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Design of a serious game learning mechanism for the implementation of ISO 22000:2018 in the swallow's nest industry

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Abstract
A food safety management system standard, such as the International Organisation for Standardisation (ISO) 22000:2018, is required for food items like swallow's nests to be approved for entry into most countries. Although ISO 22000:2018 is already well known to many businesses, its manual documentation rules are onerous. As a result, a digital approach is needed to expedite the adoption of this standard. If changes in user behavior do not support a digital approach in the form of an information system, then the process may become more complex. To increase user participation, a computational flow incorporating a learning idea is required. A serious game framework that emphasizes enjoyment and has a clear objective—implementing the ISO 22000:2018 flow—is used to construct a digitalization of ISO 22000:2018 that is based on understanding serious game mechanics. Employing research using swallow's nest management information system (SN-MIS), serious game design software engineering is demonstrated using a hierarchical finite state machine, which has three superstates: initial sorting, processing, and final sorting. On the serious game learning mechanism side, there are learning elements in the form of game actions, learning activities, and instructional activities. Gamification is achieved within the game action elements. The user interface plays a major role in gaining users' attention to inform them about the system being used and influence their behavior to facilitate the effective implementation of ISO 22000:2018.

Keywords
Gamification, ISO 22000:2018, Serious game, Learning mechanism, Swallow's nest industry.

1.Introduction
The importance of the international organisation for standardisation (ISO) 22000:2018 food safety management standard is internationally recognized. Industries in the food sector use this standard to validate their production outcomes globally because it offers comprehensive assistance for implementing efficient food safety management systems (FSMSs) [1, 2]. Strict standards for food safety and quality apply to export production. Digitalization can speed up and enhance ISO 22000:2018 operations in markets that have become more competitive [3].

The swallow's nest industry needs to follow food safety regulations during the production process to export its products.

Swallow's nests are a major export commodity in Indonesia with great growth potential. Based on 2020 Indonesia maps of agricultural commodities eksport (IMACE) data the top 10 destination countries for swallow's nest exports, after China, are Taiwan, Malaysia, Australia, Thailand, Canada, France, Hong Kong, Singapore, Vietnam, and the United States [4]. The number of export destinations is increasing, so food safety regulations must be implemented as quickly and precisely as possible. Customers, both domestically and abroad, are more likely to trust and be satisfied with swallow's nests of higher quality.

It is envisaged that Indonesian swallow's nest products have a competitive edge in the global market [5]. Several methods are used in the industry to process swallow's nest material, including sorting, dividing, removing feathers, washing, drying, molding, grading, and heating [5, 6]. Digitalization has shown to be crucial for guaranteeing precision and promptness in meeting food safety and quality standards, particularly in light of the everstricter regulations. A paperless framework can be efficiently realized, but a digital strategy by itself is unable to deliver rapid changes in

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worker behavior to comply with every ISO 22000:2018 procedure [7, 8]. The implementation of serious games (SGs) is a system approach that combines enjoyable and educational components [9–11].

User behavior can be impacted by a novel system design. In addition to operating the system, users engage in learning processes when they use SGs. To increase user engagement and ultimately achieve food safety requirements, the SGs concept focuses on accuracy and compliance with the ISO 22000:2018 process while also including a fun element. This study investigates the idea of learning processes, the advantages of employing SGs in ISO 22000:2018 compliance, and how digitalization might fortify important facets of the supply chain for the swallow's nest sector. SGs also provide it with a competitive edge by guaranteeing that stringent food safety regulations are followed.

The rest of the research paper is structured as follows: Section 2 covers the related research work. Section 3 explains the proposed method. The outcomes and analysis of this research are discussed in Section 4, and the conclusion is provided in Section 5.

2.Related work

A proprietary version of swallow's nest management information system (SN-MIS) was created based on the steps involved in the production process [12], including sifting, dividing, removing feathers, washing, drying, molding, grading, and heating. Additionally, research is being done on web-based management of swallow's nest production to help businesses manage their inventory and streamline their processes to speed up the reception, production, and delivery of goods [13]. There is also research on the impact of managing swiftlet nests, where optimal management can reduce negative impacts on surrounding communities [14]. Several ways to make swallow nest quality optimal is by classifying its quality using a support vector machine based on computer vision [15]

A key safety standard for companies in the global food chain is ISO 22000:2018, developed by the ISO to ensure that they stay within the norms of FSMSs. Businesses using ISO 22000:2018 can become certified based on standards covering all food chain entities, from farmers to consumers or the public at large [16]. With a preventive approach to food safety, ISO 22000:2018 combines and enhances the key components of ISO 9001, namely, quality management system requirements and hazard analysis and critical control points (HACCP) [17]. The primary goals of HACCP are to identify, avoid, and eliminate food safety hazards. As outlined in ISO 22000:2018, the major components of an FSMS are as follows:
– procedures to guarantee a hygienic and clean atmosphere;
– system management, encompassing documentation procedures;
– interactive communication within the organization.

By incorporating gaming components, SGs seek to educate, enlighten, and train users in addition to amusing them [18, 19]. The following are highlighted in the SGs learning mechanism:
– well-defined learning goals;
– real simulation aspects;
– game elements;
– feedback mechanisms;
– interactive concepts;
– support for adaptive learning;
– real-world context;
– clear storytelling;
– points;
– accessibility;
– difficulty.

Research has been performed on optimizing the flow of SG scenarios using a variety of models, including pareto optima, fuzzy, evolutionary algorithm, neural networks, and polynomial functions [20–25]. With the aim of learning, a lot of research has also been carried out on SGs for training purposes, especially to increase motivation, learning effects and transfer of knowledge [26–28]. In industry, the use of SGs also plays an important role, such as various research that has been carried out in the manufacturing industry. Although manufacturing education has used simulations to facilitate a better understanding of theoretical concepts, the shift to the use of SGs is prone to errors, so SGs may be a solution to minimize such errors. Apart from these business conditions, several behavioral factors also play a role in the success of the industry. First, the limited rationality possessed by economic actors is only an additional element that makes the situation worse. Second, decision-makers, like society in general, are susceptible to misperceptions of feedback, which means that their performance is in complex and dynamic systems. Third, decision-making in a dynamic system is difficult because it requires dynamic decision-making. And fourth, decision-makers are also limited by numbers as a form of success. So, an approach is needed to classify SGs. First, the virtual organization life cycle is analyzed by identifying relevant processes in each phase. The second approach is based on the definition of the game genome. To do so, we analyze the background that makes it increasingly difficult to maintain an overview of the existing game [9, 29].

3.Methods

SN-MIS, which is used to facilitate the implementation of ISO 22000:2018 at one of the companies that process swallow's nest material, was examined as part of the research. The procedures for receiving, producing, and distributing the items are all included in the management of swallow's nest material production. The end product is swallow's nest material, which is ultimately sold to end consumers. *Figure 1* shows the overall functionality of the information system.

Figure 2 illustrates the mapping that was developed for the categories of SGs mechanisms, in the learning mechanism section from an earlier study on multiplayer SG mechanisms [20, 30] after analyzing the operational information system.

Figure 1 The general flow of SN-MIS

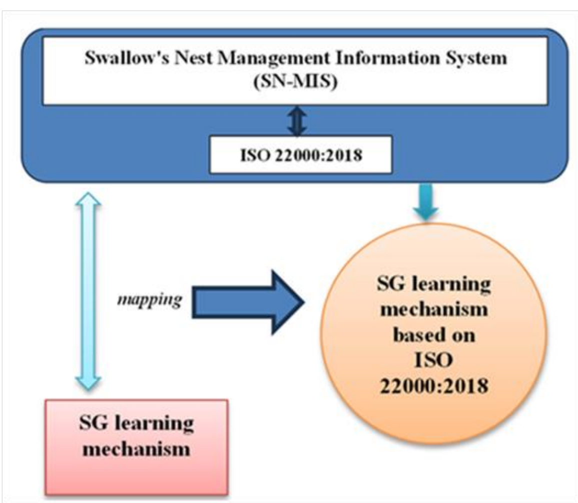

Figure 2 Mapping SN-MIS, the SGs mechanism, and ISO 22000:2018

Matching learning mechanisms with SGs takes place based on the flow of information from SN-MIS. Through the integration of gaming features, SGs seek to educate, enlighten, and train users in addition to amusing them. *Figure 3* shows the SG's learning mechanism, which is a key component.

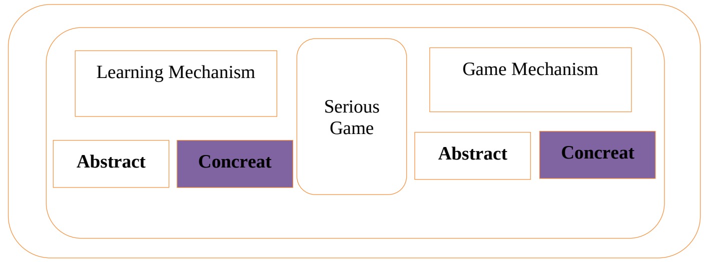

Figure 3 SGs learning mechanism [20]

The idea of an SGs learning mechanism connected to an information system for managing a swallow's nest is the focus of this study. The production of nest material is simultaneously represented by the SN-MIS.

4.Results and discussion

4.1SN-MIS flow based on ISO 22000:2018

When items are delivered and placed in the raw materials warehouse, documentation is kept of their origin as well as the recipient, the person responsible, and the shrinkage value. When the products arrive, there may be computation errors or weather-related shrinkage. Sorting, dividing, hair removal, washing, drying, molding, grading, and heating are all included in the production process flow [12]. *Figure 4* provides the complete information.

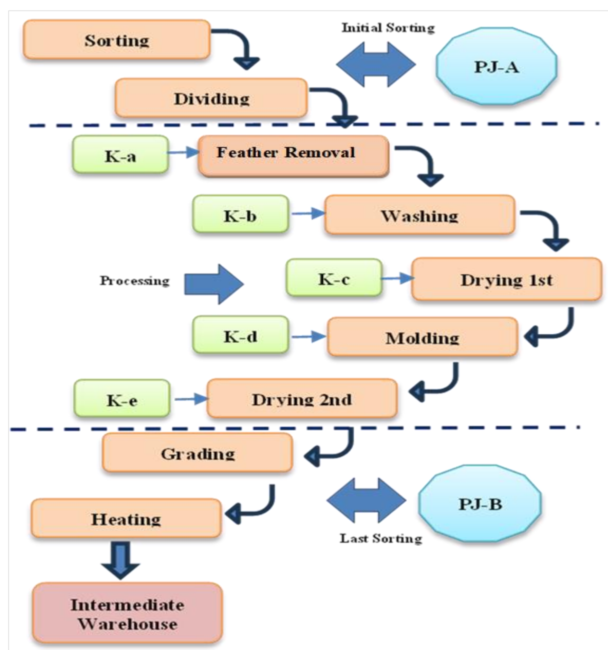

Figure 4 SN-MIS production flow

Figure 4 illustrates that every production process has a designated individual. Sorting and distribution are the responsibilities of the worker PJ-A, and grading, heating, and transportation to the intermediate warehouse are the responsibility of PJ-B. In the meantime, K-a performs hair removal, K-b washing, K-c the first drying process, K-d molding, and K-e the second drying process.

The product must next be packaged, consisting of primary, secondary, and tertiary packaging for eventual transport and delivery. Each package must be kept under control and properly recorded in the information system by a single individual.

4.2Mapping the learning mechanism in SGs and SN-MIS

The activity theory-based model of serious games (ATMSG) methodology is used for the SG learning mechanism. SGs are viewed by the ATMSG paradigm as a learning tool and medium rather than as a distinct component. Three activities are identified from an educational standpoint: instructional, learning, and play [31]. The domain of learning activities using SN-MIS is represented by the idea of SN-MIS mapping, which is linked to the learning process in SGs, as shown in *Figure 5*.

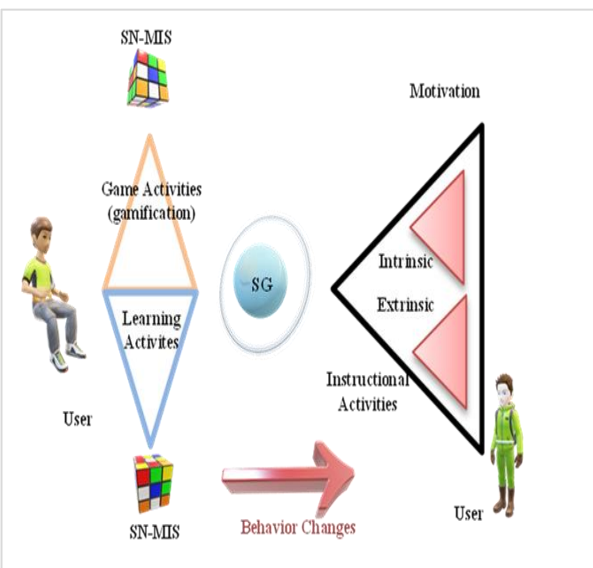

Figure 5 Mapping SN-MIS with SG learning mechanism

By stressing learning activities and instructional activities to provide overall internal and extrinsic incentives when using the system, SGs are predicted to cause behavioral changes in SN-MIS users.

4.3SN-MIS's SG learning mechanism

The design of the SG system flow is the topic of intrinsic learning activities, and a feedback mechanism is included. In contrast, user participation in the SG system is necessary for extrinsic learning activities. Users must apply specific concepts to both intrinsic and extrinsic activities for them to be precisely defined by active learning, learning interaction, and the creation of challenges [32]. Activities are broken down into user actions, and then into portions with distinct purposes, in the hierarchical analysis of the ATMSG approach, as shown in *Figure 6*.

The elements of the SN-MIS are dependent on the production process. Even though each feature has a specialized function, the overall system goal is still met. Every feature has an action that needs to be performed appropriately by the user. Every stage of the feature can provide additional experience when instructions are accompanied by feedback, which directly affects how the user behaves when using the SG system.

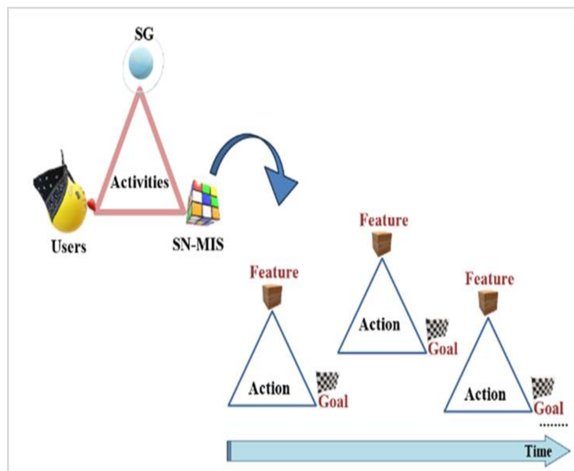

Figure 6 A thorough breakdown of the steps involved in achieving each goal in the SG learning method

A hierarchical finite state machine (HFSM) is used as the learning mechanism to give the SG's flow a more complex appearance. The initial sorting superstate, the processing superstate, and the final sorting superstate are the leading states in the HFSM, which represents the production flow in the swallow's nest business. There are two substates in the initial sorting superstate: sorting and sorting division. There are five substates in the processing superstate: hair removal, washing, drying, molding, and drying 2. There are three substates in the final sorting superstate: grading, heating, and intermediate warehousing. See *Figure 7* for further information.

The check sort transition in the first sorting superstate, the check process in the processing superstate, and the check sort in the final sorting superstate are examples of the transitions used to track the active process that are present in each superstate, as illustrated in *Figure 7*. If the condition is satisfied, the transition has a value of 1; otherwise, the start of each superstate undergoes a repetition process.

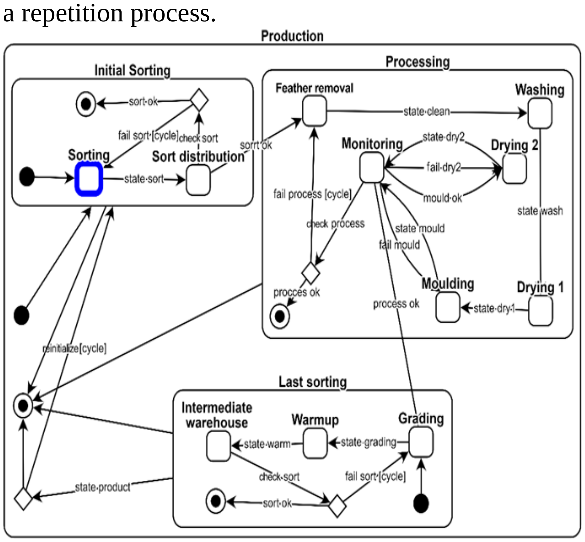

Figure 7 HFSM swallow's method of producing nests

When a user operates the system, learning activities and instructional activities are visible from HFSM in the production of swallow nests. This is how the learning process in SGs works.

4.4Components of the gaming activity

Gamification places a premium on users having fun in gaming activities. Aiming to activate the user's intrinsic drive and promote joyful learning, it involves adding more entertaining components to a system [33, 34]. SN-MIS is designed with this idea in mind. This means that the display is made as visually appealing and accessible as possible, which will help users become accustomed to carrying out production flows that adhere to ISO 22000:2018. Gamification of the learning mechanism-game mechanism (LM-GM) for the production of swallow's nests is part of the SG concept [30, 35] and consists of actions, system characteristics, and targets. Gamification actions fall into several categories, as shown in *Table 1*.

Table 1 The action category in the SG system has been gamified

Category	Element
Entity	UI, Icon
Manipulation	Cursor movement
Information	Question or reminder

The idea of user interfaces (UIs) or icons with distinct cursors for various activities is an intriguing one found in the entity category. In addition, there is information that serves as a reminder when a user interacts with the system; an example of this is the UI shown in *Figure 8*.

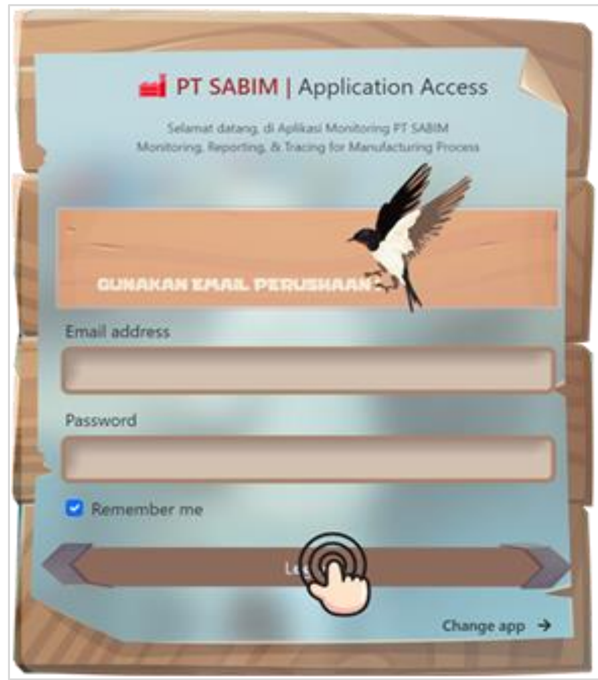

Figure 8 Action categories in the SG system are gamified

Figure 8 illustrates how the UI and icon elements are gamified to enhance their visual appeal. In addition, certain features alter the icon's shape throughout the graphic display manipulation process and include information meant to serve as a reminder to users. Objects, stories, and feedback are examples of system features that apply the gamification concept; these are shown in *Table 2*, and a UI is shown in *Figure 9*.

Figure 9 shows how to create a 3D visual model of an object in the shape of a bird with a flow explanation to give the user a story and feedback alerting them to problems, similar to *Figure 10*. As presented in *Table 3*, the goals for the gamification idea include points, reports, and reminders.

When a user progresses through a timeline like in *Figure 9*, they can encounter more challenges in a single production cycle. For example, they can report every step of the process as shown in *Figure 11*, which will eventually lead to a reward from a single production cycle. This reward grows as more cycles are completed, as shown in *Figure 12*.

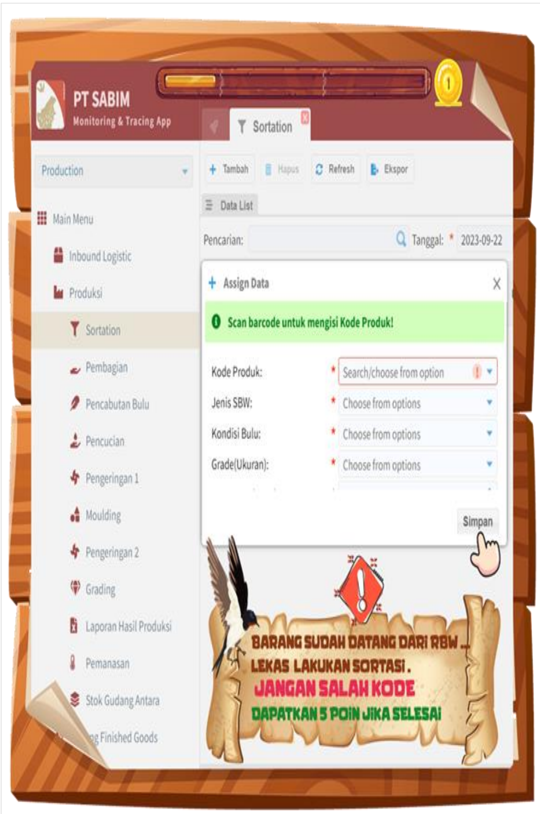

Figure 9 Targets and feature categories in the SG system are gamified

Table 2 The types of system features in the SG system

Category	Element
Object	2D/3D
Narration	Flow explanation
Feedback	Warning

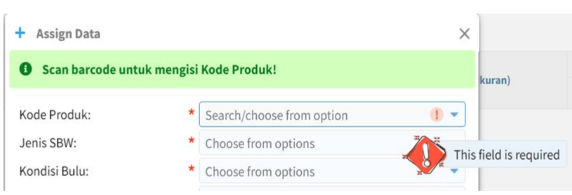

Figure 10 Gamification of the SG system's feedback

Table 3 SG systems' target categories

Category	Element
Point	Timeline point
Report	Reporting per process
Reward	Finishing all process

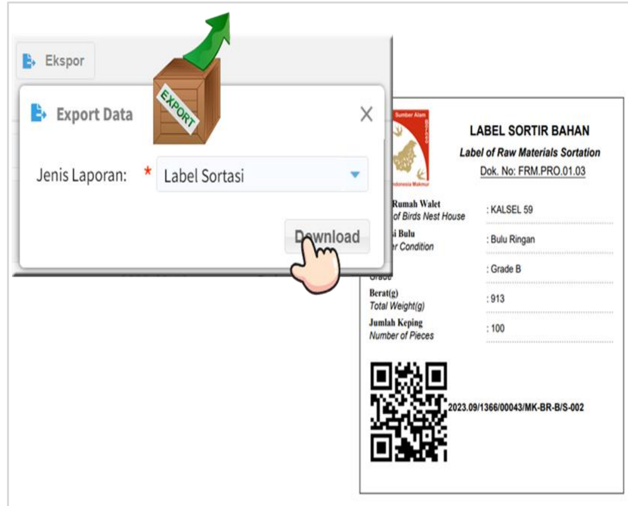

Figure 11 Gamification reporting within the context of SGs

Figure 12 The completion of gamification in the SG system

4.5Elements of learning activities

Bloom's taxonomy serves as the foundation for most learning elements. It outlines learning objectives and an experiential learning cycle that blends a constructivist viewpoint with learning objectives that place a greater emphasis on transferrable abilities [36, 37]. Through their activities, learning resources, and learning objectives, users engage in learning activities. *Table 4* illustrates how users access data about the production of swallows' nests, such as information on personnel who perform the production process and data on coding, identifying, and classifying types of swallows' nests. Web based media is used in all user learning activities to apply the gamification idea to the production implementation of ISO 22000:2018.

Table 4 Learning action category in the SG system

Category	Element
Remember	Search function, data entry, data deletion, data editing
Understand	Data export, data filter
Carry out	Data calculation, data classification
Analyze	Data identification error
Evaluate	Data verification, data tracing

4.6Elements of instructional activities

A variety of themes are covered in learning activities when SGs are used by an instructor. Because instructional teaching and learning activities complement one another in the same process, they have a conceptual overlap. Through the provision of suitable conditions, teachers enable the learning process, which is exemplified by instructional activities.

The distinction between intrinsic and extrinsic learning components is not made by the learning taxonomy. They are only separated by the application of the components. If a component is outside of an SG, it is irrelevant teaching; if it is inside, it is essential. As demonstrated in *Table 5*, learning activities and tools are actions taken by instructors or SGs as part of the system process that users utilize to encourage learning and support learning objectives.

Table 5 Components of educational exercises inside the SG system

Category	Element
SG Actions	High point challenges, Information, Warning, Guiding, Narrative

The learning mechanism in an SG that is a part of the information system for the production process of swallows' nests is the main topic of this study. Thus, several elements are included in the information system's software planning concept, such as the flow of the swallow's nest production process and learning processes.

The use of the SG concept in SN-MIS can be seen from several aspects, namely:
User motivation and involvement: without the game activity component, the user feels bored or less interested because it is monotonous, whereas by using the game activity component, the user is more motivated and involved with the game elements, as in *Figure 8*. Another part of the serious game concept is learning and retention in the form of more effective and interactive information. Without these components, the information conveyed is difficult to understand. Still, game elements can help users comprehend because they involve informative learning methods, as shown in *Table 3*: points, reports, and rewards. To enhance user creativity and problem-solving skills, the SN-MIS system can encourage users to think creatively and solve problems more interactively and engagingly. It incorporates learning elements such as Remembering, Understanding, Carry out, Analyzing, and Evaluating, as detailed in *Table 4*, which outlines the learning action categories in the SG system.

The aspects of games, learning, and instructional activities make up the initial part of the learning mechanism. As evidenced by the findings in *Figures 8–12*, game activity aspects are developed in the gamification area to generate more interesting and enjoyable icon models and UIs employing cartoon imagery.

In the meantime, the learning activity component concentrates on ideas to help users remember, comprehend, apply, analyze, and evaluate information more effectively. The instructional activity element, on the other hand, describes how the teacher supports the learning process by creating the necessary circumstances for the user to complete a certain task. This helps to develop instructional system features. When designing a system using an HFSM, as shown in *Figure 7*, the software adheres to the production process flow as shown in *Figure 4.* Three superstates are identified by the HFSM: superstate processing, superstate final sorting, and initial sorting. A complete list of abbreviations is listed in *Appendix I.*

5.Conclusions

By adding game elements—gamification—to UIs, research on learning mechanisms in SN-MIS can be leveraged as a tool to modify user behavior. Since SN-MIS incorporates gamification, it might be considered an SG. Because the system influences users through gamification aspects that activate intrinsic learning ideas, users are happier using it. Initial sorting, processing, and final sorting are the three superstates of an HFSM, which are used in software engineering to illustrate SG design. This narrative is a scenario that incorporates crucial factors related to learning, teaching, and gaming. UIs are essential in encouraging SN-MIS users to learn more about the system in the game activity aspect, which is the core idea of gamification. They have the power to alter user behavior to facilitate ISO 2000:2018's successful implementation. The primary categories of learning activities are recall, comprehension, application, analysis, and evaluation. The system elements that support these categories are the search function features, data entry, deletion, editing, export, filtering, calculation, classification, error detection, data verification, and data tracing. Although the emphasis of SG action is on completing challenges to earn points, providing information when running, warning when an error occurs, guiding the user through problems, and providing narration to make it easier for the user to understand the system flow, instructional activities are the function of the SG itself, namely as an instructor or teacher.

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Conflicts of interest
The authors have no conflicts of interest to declare.

Data availability
None.

Author's contributions statement
Anang Kukuh Adisusilo: Conceptualization, investigation, interpretation of result, writing – original draft. **Teguh Pribadi Ikshan:** Conceptualization, investigation, design, interpretation of result, writing – original draft.

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Appendix I

S. No.	Abbreviation	Description
1	ATMSG	Activity Theory-based Model of Serious Games
2	FSMSs	Food Safety Management Systems
3	HACCP	Hazard Analysis and Critical Control Point
4	HFSM	Hierarchical Finite State Machine
5	IMACE	Indonesia Maps of Agricultural Commodities Eksport
6	ISO	International Organisation for Standardisation
7	K-a	Employee's Initials in the Hair Removal Process
8	K-b	Employee's Initials in the Washing Process
9	K-c	Employee's Initials in the Hair Removal Process
10	K-d	Employee's Initials in the Molding Process
11	K-e	Employee's Initials in the Second Drying Process

12	LM-GM	Learning Mechanism-Game Mechanism
13	PJ-A	Initials of the Person Responsible for the Initial Sorting Process
14	PJ-B	Initials of the Person Responsible for the Last Sorting Process
15	SGs	Serious Games
16	SN-MIS	Swallow's Nest Management Information System
17	UIs	User Interfaces