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Usage of Airport Operation Simulations in Aviation Training

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Abstract

Nowadays, Industry 4.0 applications have brought unprecedented technological innovations in the transportation logistics value chain. The reflection of these developments in academia and their use in universities is very significant for education. The air transport sector is one of the leading sectors in the use of new technologies. Better results can be obtained by supporting theoretical air transportation education with visual elements and simulations in aviation management education. Students of aviation management departments receive theoretical training. In aviation management departments, students are getting trainings to work different departments of aviation companies. These departments can be supported by hands-on courses such as simulations or laboratories that show how to use information in real life. Within the scope of the research, a trial version of 19 different airport management simulations that can be used for airport management in aviation management departments. It has been evaluated in which simulation the theoretical knowledge of the research airport management course can best be put into practice and contribute to professional development. It is shown which simulations of different scenarios involve airport management strategies.

Keywords: Aviation, airport management, game simulations, educational software, computer-based education

1. Introduction

The attitudes and motivations of educators directly affect the quality of education. The higher the motivation of individuals can be kept, the better the results will be in education. It is difficult to achieve this in the classical classroom environment and the classical education process with crowded groups. So, providing this motivation is one of the most important challenges that educators face today. Educational scientists are working hard to solve these problems and provide more positive teaching environments and processes to individuals by using today's opportunities. Computer-based education takes into account the personal characteristics and preferences of students. Studies such as simulations, experiments, case studies show students the practical value of theoretical knowledge. These studies enable students to be more willing and learn with passion [1].

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Education and technology can be thought of as two concepts that support each other. Because when technology begins to develop in the light of the information that emerges after a disciplined working order, service to education and many different fields is a phenomenon. In order to keep up with the times, technological applications should be integrated into the education system [2].

Technological developments enable different media to be used together in learning-teaching environments. The use of interactive teaching materials such as textbooks as well as interactive audiovisual learning materials can be very useful for students with different learning styles and needs [3].

Educational games and simulations provide powerful systems for training. Within the broad category of educational gaming, there are several types of games such as Serious Educational Games (SEG), Educational Simulations (ES), and Serious Games (SG) [4].

Early examples of training simulations are the software and hardware used in training fighter pilots in the 1940s [5]. The first educational game, created in 1973, Lemonade Stand, was an example of an initial foray into computer game use in a class. However, Lemonade Stand was significantly limited in its ability to assess outcomes and more broadly simulate actual tasks in the real world [4].

Simulation games are guided by the participants within certain rules and limits. The game reflects a representation or model of reality. Users interact with this reality and make relevant decisions. Simulation games include business games, urban simulations, etc. [6].

Many research suggests that computer-aided applications are effective in reinforcing behaviors and structuring the learners' knowledge in the teaching process [7-10].

More is now expected from education and trainers. It is discussed that trainers should be more active in the lesson, apply different strategies and methods, how students can reach deep learning and increase their cognitive level [11]. For instance, The Next Generation Science Standard (NGSS) is an educational standard used in the United States. Next Generation Science Standards (NGSS) are developed based on students worldwide, who are undergoing very rapid changes. To meet this standard, trainers must plan learning that helps students to be ready to pursue further education [12] also career [13].

The main purpose of this research is to search simulation games for airport management. There are many simulation applications in pilot and technician training but aviation management training has only theoretical education. This is our main motivation to study on this research.

2. Literature Review

2.1. Computer-Based Education

Alessi and Trollip (2001) mentioned in their study that they discussed their educational philosophy and approaches to the use of computers, multimedia, and the internet in education. The existence of a wide variety of software is suitable and useful for use in different fields of education. Their study presents extensive research on the design of educational software. Developing some educational software (tutorial and drill) is simple while developing some educational software (simulations and open-ended learning environments) is more difficult and complex [14].

With the developments in the field of information technologies, computer-based structures have started to be used in the field of education. Sometimes, without even the need for an educator, teaching activities were started with direct human-computer interaction [15].

Cognitive multimedia learning theory forms the basis of multimedia learning. This theory explains how people learn with words and pictures in multimedia environments. The cognitive multimedia learning theory is shown in Figure 1.

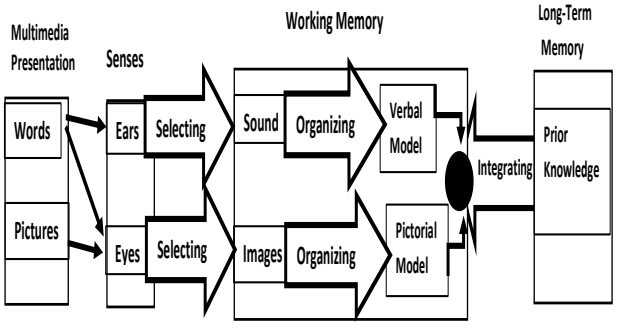

Figure 1. Cognitive theory of multimedia learning.

In computer-based education, the computer is used as an environment where learning occurs. CBE is a teaching method that strengthens the teaching process and student motivation, that the student can benefit according to his learning speed and is a

combination of self-learning principles with computer technology. In other words, CBE is the transfer of educational content or activities via computer. The use of new technologies in education facilitates educational activities because of the interaction of more sensory organs compared to the traditional method [16].

With the widespread use of educational technologies, cooperative learning, which is increasingly important both in daily life and in educational environments, is constantly developing and enriched with different methods and techniques. One of these techniques is the realization of cooperative learning using computers, which is used to facilitate learning among learners. How computer-supported cooperative learning can strengthen interaction and work between individuals within a group has received a lot of attention lately [17].

2.2. Simulation

One of the commonly used formats of computer-based education is a simulation [18]. When people use more senses to learn something new, information becomes more permanent and easier to learn. With artificial environments created in simulation technologies, people can use more senses and facilitate comprehension [19]. With the usage of simulations, it was seen that there was a great decrease in the misconceptions of the students. In addition, it is reported that simulations designed by considering students' prior knowledge can help to create conceptual change in students [20].

In addition, simulations allow you to experience the closest realistic results in a risk-free virtual environment. Many different simulation and training applications in operational and management areas are used in university's educational programs. Simulation and game software enterprises also produce various simulations and games that can serve to acquire the necessary knowledge and skills in today's competitive environment [18].

Students, who use computer simulations reveal the properties of the system in the simulation through experiments (Figure 2). Simulations are very suitable systems for exploratory learning. Computer simulations can be used to learn a system or process. Types of computer simulations are conceptual models and operational models. Conceptual models include principles, concepts, and facts. Operational models include cognitive and non-cognitive process sequences. It can be used in areas such as economy, physics, radar control, etc. [21].

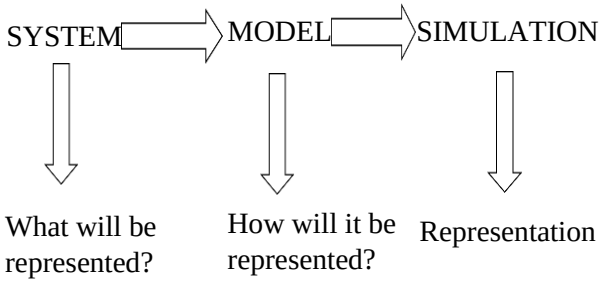

Figure 2. Simulation, Model and System Relation

Simulations are used for intelligent and complex operations and designs in production. In addition, it provides optimum decision-making by making exploration and planning models. Moreover, companies provide convenience in transition to industry 4.0 by making cost, risk, procedure, and performance evaluations [22].

2.3. Simulation Applications in Aviation

Working in the aviation industry requires communication, teamwork, problem-solving. Due to the differences between what students learn in the classroom and real life, the risk of accidents or incidents increases. With the rapid development of computer technology, simulation technology has emerged to solve these problems in aviation [23].

Flight simulators are one of the most widely used simulators in aviation. Engineers use the latest technologies to simulate a real airplane. Over the years, experts have come up with more complex and advanced simulations. Simulations are now expected to not only perform pilot duties but also understand complex human responses. As a result, the human-centered approach in simulations has become increasingly common [24]. One of the advantages of flight simulators is that they create the reality that a pilot is sitting on an airplane. There is a real cockpit layout from simulation and real control mechanisms of aircraft. Another advantage is that simulation training is less costly than real aircraft training. It also increases safety as it allows many flight and emergency attempts [25].

Apart from training simulators, there are also simulations used for research and development.

These R&D simulations have to adapt to ever-changing environmental conditions. These simulations are mostly used for controlling airports and air traffic. Airports are complex systems with many stakeholders such as operators, ATC providers, airlines, ground handling services. To optimize the usability and performance of these systems, examine the interaction of operators with their work environment, for development, testing, and validation purposes an experimental environment is needed [26].

Donohue, et al. 2002, explained many new simulation technologies are used to decrease congestion and increase safety and capacity in air transport. Some of those: [27].

- SIMMOD- FAA's airport and airspace simulation model
- TAAM- Total Airspace and Airport Modeler are used to simulate aircraft at and in the airspace around the airport.
- RAMS- European Reorganised ATC Mathematical Simulator

Total AirportSim is a computer software that can model both air and land sides. The model has been developed gradually and implemented over the years together by LeTech and the International Air Transport Association (IATA). The system consists of 3 main modules [28].

- Airport/Runway
- Gate
- Passenger Terminal

Morlang, 2006, stated in his research that increasing demand increases the capacity. For capacity increases to be made without sacrificing safety, it is necessary to simulate before the actual operation. The research focuses on the following realtime Human – in – the – Loop (HIL) simulation facilities: [29]

- Air Traffic Management and Operations Simulator (ATMOS)
- Apron and Tower Simulator (ATS)
- Airport and Control Centre Simulator (ACCES)
- Generic Cockpit Simulator (GECO)

3. Theoretical Method

Secondary sources were used in the literature part. In this study, a literature search was carried out. Priority was given to master and doctorate theses and research, articles, and books were utilized. In addition, current airport management simulations were examined and compared using an educational software evaluation scale which is Ateş (2011) Educational Software Evaluation Scale. This research covers airport management simulations reviewed in 2018. The most downloaded 30 airport simulation mobile and pc games were reviewed by researchers. 30 of these simulation games were examined by 4 doctoral students. Within the scope of the sample selection, the main titles of the airport operation games, and visual videos were watched. Educational training is the closest to the real airport operation scenarios created on Queue Management, Crowd Management, Slot Management, Baggage System. It includes methodological techniques for research purposes.

The educational software evaluation scale includes 6 dimensions and 41 items that are educational software features, visual design features, multimedia features, content, orientation and help, installation and usage features. 19 simulation games were selected which have free trial versions among 30 simulation games.

The research was carried out for the purpose of determining the situation of one semester (fall semester 15 weeks) in the 2018-2019 academic year in Eskisehir Technical University and Muğla Sıtkı Koçman University.

Data were collected within the scope of the airport final assignment with Aviation Management students. For simulation evaluation, homework was assigned to 40 Eskişehir Technical University students and 40 Muğla Sıtkı Koçman University students. Each game was distributed into groups of 4 people to evaluate them. Final assignment was completed by 76 students from 80 students.

The students were asked to play the games in this context in Queue Management, Crowd Management, Slot Management, Baggage System scenarios. The scenarios were applied on every games and each game was evaluated by a group. In the comparison, Educational Software Evaluation Scale was used [5].

Educational Software Evaluation Scale dimensions were evaluated with the weighted average and the ranking was made in accordance with the formula below, in the research.

$$C\bar{\pi} = \frac{\sum_{i=1}^{n} E_i\ VD_i\ M_i\ C_i\ OH_i\ U_i}{\sum_{i=1}^{n} SI_i}$$

E=Educational Features
VD=Visual Design Features
M=Multimedia Features
C=Content Features
OH=Orientation and Help
IU=Installation and Usage
SI=Scale Total Item

The following hypotheses about the first three software, which came out as a result of the weighted average ranking, were analyzed with the SPSS program Analysis Program.

H0 hypothesis: There is no difference between the educational features evaluation scores of the games among the first 3 games with the highest weighted average.

H1 hypothesis: There is a difference between the educational features evaluation scores of the games among the first 3 games with the highest weighted average.

4. Analysis and Findings

Sample scenarios covering research can be grouped as follows:

Scenario 1: Queue Management

Incorrectly placed check-in counters: The students participating in the research were asked to determine the number of check-in desks, boarding desks, and security checkpoints. Because we have to put up with the operating costs as well as the cost of purchasing these factors, and we have to hire personnel for each one. It has become very difficult to create a queue because check-in and boarding counters are located on a small area. Waiting times have increased. The flights at the same time do not arrive on time because check-in starts at the same time.

Display of the queue labyrinth: First of all, it is necessary to create labyrinths in order to enter the proper sequence. This prevents the formation of turmoil in the queues. In addition, the baggage bands need to be linked to all check-in counters so the necessity of putting them side by side is a constraint for us. It is necessary to put the check-in desks side by side and at certain intervals so we cannot put them in very different places.

Crowded security points: Another point that forms the queue is the security checkpoints. The same labyrinths have to be created here as well. Also, another problem is that staff also have to pass through safety points and wait in queues with passengers. The solution to this problem is to allocate different safety points for passengers and personnel.

Example of a flight plan: Lastly, planning flights with one or two hours of shifts without taking the departures of the aircraft at the same time, could be another step in the solution.

Scenario 2: Crowd Management

Entrance crowd: The greatest cause of crowd formation in airports is the inadequacy of the guiding signs and advisory banks. People are having difficulty finding places to go and causing a big crowd. Trying to find something on their own is causing passengers to get angry, bored, and sometimes unable to reach their flights.

Crowd at bus stops: Crowded places are bus stops and passengers dropping and picking points. Bus stops must be in sufficient number and in suitable places.

Crowd in baggage pickup points: Baggage pickup points are always the most crowded places and waiting times are long here. First of all, enough seats should be placed for passengers to sit. There must be enough baggage points and staff to avoid any delays. The number of baggage handling areas should be increased according to the number of aircraft landing at the airport.

Scenario 3. Slot Management

Draft Flight Plan: There are a few things that restrict us when we sign slot agreements with airlines. Which are; operating hours of the airport, if a flight is delayed this reflected on all flights, at least 3 hours before the flight time, the flight must be set in the schedule, and airport and parking position capacity of the airport.

An Example Contract: The first step for slot management is to sign agreements with airline companies. As you can see, the contracts include the conditions of the companies and the amounts they will pay for the airport. We, as the airport manager, read these contracts and sign or decline according to whether our airport is suitable for these flights and

whether there is a profitable agreement. Successful flights are transformed into green. Delayed flights are shown in red.

Scheduled flight plan: If a flight is delayed, it is necessary to decide whether the flight should be delayed or not. If we do not allow it to be delayed, some passengers may be out. But if you let it delay, other flights may be delayed. Here, the manager should make the most appropriate decision. The suitability of parking positions at the airport is also of great importance when planning a slot. Large planes cannot park in small positions, so when signing a contract, it is necessary to pay attention to which aircraft will be operated.

Scenario 4. Baggage System

Display of the baggage bands: It is very difficult to set up a baggage system at the airport. A given baggage needs to be reached as soon as possible. However, the luggage band is a very long way to go at a certain speed. This band must first be connected to check-in counters. As mentioned in the queue problem section, check-in counters have to be side-by-side for this reason.

Baggage bands from underground and over ground: Some of the luggage straps should go from the top to the bottom of the straps. Building from under the ground after the check-in counters finishes will be the right decision in terms of space savings. Baggage moving in the bands is gathered at the baggage collecting places that are more visible and loaded onto baggage cars and taken to the plane. Incoming flights are left here again by baggage.

Baggage collecting area: Lastly, they are sent to baggage claim areas to pick up passengers' luggage. We must determine the number of baggage reception areas according to the density of the airport.

Reviewed Airport Simulation Games and Features

The following codes were used when entering the airport simulations that can be used in airport trainings into the SPSS analysis program. In the analysis section, the software will be mentioned through coding.

1. Airport Clash 3D
2. Airport Inc
3. Airport Master
4. Skyrama
5. Airport Tycoon Deluxe
6. Airport Simulator
7. Sim Airport
8. Airport Ceo
9. Airport Simulation 1-2 2018
10. Airport Parking
11. Airport Control
12. City Airport Super Flights 3D
13. Airport Terminal On Stream
14. Airport Rush
15. Airport Guy: Airport Manager
16. City Island Airport
17. Airport City: Airport Tycoon
18. Prg Live
19. Airport Dme

The Reliability Statistics of the Educational Software Evaluation Scale, which includes 41 items of the survey in the research, are given Table 1.

Table 1. Reliability Statistics

Cronbach's Alpha	N of Items
,914	41

Figure 3 was prepared by visualizing the weighted averages of the answers given by the software to the Educational Features Dimension Scale Items with the formula. Code number 6 is Airport Simulation, 7 is SIM Airport and 8 is Airport CEO. Educational Features, which take motivation and education within the scope of the research, will be examined in more detail in later analyses.

$$C\bar{\pi} = \frac{\sum_{i=1}^{n} E_i}{\sum_{i=1}^{n} EDI_i}$$

E= Educational Features
EDI= Educational Features Scale Dimension Items

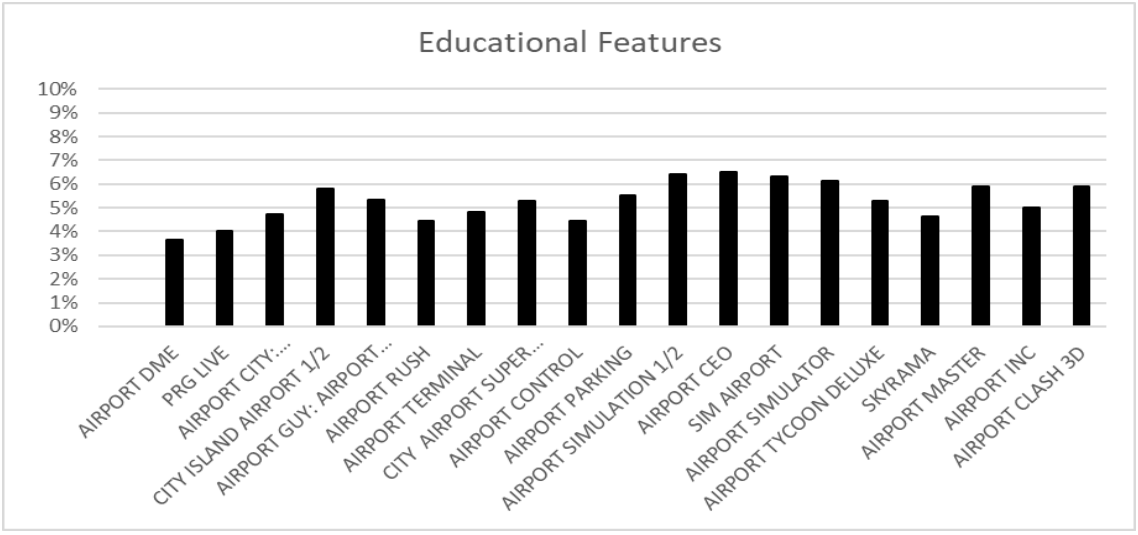

Figure 3. Educational Features of Reviewed Airport Simulation Games

Visual Design Features are parts that students consider graphic design on the simulation side. With the developing technology, depending on the graphics cards, very realistic 3d graphics are used in games. Even if it is not directly related to education, it is accepted as a criterion in determining the quality of the tool used. In the research, Airport Tycoon Deluxe with code number 5, SIM Airport with number 7 and Airport CEO with number 8, Airport clash 3d with number 1 are the programs with the highest visual design ranking. Visual Design weighted averages of other programs are shown in Figure 4.

$$C\bar{\pi} = \frac{\sum_{i=1}^{n} VD_i}{\sum_{i=1}^{n} VDI_i}$$

VD= Visual Design Features
VDI= Educational Features Dimension Scale Total Items

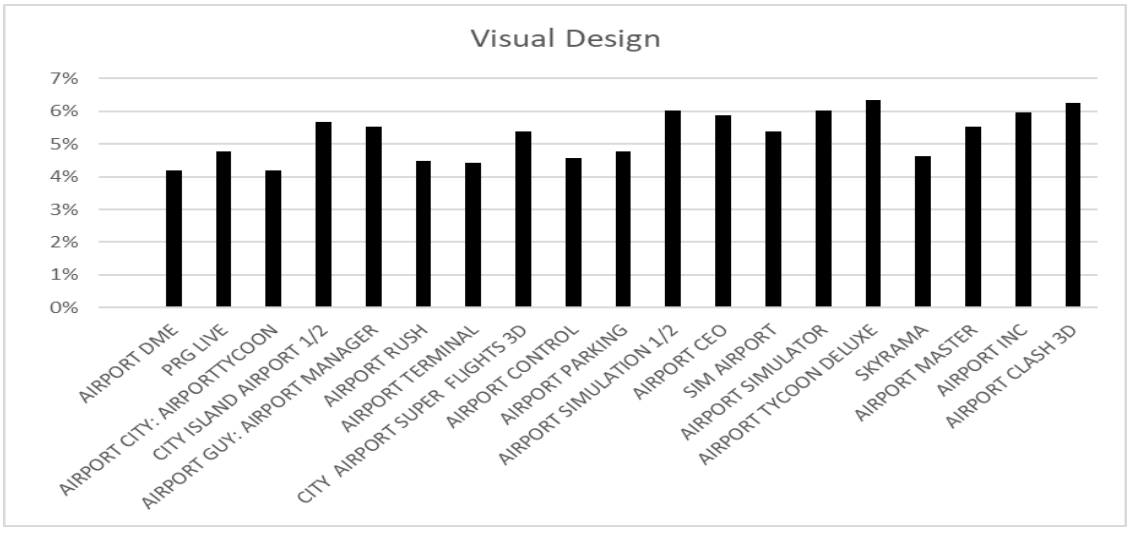

Figure 4. Visual Design Features of Reviewed Airport Simulation Games

Designs such as sound and simultaneous connection are auxiliary elements in educational software. These items were evaluated in the Multimedia Dimension Scale with the formula above. Figure 5 was prepared based on the results obtained. Airport Master with code number 3, SIM Airport with number 7 and Airport CEO with number 8 have higher average scores on this dimension of the scale.

$$C\bar{\pi} = \frac{\sum_{i=1}^{n} M_i}{\sum_{i=1}^{n} MDI_i}$$

M= Multimedia Features
MDI= Multimedia Features Dimension Scale Total Items

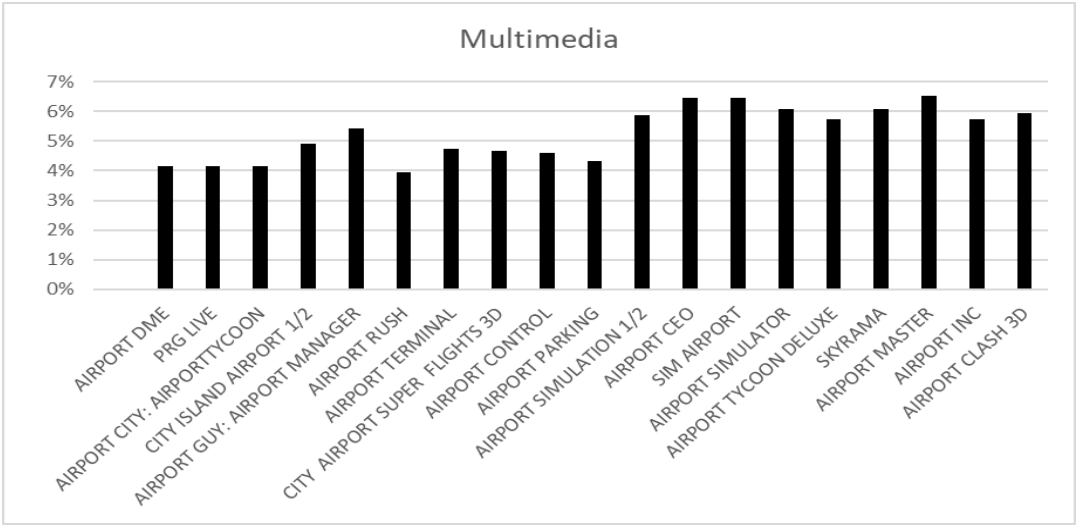

Figure 5. Multimedia Features of Reviewed Airport Simulation Games

Another important issue in the evaluation of software used in education is their content. Content Features data are given in figure 6. Sim Airport, Airport Tycoon Deluxe and Airport simulator software are in the top three in the ranking.

$$C\bar{\pi} = \frac{\sum_{i=1}^{n} M_i}{\sum_{i=1}^{n} MDI_i}$$

C= Content Features
CDI= Multimedia Features Dimension Scale Total Items

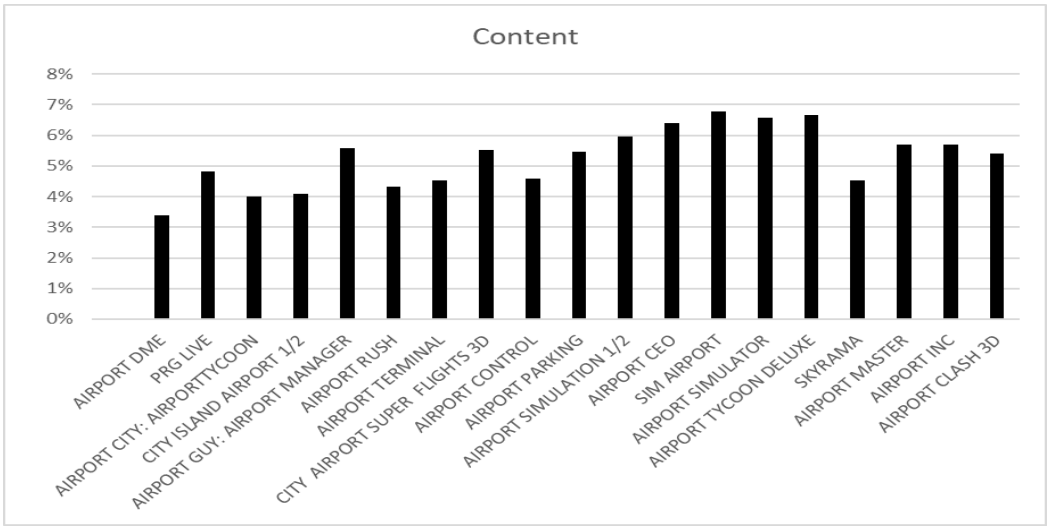

Figure 6. Content Features of Reviewed Airport Simulation Games

The arithmetic mean and standard deviation of the scores of the Educational Software Evaluation Scale and one of the sub-dimensions Educational Features of the software that can be used for education were calculated. They are ranked from highest to lowest average. Accordingly, hypothesis tests were conducted regarding user comments on Airport Simulation 1-2, Airport CEO and Sim Airport.

• H0 hypothesis: There is no difference between the educational features evaluation scores of the games among the first 3 games with the highest weighted average.

• H1 hypothesis: There is a difference between the educational features evaluation scores of the games among the first 3 games with the highest weighted average.

In order to determine whether the attitude scores of the first 3 weighted average software included in the study differ significantly according to Educational Features, the independent groups chi-square test was conducted. However, since the variances did not show a homogeneous distribution according to the Levene F Test results, the Kruskal-Wallis Test was used for independent measurements. The difference between the mean rankings of the Kruskal Wallis-H software groups, which was made

to determine whether the mean of the rankings of the Educational Features scale differs significantly according to the variable of "Compliance with The Learning Needs of the Target Audience", was not found statistically significant (Table 2, Table 3, Table 4).

Table 2. Descriptive Statistics

	N	Mean	Std. Deviation
Compliance with the learning needs of the target audience	76	2,54	,840
Game Name	76	10,00	5,514

Table 3. Ranks

	Game Name	N	Mean Rank
Compliance with the learning needs of the target audience	AIRPORT SIMULATION 1/2	4	6,88
	AIRPORT CEO	4	8,25
	SIM AIRPORT	4	4,38
	Total	12	

Table 4. Test Statistics(b)

	Compliance with the learning needs of the target audience
N	12
Median	3,00
Chi-Square	2,667(a)
df	2
Asymp. Sig.	,264

(a) 6 cells (100,0%) have expected frequencies less than 5. The minimum expected cell frequency is 1,0.
(b) Grouping Variable: Game Name

The difference between the mean rankings of the Kruskal Wallis-H software groups, which was made to determine whether the mean of the rankings of the Educational Features scale differs significantly according to the variable of "Compliance with The Learning Needs Of The Target Audience", was not found statistically significant. H1 hypothesis was rejected.

5. Conclusion

As a result of the educational software evaluation scale, analyzes were made on the game which got the highest scores. In mobile simulations, the highest score is Airport simulator 1-2. In computer simulations, Airport CEO got the highest score. Considering all the simulations, the Airport CEO is the most successful, so it is emphasized how airport management strategies are implemented in an Airport CEO simulation. When compared to 19 airport management simulations, it was observed that the airport management strategies could be implemented as simulated as Airport CEO. A simulation that allows for different strategies to be applied both on the air and on the landside needs to benefit from the information taught in aviation management courses and not to think like an executive. Simulation with this aspect allows an aviation management department student to develop their professional orientation before start to work in the sector.

The use of simulation in distance education will provide great benefits to students. Simulations can be used in the COVID-19 interactive lecture environment.

In addition, airport simulations, which we expect to become more widespread in the future, can make airports more effective and efficient. For example, it can reduce long waiting times, solve vehicle parking and capacity problems. Airports can be easier to manage with better planned airports.

The future research scope can be expanded in later studies and compared with control and experimental groups.

Ethical Approval
Not applicable

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