyse user performance in serious games. The expected output will be a small-scale serious game task that integrates all the theory found whilst researching the paper and provides a quick real-time feedback system to demonstrate how the user is being taught.

1.2 Objectives

- Understand the effectiveness of serious games and what the current market has to offer.
- Research analytics packages and their uses in current gaming systems.
- Discover the downfalls and limitations of both serious games and analytics packages.
- Build a small serious game that utilizes a reactive feedback system to find the successfulness of developing a user's target skill.

1.3 Context

Djaouti (2010) defines the specification of a serious game as "any meaningful use of computerized game/game industry resources whose chief mission is not entertainment." Serious games have been around for a long time, and it is debated on what the first industry considered game is. According to Djaouti (2010) it is America's Army (U.S. Army, 2002). It is a game that Sawyer, co-founder of Digitalmill, considers as "the first successful and well-executed serious game that gained total public awareness" (Djaouti et al., 2010). Sawyer is well recognised in the games industry for his innovation within the serious game field.

More recently serious games are being used corporately to help train employees, therefore online training has become a major part of work life. Peck (2025) states that "More than 3 in 4 companies provide online learning opportunities". This is useful for employees as it allows them to learn at their own speed and within the comfort of their own home. There was a large shift toward online training following the COVID-19 pandemic, making e-learning a preferred method for corporate training, the below graph on market sales proves this. In Japan for example, 2019 and 2020 saw a huge increase in sales which can be linked directly to the pandemic.
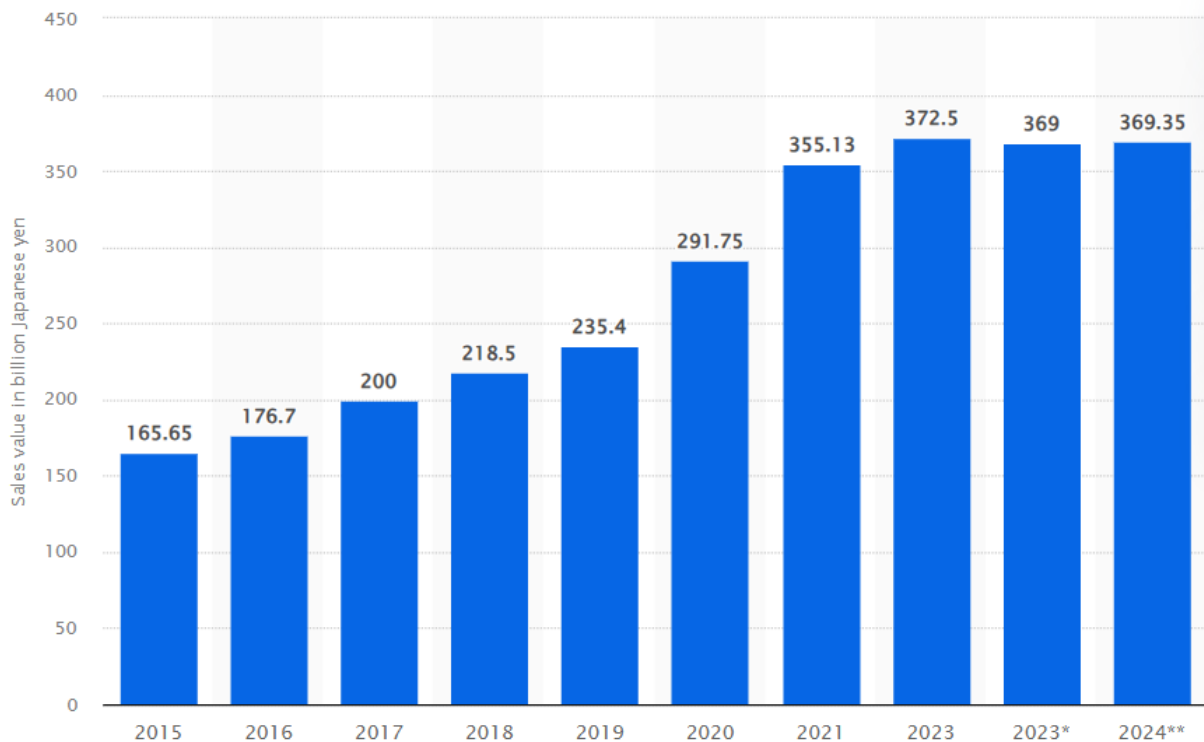
E-learning Sales 2015-2024 (Yano Research, 2024)

El-Nasr (2013) defines the goal of game analytics as "to support decision making, at operational, tactical and strategic levels and within all levels of organization – design, art, programming, marketing, user research, etc."

This paper examines the optimal form of serious game to develop and the most effective game analytics package for data storage and combines them to design a product to assist with the training of a user. This product will link the benefits of serious games with the power of data analytics to create a system that tests a user and provides reactive feedback to help them improve their trained skill.

2 Literature Review

2.1 Serious Games

2.1.1 Background of serious games

"Serious Games were developed in the military field in 1948 and then implemented in various disciplines to support learning, knowledge transfer, and management of research and practice problems" (Lami, 2023). This is supported by Laamarti (2014) who states that "Furthermore, links between the military and gaming are far from new: during World War II, the US army general staff were the first to use "wargames" and employed them to improve their image with the population".

The technological advancements of virtual reality (VR) in the early 2010's, driven by the commercial release of the Oculus Rift in 2016 (Meta, 2025), which opened new options for serious games and training simulators. Due to these technological advances in interactive and immersive content it has allowed for better, more advanced learning experiences to be created. A game that shows off the power of VR immersion is Edge of Nowhere (Insomniac Games, 2016). During this game the player is tasked with exploring the Antarctic as the VR immerses them in their own thoughts. This technological development has enhanced the creation of these serious games so that they can connect with the users by developing their empathy, motivation and learning skills through full immersion.

Edge of Nowhere Gameplay (Insomniac Games, 2016)

A company utilising the potential of the current haptic technology is F1 Authentics (F1 Authentics, 2025), they are creating custom car rigs that can be completely customised to fit the driver and car specifications. On their website they state, "Each simulator is built in partnership with the F1 teams themselves, meaning each detail is carefully reproduced, offering the ultimate experience." (F1 Authentics, 2021). These car rigs are fitted with motion technology so the drivers can practice racing the tracks without having to physically drive them. With these rigs, drivers can practice in any weather conditions and at any time of day. This is a major benefit to F1 drivers as they can simulate training conditions that normally would be environment dependent. This advancement is also very ecofriendly as it reduces the amount of petrol required

per training session to zero, it also does not require the driver to travel to different tracks for test runs as they can simulate any track they require.

Max Verstappen, a four-time World Drivers' Championship winner, stated in an interview with David Coulthard that he uses racing simulators as his downtime to challenge himself and improve on his time around the track (F1 Jackman, 2021). Verstappen during the interview talks with real motivation and passion for sim racing and confirms that they assist with helping to improve in real life. Schemas, find learning the movement and corners on certain tracks can really help drivers lower their lap times by improving their muscle memory. Another benefit is the huge effort on the enjoyment factor of sim driving games. Verstappen explains that he competes against other sim drivers, who play for fun rather than training. This proves that the popularity of driving games for the enjoyment factor is also extremely useful as it can make learning and improving a fun experience.

2.1.2 Current public games and companies

Currently the market for serious games appears to be growing quickly. According to (Laamarti et al, 2014) "A recent market study showed that the worldwide serious games market is worth 1.5 billion € in 2010, with a growth rate, over the last two years, nearly 100% per year." This is old data however when compared with the current figures on the market which Mordor Intelligence (2024) suggest are 17.64 billion $ in 2025. We can clearly see that the market is growing and constantly improving its technology.

Serious Games Market
Market Size in USD Billion
CAGR 25.43%

USD 54.75 B

USD 17.64 B

2025   2030
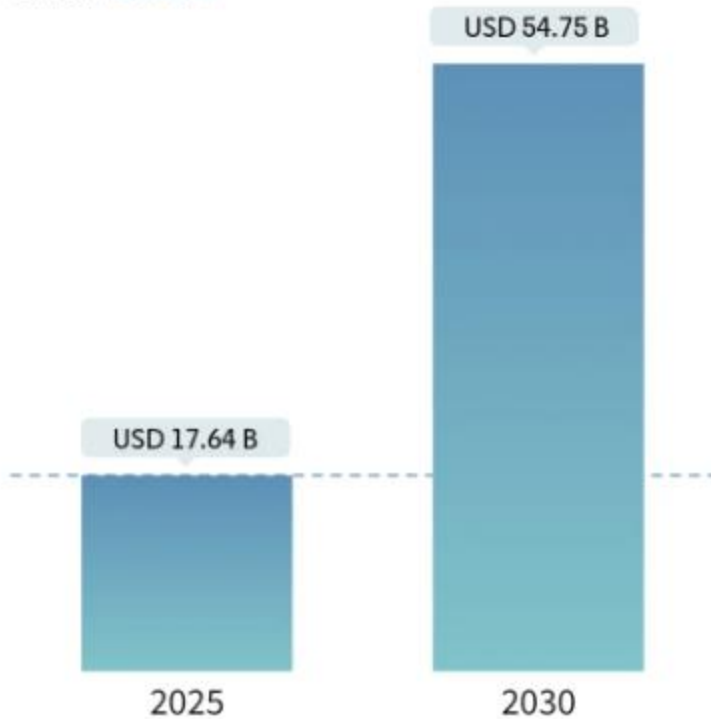
Serious Games Market Size (Mordor Intelligence, 2024)

There are currently lots of companies producing serious games in the form of training and assisting a user's learning process. A large one being Grendel Games (Grendel Games, 2025). At Grendel Games they state, "From helping surgeons to train and develop their laparoscopic skills to children getting better at math: we strive to make the world a better place by making learning and training fun through gaming." (Grendel Games, 2025). After conducting research into their current projects, they specialise in educational training. One of their most successful serious games called Water Battle (Grendel Games, 2025), aims to help families reduce their water consumption by educating children about saving water, energy and other resources. They have scientifically validated results proving that Water Battle has reduced water usage by 7% across

the users. Interestingly they have the added feature to attach the game to the families' smart meters to allow the gamification of their personal household resources and help utility companies improve customer interaction and contribute to climate objectives. This can be seen as both beneficial and harmful. A positive is the personalised feedback it gives, as the families can see the real-time impact that they are achieving with their saving efforts, it is also very engaging for the children and can lead to long-term sustainable habits that they will use when growing up. There are concerns with this attachment however, one being the extra data that is collected by the utility companies. With this extra data they could exploit the customers by making calculated price adjustments or targeted marketing.

Another large competitor in the serious game market is Serious Games Interactive (Serious Games Interactive, 2025). According to Serious Games "Our co-creation process uncovers your specific needs, sets the perimeters, defines resources, develops the right solution and ensures impact: Scope, Concept, Design, Production and Delivery" (Serious Games Interactive, 2025). Researching further into their products it shows that they produce custom delivered serious games, they work together with the company to ensure that a bespoke style of game is reached. They do have some publicly available demos as examples of previously created content, one being Groundhog Day (Serious Games Interactive, 2025) for the client Ørsted. In this bespoke game "New employees will have to complete the learning program to fully understand the information security culture and why it is crucial." (Serious Games Interactive, 2025). This game has the added feature of immediate feedback on completion of the level, informing the employee of any mistakes they made and making them replay levels if any of them were major security risks. This type of learning shows the importance of data collection. During the tasks the analytic package attached to this system will be reviewing the decisions of the user and creating a profile of them that can be passed back to higher management. This form of testing is extremely useful

as the management can see who the biggest security risk is and provide extra training based on the outcomes the data provides.

2.1.3 Limitations of serious games

As this market is growing it is uncovering many downfalls in educating humans with serious games, one of the main downfalls is the over gamification of learning. An example of this is the misuse of cognitive flow. Cognitive flow is defined as "a mental state characterised by extreme involvement, concentration, engrossment, restricted awareness, altered sense of time, insensitiveness to hunger and insensitiveness to fatigue" (Westera.W, 2022). He also states, "Such state of intensive mental activity is considered highly favorable for deep and sustained learning." However, Westera suggests there is an issue with cognitive flow in serious games. He explains that just having the learning section of a game is not enough anymore, people require self-reflection and an evaluation on what they have just learnt. This means that the standard development of games, which is to make sure the game follows a flow, disadvantages a serious game when it comes to someone trying to learn something new. Westera states "Therefore, serious games should expressly not aim to prolong the state of cognitive flow but instead should deliberately put the game on hold from time to time, in order to allow the students to review their actions, strategies and progress" (Westera.W, 2022).

Another potential limitation is the difficulty of training in VR due to the complexity of the controls required to play. This can create an issue if the user is not proficient in controlling the game and requires extra training to ensure they can play correctly. This is an issue as there is a danger of assessing how good the user is at playing the game and not how good they are at completing the job or training.

2.2 Data Analytics

2.2.1 Current game analytic software's

Analytics, which can be defined as "a process in which a computer examines information using mathematical methods in order to find useful patterns" (Cambridge Dictionary, 2025). In the current games industry, there are many main contributors for analytic software. The two leading game engines Unity (Unity, 2025) and Unreal (Unreal Engine, 2025) both have different methods of including analytics into a developers' game.

Starting with Unity Analytics (Unity, 2025) which offers inbuilt plugins and tools to assist a developer in accessing quick and useful data of their game. They state, "After prioritizing the data that is most important to your business, you can use tools to help better analyze that data and view how it changes over time to make well informed decisions for your games." (Unity, 2025). This makes it a very viable option for developers making a game in Unity as they will not need to attach any extra plugins to receive quick feedback for their game. Alongside this, Unity also offers the ability to use external plugins to give the developer an option to include a custom or more bespoke analytics package for their system.

Unreal does not include an inbuilt analytic package, therefore a developer creating a game in Unreal Engine will have to use plugins and external tools, increasing the work required to attach an analytic package. This can also be seen as a benefit as it requires the developer to choose an analytic package which works best for their system.

There are many external analytic companies for developers to choose from. Currently Game Analytics (Game Analytics, 2025) is the most used company to provide game analysis. They suggest that it is trusted by 60,000+ gaming studios which include large names such as Ubisoft, Meta and Kwalee. When diving deeper into how their package works, it was found that the

package can be integrated with over 30 public game engines and can also be included within custom engines.A smaller company that provides a different kind of analysis is Motion Analytics (Motion Analytics, 2025). This company appears to provide in-depth analysis of movement in an athlete completing sports exercises. They state that their goal is to "democratize advanced AI analysis for all sport types, offering, personalized to the athlete's physiology, actionable feedback, and a new level of strategic support to coaches." (Motion Analytics, 2025) After some in-depth research it was found that no hardware was required to provide feedback analysis on the video footage provided. The system runs the video though their custom built large biomechanical model technology which analyses the content and provides the user with personalised recommendations for improvements.

2.3 Analysis within serious games

2.3.1 Integrating game analytics with serious games

There are many benefits to using an analytic package in a serious game. A major benefit would be the ability to include assessment mechanics in the game, that when paired with the analytics tool will provide feedback points. According to (El-Nasr et al, 2013) "Assessment mechanics help game designers select or design game mechanics that generate useful game metrics that allow us to measure variables related to learning, including learning outcomes (cognitive, behavioral, social, affective)". This can also be paired with AI tools to create a learner profile that allows the developer to create a more customized scenario for the user.

2.3.2 Case studies of game analytics in serious games

A good example of a serious game utilising analytics to benefit the user is Duolingo (Duolingo, 2025). It is a game targeted at training language development. Duolingo (Duolingo, 2025) has personalised courses to cater for either full beginners or partially fluent speakers wanting to improve. To achieve this, they use a five-step method:

"1. Our courses are interactive, so you learn new skills right from the start.

2. Our courses use AI and learning science to personalize your learning.

3. Our courses teach the most important content and skills.

4. Our courses motivate you to reach your goals.

5. Our courses are designed to entertain and delight." (Freeman. C, 2023)

Researching further into the second bullet point it can be found that they have produced a machine learning model called Birdbrain (Duolingo, 2025). This model uses analytics stored

about the player to calculate the level of complexity the lessons need to be. According to Bicknell and Brust (2020), Duolingo ran tests on this new feature before releasing it to the public and found that "The results of A/B tests using Birdbrain show that using information from Birdbrain to construct lessons at the right difficulty level for each learner has consistently helped our learners learn more."

A more gamified approach to this topic can be found by Nintendo (Nintendo, 2025). They have produced their take on analytics and training within a serious game format by taking their extremely popular game, Super Smash Bros Ultimate (Nintendo, 2025) and pairing it with Amiibo (Nintendo, 2025) figurines.

Super Smash Bros Ultimate Gameplay (Nintendo, 2025)

The player can train the Amiibo by battling against it and teaching it new moves and tactics. By using analytics provided by the player when battling, the AI will improve, therefore making it harder for the player to win. This can also be looked at as the AI training the player as it will get to a stage where the Amiibo is more skilled than the player providing a challenge for the player to improve their skills. According to ApolloOXXI (2019) they were impressed "by how much

stronger than a level 9 CPU they seemed back then" and "It got to level 36 and almost beat me last night.". These forum quotes prove that Amiibo AI can provide a harder level of training than CPU's and can potentially beat a human player by ensuring they are met with a challenging fight.

2.3.3 Limitations of game analytics in serious games

When personal data is involved there are many concerns and limitations that must be addressed. A major factor to consider when using an analytic package with a serious game is how to correctly store the user data. According to GDPR (2025) personal data shall be "processed in a manner that ensures appropriate security of the personal data, including protection against unauthorised or unlawful processing and against accidental loss, destruction or damage". These regulations ensure the security of European data and provide strict guidelines that a data collector must adhere to. Looking closer into the ethics of data collection within game analytics El-Nasr (2013) states "The digital analytics association has developed the Web Analyst Code of Ethics, which are directly applicable to game analytics, however there is currently no widely agreed upon standard for game analytics."

A second concern for the developers is misrepresenting its user. The developer can incorrectly conclude that when two events simultaneously happen it does not necessarily mean that one was caused by the other. This can occur in the form of exiting the training resulting in an incorrectly answered question, the outcome could be misinterpreted by the analysis package and therefore provide incorrect data about the user.

2.4 Conclusion

This literature review has provided insights into both serious games and analytics within current gaming systems. Serious sims have developed greatly since their conception, it was found that with current technological updates the market has thrived. VR is a major contributor to this as it allows for fully immersive experiences to be created. Combining serious games with analytics can provide the developer, employer and employee with access to deeper insights that can inform improvement in its users. Utilising the full extent of data analytics can assist with creating profiles for employees and can help with understanding how they learn and how to provide them with the optimal form of teaching.

Within the paper two separate games have been examined on their use of analytics. Duolingo (Duolingo, 2025) was found to model a user profile for each user, to ensure the correct level of training is taught. Whereas Super Smash Bros Ultimate (Nintendo, 2025) requires the user to train an AI Amiibo (Nintendo, 2025) to play against, progressively making it harder to beat, therefore producing a training AI for themselves. During this review a limitation which should be carefully considered when creating a product that uses analytics within serious games has arisen. This limitation is the way of correctly storing player data. As this data is personal information, it is of utmost importance to ensure that it is being stored and used in an ethical manner. This means that it should only be accessed by developers and higher management in companies to review the employees' progress and learning ability.

To conclude, this research suggests that game analytics, if used correctly can be a major benefit for the production of serious games. Allowing for more advanced systems to be created with the goal of assisting a user to learn within the fun environment of a game.

3 Output Design

3.1 Introduction

After reviewing the available literature on this topic, it has been decided that a game will be created with the purpose of training the user in a specific task. Data analytics will be used to collect useful information, like the time taken for task completion and number of incorrect inputs. To ensure that useful results can be collected, a system will be created that gives actionable feedback to the user to train them and overall attempt to improve their ability in the chosen skill.

3.2 Project Design

The project that will be created is a strategy game that tests the user's ability to follow cooking recipes. This game will be keyboard and mouse, as it will make the controls of the game simpler and allow for a larger target market. It will also help to reduce the amount of incorrect data that is collected because some users may not be proficient with other forms of control systems. Keyboard and mouse are one of the most commonly used controls. The game will be set up in a 3D environment within a fully stocked virtual kitchen, the user will be given a recipe depending on their initial complexity level survey result, this will be taken during an account setup to ensure a correct starting level.

The game will function by first showing the player a recipe and allowing them a short amount of time to familiarise themselves with the simulated kitchen environment. Once the training has begun the analytic package will start recording all input and movements that the player completes scoring them based on the correct recipe steps. Users will gain points for completing

tasks correctly and lose points for incorrectly following the recipe. An example of a task that would be completed during the recipe is;

The recipe instructs the user to sear their steak for 30 seconds

on both sides before putting the pan in the oven.

The user will be awarded points for correctly identifying

when the steak is ready to be flipped

and when it is time to put it in the oven.

The target audience of this application will be the catering industry. It will benefit commercial companies and catering schools as it provides an interactive way of learning new recipes without wasting ingredients on failed attempts or wasting extra unrequired training days. Another benefit would be the ability to complete this training in the comfort of your own home, this will hopefully increase the enjoyment factor of learning new recipes in the environment of a fun interactive game.

Finally, a range of data will be recorded. This will include the time taken to perform tasks, the ability to follow instructions correctly and the overall score of final dishes. The data will be used to create a user profile that can be displayed in an easy and visual manner. This will allow the management or teaching staff to correctly identify any weaknesses among their employees or students.

3.3 Software Usage

After careful consideration of the literature review the software option decided upon was Unity due to Unity Analytics being a built-in analytic system which would require very little set up. This would then allow more time to be spent focusing on the type of data that is collected and the range of levels of complexity that the game is able to teach.

References

ApolloOXXI (2019). Are amiibos good for training yourself Available at:

https://gamefaqs.gamespot.com/boards/234547-super-smash-bros-ultimate/77360571 Accessed:

03/2025

Bicknell, K., Brust, C (2020). Learning how to help you learn: Introducing Birdbrain!, Duolingo

Blog. Available at: https://blog.duolingo.com/learning-how-to-help-you-learn-introducing-

birdbrain/ Accessed: 02/2025

Cambridge Dictionary (2025) Available at:

https://dictionary.cambridge.org/dictionary/english/analytics Accessed: 02/2025

Djaouti, D., Alvarez, J., Jessel, JP., Rampnoux, O (2011). Origins of Serious Games. In: Ma, M.,

Oikonomou, A., Jain, L. (eds) Serious Games and Edutainment Applications. Springer, London.

pp. 25–43. Doi: https://doi.org/10.1007/978-1-4471-2161-9_3 Accessed: 01/2025

Duolingo (2025) Learn a Language for Free, Duolingo. Available at: https://www.duolingo.com/

Accessed: 02/2025

El-Nasr, M.S., Drachen, A. and Canossa, A. (eds.) (2013) Game Analytics: Maximizing the

value of player data, Springer eBooks. London: Springer. Doi: https://doi.org/10.1007/978-1-

4471-4769-5 Accessed: 02/2025

F1 Authentics (2025) Available at: https://www.f1authentics.com/collections/f1-simulators

Accessed: 01/2025

F1 Jackman (2021) Max Verstappen Talks About Sim Racing, YouTube. Available at:

https://www.youtube.com/watch?v=Ckv7U81K9nE Accessed: 01/2025

Freeman, C (2023). The Duolingo Method: 5 key principles that make learning fun and effective, Duolingo Blog. Available at: https://blog.duolingo.com/duolingo-teaching-method/ Accessed: 02/2025

Game Analytics (2025) Available at: https://gameanalytics.com/ Accessed: 02/2025

GDPR (2025). Principles relating to processing of personal data. Available at: https://gdpr-info.eu/art-5-gdpr/ Accessed: 03/2025

Grendel Games (2025) Available at: https://grendelgames.com/ Accessed: 01/2025

Insomniac Games (2016) Edge of Nowhere. Available at: https://insomniac.games/game/edge-of-nowhere Accessed: 03/2025

Laamarti, F., Eid, M., El Saddik, A (2014). An Overview of Serious Games. In: International Journal of Computer Games Technology, 2014(1), p.358152. Doi: https://doi.org/10.1155/2014/358152 Accessed: 01/2025

Lami, I., Abastante, F., Gaballo, M., Mecca, B., Todella, E (2023). Learning Urban Sustainability by Playing. In: Gervasi, O., et al. Computational Science and Its Applications – ICCSA 2023 Workshops. Springer, Cham. pp. 468–482. Doi: https://doi.org/10.1007/978-3-031-37117-2_32 Accessed: 01/2025

Meta (2025) Available at: https://www.meta.com/gb/quest/setup/ Accessed: 01/2025

Mordor Intelligence (2025). Serious Games Market Size & Share Analysis - Growth Trends & Forecasts. Available at: https://www.mordorintelligence.com/industry-reports/serious-games-market Accessed: 01/2025

Motion Analytics (2025) Available at: https://www.motionanalytics.io/ Accessed: 02/2025

Nintendo (2025). Available at: https://www.nintendo.com/en-gb/ (Accessed: 02/2025).

Peck, D (2025) Online Learning Statistics: The Ultimate List in 2025. Available at: https://www.devlinpeck.com/content/online-learning-statistics Accessed: 02/2025

Serious Games (2025) Available at: https://www.seriousgames.net/en/ Accessed: 01/2025

Unity (2025) Available at: https://unity.com/products/unity-analytics Accessed: 02/2025

Unreal Engine (2025) Available at: https://www.unrealengine.com/en-US Accessed: 02/2025

U.S. Army (2002). America's Army. [Video Game] U.S. Army. Available at:

https://www.americasarmy.com Accessed: 03/2025

Westera,W (2022). The Devil's Advocate: Identifying persistent problems in serious game

design. In: International Journal of Serious Games, 9(3), pp. 115–124. Doi:

https://doi.org/10.17083/ijsg.v9i3.547 Accessed: 01/2025

Yano Research (2024). Total sales value of the e-learning market in Japan from fiscal year 2015

to 2022 with a forecast until 2024 (in billion Japanese yen). Statista. Statista Inc. Available at:

https://www-statista-com.glos.idm.oclc.org/statistics/692405/japan-e-learning-market-size/

Accessed: 03/2025

Bibliography

Cloke, H (2023). Game-Changers: 18 Serious Games That Changed the World. Available at:

https://www.growthengineering.co.uk/serious-games-that-changed-the-world/ Accessed:

02/2025

Kaplan, A. D., Cruit, J., Endsley, M., Beers, S. M., Sawyer, B. D., Hancock, P. A (2021). The

Effects of Virtual Reality, Augmented Reality, and Mixed Reality as Training Enhancement

Methods: A Meta-Analysis. Human Factors, 63(4), pp.706-726. Doi: https://doi-

org.glos.idm.oclc.org/10.1177/0018720820904229 Accessed: 02/2025

Kara, N. (2021). A Systematic Review of the Use of Serious Games in Science Education.

Contemporary Educational Technology, 13(2), ep295. Doi:

https://doi.org/10.30935/cedtech/9608 Accessed: 02/2025

Nisansala, A. et al. (2015). Flight Simulator for Serious Gaming. In: Kim, K. (eds) Information

Science and Applications. Lecture Notes in Electrical Engineering, vol 339. Springer, Berlin,

Heidelberg. Doi: https://doi.org/10.1007/978-3-662-46578-3_31 Accessed: 02/2025

Processim Labs (2025) Available at: https://www.processimlabs.com/ Accessed: 02/2025

Egenfeldt-Nielsen, S., Smith, J.H., Tosca, S.P (2019). Understanding Video Games: The

Essential Introduction (4th ed.). Routledge. Doi: https://doi-

org.glos.idm.oclc.org/10.4324/9780429431791 Accessed: 02/2025

Susi, T., Johannesson, M., Backlund, P (2015). Serious games: An overview. Available at:

https://www.researchgate.net/publication/220017759_Serious_Games_-_An_Overview

Accessed: 01/2025

Wulff, M (2015). Review of GameAnalytics by Lead Data Scientist at Miniclip. Available at:

https://www.linkedin.com/pulse/review-gameanalytics-lead-data-scientist-miniclip-free-wulff

Accessed: 01/2025

Zhonggen, Y. (2019). A Meta-Analysis of Use of Serious Games in Education over a Decade. In:

International Journal of Computer Games Technology. Doi:

https://doi.org/10.1155/2019/4797032 Accessed: 02/2025