MANUAL

USE OF AN INTEGRATED E-LEARNING TOOLBOX IN UNIVERSITY TEACHING WITH A SPECIAL FOCUS ON SERIOUS GAMES

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USE OF AN INTEGRATED E-LEARNING TOOLBOX IN UNIVERSITY TEACHING WITH A SPECIAL FOCUS ON SERIOUS GAMES – MANUAL

This is the intellectual output 3 of the Erasmus+ KA2 project INSYSTED – Integrated System for European Digital Learning. Project number: 2019-1-DE01-KA203-005038

This manual is complementary to intellectual output 1 (**INSYSTED pedagogical framework**) and intellectual output 2 (**serious game ProTUce**).

Licence

Acknowledgments

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Disclaimer

INTRODUCTION

This manual will help you to:

- incorporate MOOCs, serious games and forum-based online learning communities into your course in a blended learning setting;
- identify the **challenges** that emerged in the wake of the pandemic, with some students attending in the classroom and others participating at the same time remotely online (hybrid mode);
- discover the guidelines to **integrate a serious game** within a course and the features of **ProTUce**;
- explore the redesign of a sample course through the **INSYSTED pedagogical framework**;
- apply the **instructions on how to use the ProTUce** serious game;
- get more **inspiration from another example** of serious game integration (DAC - Detectives for Accident Courses).

It is a practice guide primarily for university teachers, but also for non-academic staff interested in using the INSYSTED pedagogical framework and the serious game. It is targeted towards industrial and management engineering education, it is meant to be used in any other university context.

MORE ABOUT INSYSTED

More than ever, students in higher education will be working in jobs that may not yet exist. **The Erasmus+ INSYSTED** project aims to increase their preparedness for the challenges of a rapidly evolving labour market by promoting soft and digital skills development and internationalisation through student-centred approaches underpinned by MOOCs, serious games and forum-based online learning communities.

Student-centred approaches are instructional approaches where students are active participants in their learning process, rather than passive recipients (active learning).

INSYSTED uses the **eLene4work skills framework**, which identifies the soft and digital skills most demanded in the EU by employers, graduates and novice workers.

The instructional booklet about the INSYSTED pedagogical framework is available here with concrete examples and low-hanging fruit ideas: **https://doi.org/10.5281/zenodo.4085237**

In addition to that, here you can find the INSYSTED webinars, which explore targeted topics to support you in making the most of the pedagogical framework and of the serious game devised by INSYSTED: **https://www.alliance4tech.eu/webinars-for-integrated-e-learning-toolbox/**

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CHALLENGES EMERGED IN THE WAKE OF THE PANDEMIC

Hybrid learning refers to the modalities of accessing classes, with some students attending in the classroom and others participating at the same time remotely online, basically via videoconference. It gained momentum because of the pandemic, as it allows to reduce the number of people in the classroom as a sanitary precaution and supports participation of persons with a condition preventing them from on-campus attendance. This results in an online extension of the physical classroom that blurs the boundaries between physical and online learning spaces.

The manual gives an overview of how course components combine in the blended / hybrid paradigm so that you can redesign your teaching.

TAKING INNOVATION ON BOARD: IDENTIFYING OPPORTUNITIES FOR ACTIVE LEARNING

This part of the manual offers some guidelines on operationalising the INSYSTED approach in a hybrid setting more quickly.

You can conceptualise the sequence and combination of learning activities that make up your course (e.g. lectures, exercises, independent study) to spot active learning opportunities and prioritise changes required to meet the respective learning outcomes depending on course topic, level and cohort size.

For example, you can think about how your weekly content might be broken down in this way and represented as an arrangement of components in terms of learning activities.

Find out more

GUIDING PRINCIPLES AND RULES OF THUMB

We are providing here some practical indications to support student learning while operationalizing the INSYSTED approach in a hybrid setting.

EQUITY IN COURSE PARTICIPATION

It is crucial to ensure that students have access to an equitable learning experience independently of the modality they are using to access it: it implies to cater for the needs of both students that are on campus and students that participate online synchronously. Instructors operate technology and facilitate interaction between on-campus and online students' cohorts: typically, a crucial issue is to manage the **audio in the physical space** so that those participating via video conferencing can hear properly. It is important to consider class size, instructor to student interaction, student to student interaction, and possible constraints in scheduling class times.

Strategies to ensure equity in course participation include

- **more detailed planning** and course **schedule with associated tasks and deliverables** expected from students (including required technology);
- **weekly outline/summary with key points to remember** and links to assigned readings and resources;
- **milestones / incremental deadlines** for larger projects or assignments;
- **breakout rooms with deliverables:** sub-meetings within a video conference meeting for smaller groups of participants (usually 3 to 5-8 people) to collaborate and have discussions generally work well when students are assigned a clear task/deliverable to accomplish within parentheses.

STUDENT ENGAGEMENT

It is integral to the INSYSTED approach which supports active learning pedagogies. In a hybrid setting it is particularly important to understand the level of prior knowledge of your students, as it influences the intrinsic load that is inherent to the new thing to be learned. Knowledge stored in the long-term memory can be retrieved to assist in the processing of the new information, then the intrinsic load of the task is reduced.

The brain stores information not as separate distinct items, as a computer hard drive would, but as webs of interrelated ideas. When processing new content, the brain searches the long-term memory for possible connections. The more it can use previous learning to process the new learning, the less pressure is placed on the new learning, e.g. in flipped classes, as students might have difficulty with self-regulation and keeping up with course materials.

Strategies to promote student engagement entail

- **Low-stakes grade incentives** interspersed throughout the course to increase students' self-regulation and memory of key concepts so they can easily recall them when necessary (this can be done by asking to complete a concept map about a topic or to write down what they know about a topic).
- **Visible productions** from students by requiring them to manipulate information (e.g. by taking notes on a video and writing a summary) or to discuss/debate it (e.g. by highlighting the links / implications of a specific topic for professional life) to promote active behaviours in students. In the case of recording of synchronous lectures, an index or an introductory presentation with key moments and main takeaways of the lesson;
- **Rubrics** as a tool not only for grading, but also for scaffolding in other terms, to provide a temporary support provided for the completion of a task that learners otherwise might not be able to complete quality feedback, as facilitate the connection between course learning outcomes and assessment outcomes.

BALANCE BETWEEN SYNCHRONOUS AND ASYNCHRONOUS INTERACTION

It is crucial to find the right combination of synchronous online collaboration during classes implies a risk of **cognitive overload**, and asynchronous online collaboration is conducive to developing **responsibility and autonomy** in students. Asynchronous activities can offer the possibility for students to attend and conduct tasks at their pace, and reduce **"Zoom fatigue"**: asynchronous communication tools can be used to scaffold knowledge construction activities through communication with and among students on-campus and online that is permanently available for consultation.

Strategies to enact the balance between synchronous and asynchronous interaction include

- permitting **backchannel communication** during synchronous sessions, by using a live feed (e.g. videoconference text chat) which enables everyone to ask questions and to see other students' questions, with multiple simultaneous non-interfering contributions; strategies to visually identify questions from the rest of the live feed (e.g. putting a capital Q before the question) can be used and students can be asked to answer their peers, hence potentially fostering peer interaction within and across attendance modes and reducing the instructor's burden;

- adopting **workload moderation** actions such as specifying time estimates on tasks also helps the instructor in assigning a work in a hybrid course that does not exceed the workload of the corresponding activity in a traditional setting.

- **scaffolding** knowledge construction using the forum for asynchronous discussions that address only one theme or one question over a set period of time (typically a week or two), start the discussion off by repeating the key question and remind students of it as the discussion progresses to ensure the focus of activities is clear and the task is relatively contained to encourage students to produce concise posts and, wherever possible, to use bullet-points and to break down paragraphs into two to three sentences to ease readability.

USE AND INTEGRATION OF THE SERIOUS GAME PROTUCE INTO A UNIVERSITY COURSE

THE SERIOUS GAME PROTUCE AND ITS DIFFERENT GAME MODES

The serious game ProTUce is targeting on the one hand large diverse introductory classes in operations management and on the other hand advanced classes in the fields of operations and supply chain management. The complexity and difficulty of game levels can be freely adjusted by the lecturer.

Operations management is a quantitative core area of Industrial Engineering and Management education where students need to tackle the stochastic-dynamic interdependencies of processes within a supply network. In order to do so, students need to acquire a deep understanding of the underlying theoretical concepts, methods, and tools. This is especially challenging for students at an introductory level. The heterogeneous knowledge and interests as well as the sheer number of participants in typical introductory courses urgently require new solutions for personalized learning.

Against this background, the serious game ProTUce was developed at Technische Universität Berlin. Here, problem-oriented, quantitative methods of operations management are taught – using a virtual learning factory. In subsequent game levels, students are confronted with different challenges of everyday production based on the progress of the course, experience system dynamics, and improve their analytical skills.

There are two separate modes which can be distinguished when playing the game, on the one hand the game can be played synchronously in a so-called “competition mode” where different factories compete against each other to gain the first spot on the leader board. On the other hand, the game can also be played asynchronously in an “experience mode” where the students can freely start a game to try out different strategies and experience the dynamics and performance.

In addition to that the game can be played in single-player or in team-mode. The team management can be done via the platform but is much simpler to be done in Moodle, where the student can sign up to their teams via the Moodle functionality.

THE CLASSROOM DESIGN OF THE COURSE UNIT "INVENTORY MANAGEMENT"

In the following, we will use an application example to show how a traditional university course can be transformed into a blended learning format, so that some in-class time is substituted by equally meaningful online activities. In this setting, the ProTUce serious game is integrated into the course as an essential design element. This learning design can be further adapted to the modalities of accessing classes emerged during the pandemic, with some students attending in the classroom and others participating at the same time remotely online, basically via videoconference (hybrid mode).

First, the intended learning outcomes and the planned assessment tasks are defined. In addition, we describe the current status of the course structure and the teaching and learning activities included in the actual learning arrangement. Next, the redesign of the course concept will be explained. This includes implementing the game with the two different modes as well as promoting further learning activities. For our example, we are using one learning unit within the course "Introduction to Operations Management" at TU Berlin.

Intended learning outcomes

Disciplinary skills

- **Remember:** Look up or remember inventory formulas introduced in class
- **Understand** the components of the EOQ and s/q formula and when to apply these
- **Apply:** Identify and insert case study parameters to suitable inventory formulas
- **Evaluate** the outcome of your decisions by analysing graphs and outcomes
- **Create:** revise your decisions and come up with a profit-maximizing policy

Soft skills

- **Communicate** and **work in teams** with group members
- **Transfer** the learned concepts **adaptably and flexible** to specific case
- **Self-evaluate** while reflecting on the project results
- **Inform and process data** by analysing demand and production data as well as performance data
- **Analyse** by formulating and solving the models
- **Be creative and innovative** while finding good production configurations
- **Create content** for the final output post on key findings
- **Solve problems** while tackling the business situation given by the game

Digital skills

- **Analyse:** Analyse demand and production data for level and variability
- **Modify** provided data to run the analyses in data analysis software
- **Use Excel spreadsheets** to analyse your input data and outcomes

Find out more about intended learning outcomes in the Booklet of INSYSTED pedagogical framework (pp.15)

Planned assessment tasks

- Case studies in exercise session
- Small online quizzes
- Serious game in teams during tutorial session

Find out more about assessment tasks in the Booklet of INSYSTED pedagogical framework (pp.25)

TRANSFORMING A COURSE UNIT INTO A BLENDED LEARNING SCENARIO

This part of the manual offers selected pointers to the relevant pages of the INSYSTED instructional booklet.

The main goal of transferring the current face-to-face format into a blended learning concept is to create a learning environment that makes it easier for students to achieve the intended learning outcomes. Thus, the inherent integration of the game into the overall course design is intended to promote students' problem-solving skills and thereby support the acquisition of applicable and transferable knowledge. Providing video material for lecture preparation and wrap-up also gives more time for practical interaction with the learning content in face-to-face sessions. Working in groups during the online phase, such as playing the game together and exchanging opinions in online forums, also promotes social and digital skills. The course schedule could be planned as follows:

1. In **preparation for the lecture**, students are provided with small video teaching units on the learning platform or with appropriate MOOCs. In these, the most important basic concepts for understanding the subsequent learning content are explained and, if necessary, previous knowledge is recalled. On the one hand, this compensates for possible differences in knowledge levels. On the other hand, it frees up time in the lecture to discuss unclear aspects.

For this, students may additionally be asked to note any points or questions that are still not clear. They can either share them directly via the video comment function. Or, they can bring them to the lecture, to be collected via a classroom response system and discussed.

2. The rest of the lecture will then introduce the **new learning content and important concepts**. On this basis, the simplest level of the game is introduced. For this purpose, students are given practicable starting values so that everyone has the same starting point. They form **groups of 2-4 members** and start the **synchronous game procedure** within their groups by a given time on the same day. This gives all groups the same amount of time to run the game and adapt the initial values to improve the performance.

3. Over the next few days, students will also have the opportunity to make corrections to their entries in order to **optimize the production process**. The best results achieved up to the tutorial date are displayed on a leader board. For collaboration and exchange within the groups, an online forum is available to the students. In addition, a forum is provided for everyone to ask questions and discuss possible solutions within the entire course.

4. To **review the lecture**, students get short videos that summarize the most important contents of the lecture. In the accompanying course exercise, the acquired knowledge is also applied in corresponding computational tasks. These, in turn, help students better to manage the production process in the game.

5. Finally, in the tutorial, the results of the game and the chosen solution approaches are discussed. Afterwards, all students have the possibility to **play through the level again in the asynchronous mode**. Students who have already completed the game very successfully are given an additional incentive: They can play through the game on a more difficult level, also using the asynchronous procedure. This asynchronous mode can also be made available to students later for exam preparation.

TUTORIALS AND CHEAT SHEET OF PROTUCE

PROTUCE CHEAT SHEET

Main menu

Title	Title of the (New) Game Template
Description	What the (New) Game is about
Number of prior days	Days already passed before making the first decision
Number of play days	Days to make decisions
Number of post days	Days after playing without making decisions
Days per hour	Speed of a play day e.g., 30 days per hour means 1 play day every 2 minutes in real life
Initial capital	Amount of money at the beginning
Random seed	You can select a certain random seed in order to generate the same random numbers the next time you play (or different random numbers the next time you play). All teams have the same random number.

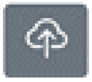
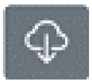
Top bar functions

The game must be saved before using **Start**, **Import**, **Export**, **Delete**, and **Save as Template**.

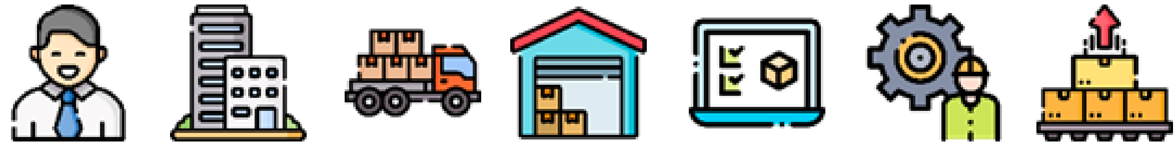
The game must have at least one team before using **Start**.

The game must be started before using **Abort**, **Pause**, **Fast-Forward**, and **Reset**.

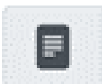
You can always **Export** your games to save it in your files and **Import** it later on.

Symbol	Description
Start	Choose a date and time to start the game
Abort	Stops the entire game
Pause	**Pause** the game from running and click **Resume** to let it continue
Fast-Forward	Let the game run faster (if the server performance allows it) and click again for normal speed
Reset	Choose a day the game should reset back to
	Import a game template that was exported in the past
	Download the game template as .json file
Delete	Delete the game and all of its associated information
Save as Template	Choose whether you want to make the template public or not. The template can be found in **Menu** → **Design** → **Templates** → **Show public** or switch back to Show Mine, click on **New Game** to initialize the game
Save	Save the game and save the game again after settings changed
Update	Updates the visualizations

Layout functions

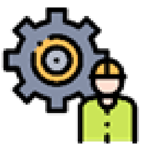


Customer | Sales Office | Supplier | Warehouse | Inv. Matcher | Workshop | Shipment

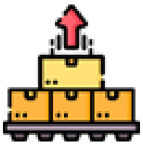
Icon	Parameter	Symbols	Description	Show	Edit
 Customer	**Name:**	-	Change the unit's name	✗	✗
	Is associated with:	-	Choose the units the customer is connected with (normal: Home Office)	✗	✗
	Distribution of order interarrival times:	-	Constant/ Normal distribution/ Exponential distribution	✗	✗
		 or	Deterministic time between orders in minutes	✓	✗
		μ	Mean value between orders in minutes	✓	✗
		σ or	Standard deviation of the time between orders in minutes	✓	✗
		λ	Parameter of the exponential distribution for the time between orders	✓	✗
	Distribution of boxes per order:	-	Constant/Normal distribution	✗	✗
		 or	Number of boxes per order	✓	✗
		μ	Mean value of boxes per order	✓	✗
		σ	Standard deviation of boxes per order	✓	✗

 Sales Office	**Name:**	-	Change the unit's name	✗	✗
	Queue policy:		FIFO – First-In-First-Out/LIFO – Last-In-First-Out->Queue policy of orders	✓	✓
	Lot size:		Number of orders that are transferred together to the next unit (batching)	✓	✓
	Contract:		Default / Lucrative	✓	✓
			Lead time in days per box	✓	✗
			Max. lead time in days per box. The price the customer pays decreases linearly between the lead time and the max. lead time. So, e.g. with a lead time of 1 day and a max. lead time of 4 days. Delivery time up to 1 day → full price 2 days → 50% of price 3 days → 25% of price 4 days → $ 0	✓	✗
		$	Price per box (paid by customer)	✓	✗
		+$	Delivery costs per order (paid by customer)	✓	✗
			Number of items per box	✓	✗

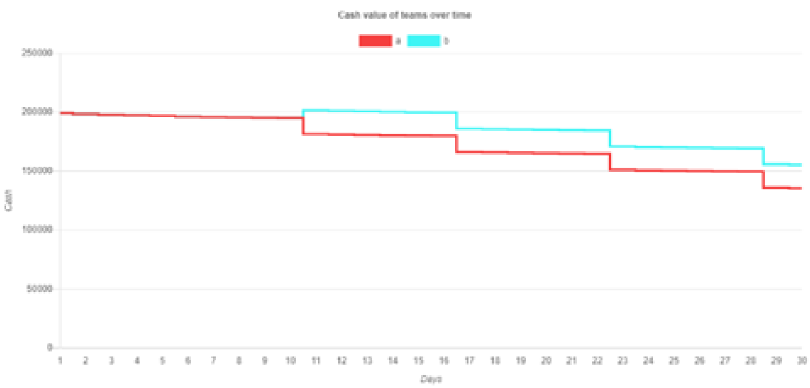
 Supplier	**Name:**	-	Change the unit's name	✗	✗
	Distribution of delivery time in days:	-	Constant/Normal distribution	✗	✗
			Delivery time of boxes in days	✓	✗
		or			
		μ	Mean value of delivery time of boxes in days	✓	✗
		σ	Standard deviation of delivery time of boxes in days	✓	✗
	Contract:		Default / Lucrative	✓	✓
			Lead time in days per box	✓	✗
			Max. lead time in days per box. The price the customer pays decreases linearly between the lead time and the max. lead time. So, e.g. with a lead time of 1 day and a max. lead time of 4 days. Delivery time up to 1 day → full price 2 days → 50% of price 3 days → 25% of price 4 days → $ 0	✓	✗
		$	Price per box (paid by you)	✓	✗
		+$	Delivery costs per order (paid by you)	✓	✗

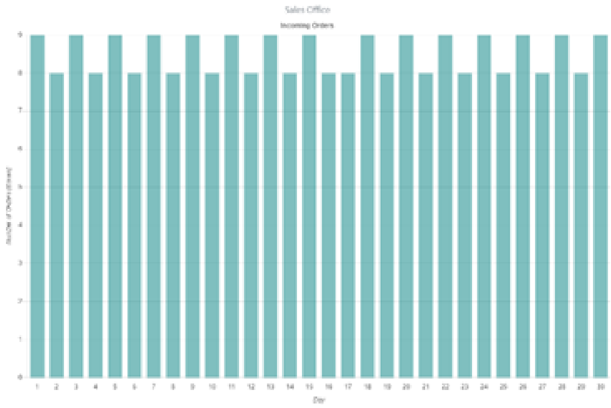
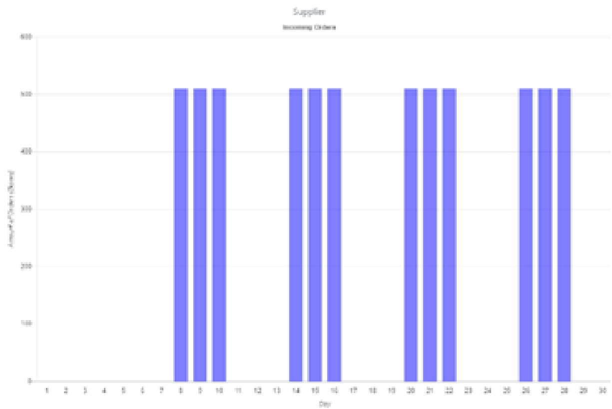
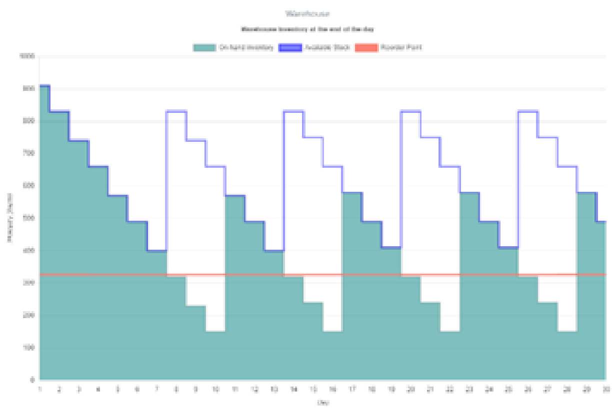
			Number of items per box	✓	✗
	**Name:**	-	Change the unit's name	✗	✗
	Is associated with:	-	Choose connection where the warehouse is supplied from (normal: Supplier)	✗	✗
Warehouse					
	Inventory in items:		Shows initial inventory and afterwards current inventory	Always shown	✗
	Storage costs per item per day:		An order containing boxes with a number of items per box will be stored with a cost per item and day	✓	✗
	Reorder point in items (s):		If the number of items in the available stock (on-hand inventory + ordered boxes) is below the reorder point, an order is placed automatically.	✓	✓
	Number of boxes per order (Q):		Number of boxes per order	✓	✓
	**Name:**	-	Change the unit's name	✗	✗
	Is associated with:	-	Choose the units the Inv. matcher is connected with (normal: Warehouse)	✗	✗
Inv. Matcher	**Queue policy:**		FIFO – First-In-First-Out/LIFO – Last-In-First-Out->Queue policy of lots	✓	✓
	**Name:**	-	Change the unit's name	✗	✗
	Queue policy:		FIFO – First-In-First-Out/LIFO – Last-In-First-Out->Queue policy of lots	✓	✓
Workshop					
	Lot setup time per lot in minutes:	-	Constant/Normal distribution	✗	✗

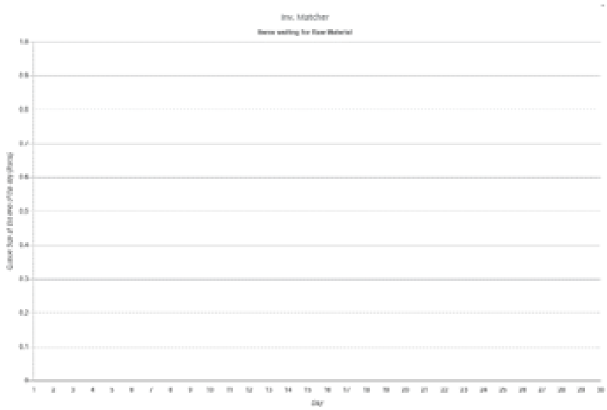
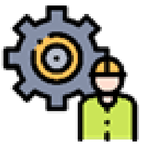
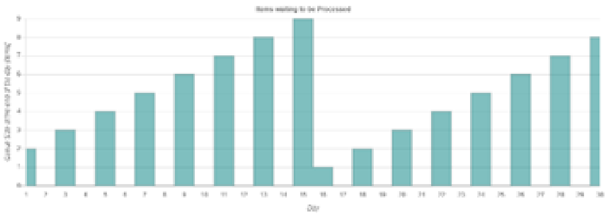
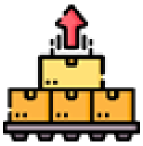
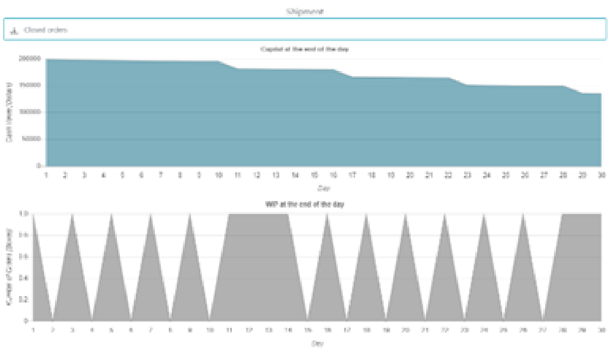
			Lot setup time per lot in minutes:	✓	✗
		or			
		μ	Mean value of lot setup time per lot in minutes:	✓	✗
		σ	Standard deviation of lot setup time per lot in minutes:	✓	✗
Item processing time in minutes:		-	Constant/Normal distribution	✗	✗
			Item processing time in minutes:	✓	✗
		or			
		μ	Mean value of item processing time in minutes:	✓	✗
		σ	Standard deviation of item processing time in minutes:	✓	✗
Machine breakdown probability:			Daily probability of machine breakdown	✓	✗
Distribution of repair time in minutes: (Only appears if the machine breakdown probability is larger than zero.)		-	Constant/Normal distribution	✗	✗
			Repair time in minutes	✓	✗
		or			
		μ	Mean value of repair time in minutes	✓	✗
		σ	Standard deviation of repair time in minutes	✓	✗
Number of machines:			Initial number of machines and machines bought	Always shown	✓
Purchase or retire machines:	**Machine purchase price:**	$	Cost to buy a new machine	✗	✗

	Machine salvage value:	$	Salvage gain when selling a machine Only non-busy machines can be sold.	✗	✗
 Shipment	**Name:**	-	Change the unit's name	✗	✗
	Unit storage costs per item per day:	$	Unit storage costs per day per item (e.g., units stored until whole order is produced and shipped)	✓	✗
	Queue policy:	|→	FIFO – First-In-First-Out/LIFO – Last-In-First-Out ->Queue policy of orders to be send to customer	✓	✓

Graphs

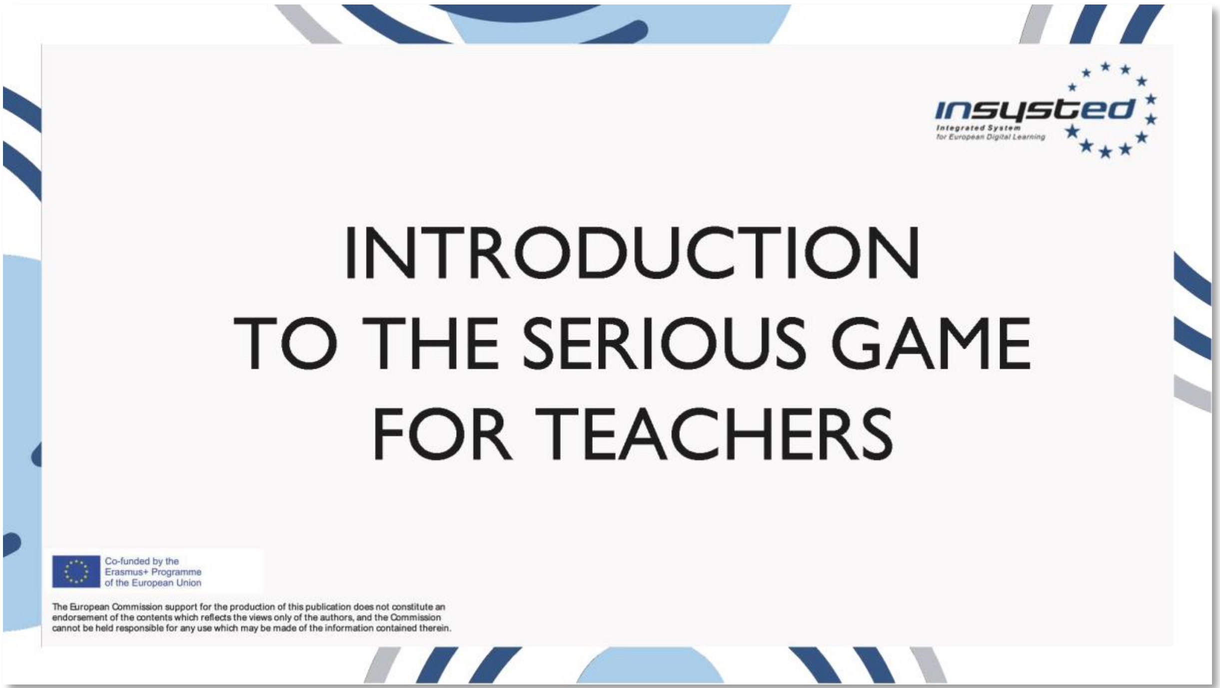
Graph	Description
	From the teachers' perspective the cash value in dollars of all teams over time can be seen. Here we have two teams. We can interpret that team b has sold their machine. The actions can also be analysed by clicking on the team names.

Icon	Graphs	Description
 Customer	no graphs available	-
 Sales Office		Shows the numbers of orders in boxes per day that are coming in from the customer. The number of boxes per order is described in customer. The number of items per box is defined in the sales office contract.
 Supplier		Shows the number of orders in boxes per day that are coming in from the warehouse. The number of boxes per order is described in warehouse. The number of items per box is defined in supplier contract. Orders are placed if the warehouse inventory is below the reorder point.
 Warehouse		After receiving the items or the raw material from the supplier, it will be stored in the warehouse. The graph shows the number of stored items per day (at the end of the day). On-hand inventory are items that are ready to be processed while available stock indicates items that were ordered at the supplier but did not

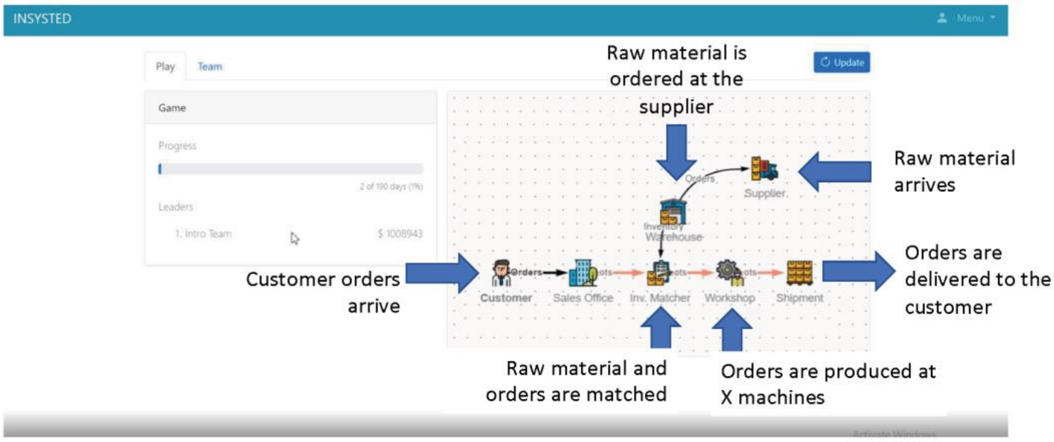
		arrive yet. An order will be placed automatically if the available stock is below the reorder point.
 Inv. Matcher		Ordered items that are coming from the sales office are waiting for raw material (item) from the warehouse, so it can be passed in lot sizes to the workshop. The graph shows the queue size in items at the end of the day.
 Workshop	 	Machines can have three states: Ready, Busy, and Broken. The graph shows the time percentage of each state every day. The second graph shows the queue of items that are waiting to be processed in front of the machine at the end of the day.
 Shipment		After the customer received their order the cash value increases with the price per box in dollars which is defined in the sales office contract. The second graph shows the number of orders in boxes per day that are still within the production system.

INTRODUCTION TO THE SERIOUS GAME PROTUCE FOR TEACHERS (SLIDE DESK)

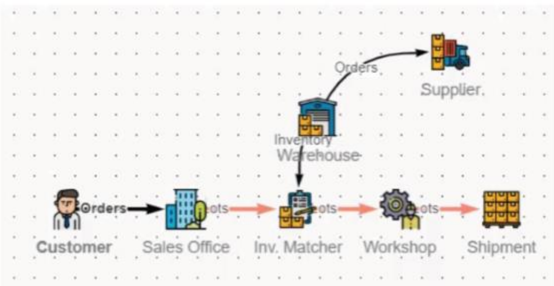
(**for video tutorial click here**)



Our supply chain



Content of the game



Introduction

Level 1: Inventory management (deterministic + stochastic)

Level 2: Capacity management

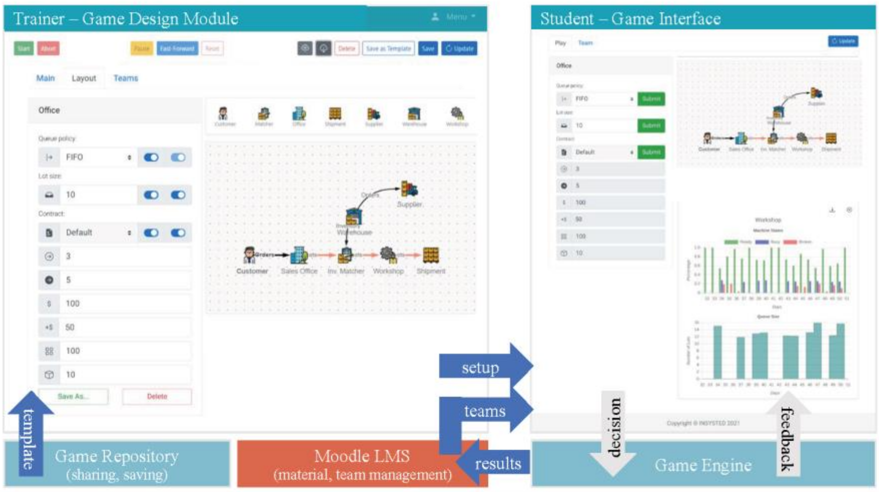
Level 3: Contract management

Learning

Level 4: Combination of all above

Online competition

Architecture of the game



Overview of game levels

Level	Input			Actions		
Problem	**Customer arrivals**	**Processing times**	**Material supply** (delivery time)	**Ordering policy** (Order quantity q and order point s)	**Capacity** (# Number type of machines)	**Terms and conditions** (Revenues, Delivery times and Delay costs)
1) Order quantity planning	Deterministic, uniform	Deterministic, constant	Deterministic, constant	Choose q	Given	Given
2) Inventory management	Stochastic	Deterministic, constant	Deterministic / stochastic	Select q + s	Given	Given
3) Capacity planning	Stochastic	Stochastic	Deterministic	Given	Choose #	Given
4) Integrated Finals	Stochastic	Stochastic	Deterministic / stochastic	Select q + s	Choose #	Choose Contract
5) Advanced	Stochastic	Stochastic	Deterministic / stochastic	Select q + s	Select s and type	Choose Contract
…	…	…	…	…	…	…

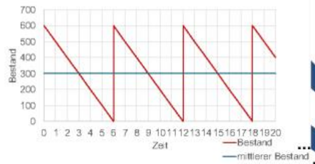
Example: Difficulty Adjustment Level 1

Difficulty

The aim is to apply the EOQ model securely and calculate the key key figures of warehouse controlling

The following difficulty levels can be passed through:

1. Basic setting: Determination of the optimal order quantity for replenishment time 0
   Analysis of the framework conditions for selecting the model (EOQ)
   - Analytical calculation of the optimal lot size (order point = 0)
   - Empirical calculation of the stock key figures on the basis of earnings
2. Determination of the optimal order quantity for replenishment time 0
   Empirical analysis of demand rate, order and storage cost rates
   - Analytical calculation of the optimal lot size (order point = 0)
   - Empirical calculation of the stock key figures
3. Calculation of optimal order points (replacement time > 0)
   - Adjust ingenues of order point
   - Calculation of inventory key figures (no change)
4. Calculation of order points for fixed lot sizes
   - Process additional information
   - Calculation of inventory key figures
5. Effects of joint orders (drastic reduction of order-fixed cost rates)



$$Q^* = \sqrt{\frac{2 \cdot k^s \cdot d}{k^l}}$$

d Demand in period t
Q Order quantity
k^s Order costs per lot
k^l Storage per unit and period

Advanced: optional components for particularly high-performing students

Play modes

Game idea

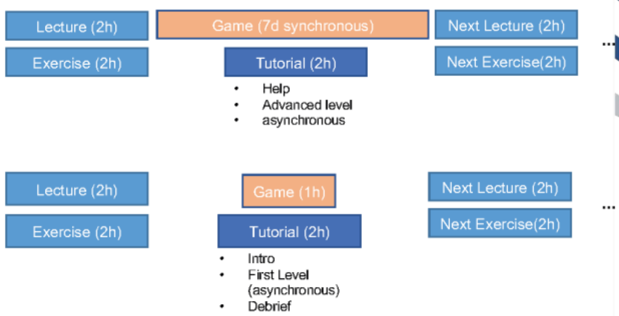
- Students play online for a specific time horizon in independent teams
- Goal: highest profit

Synchronous game procedure

- Dynamic emulation of a production plant
  (1h in the real world = 1 day in the game)

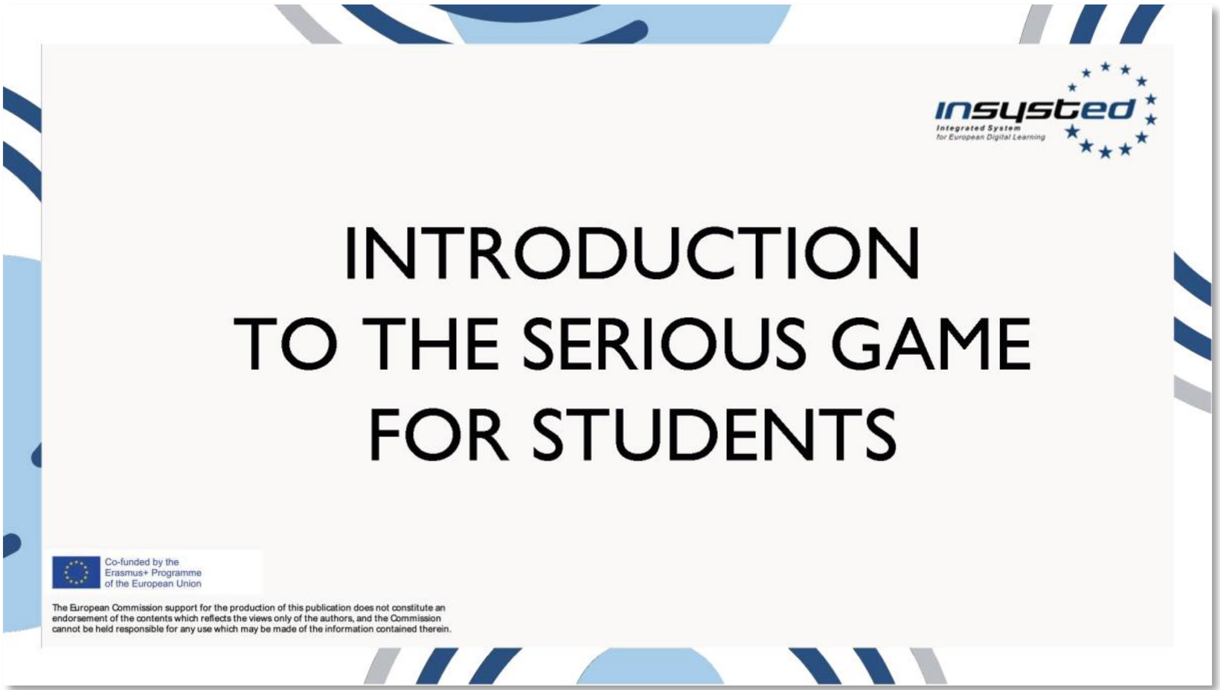
Asynchronous game procedure

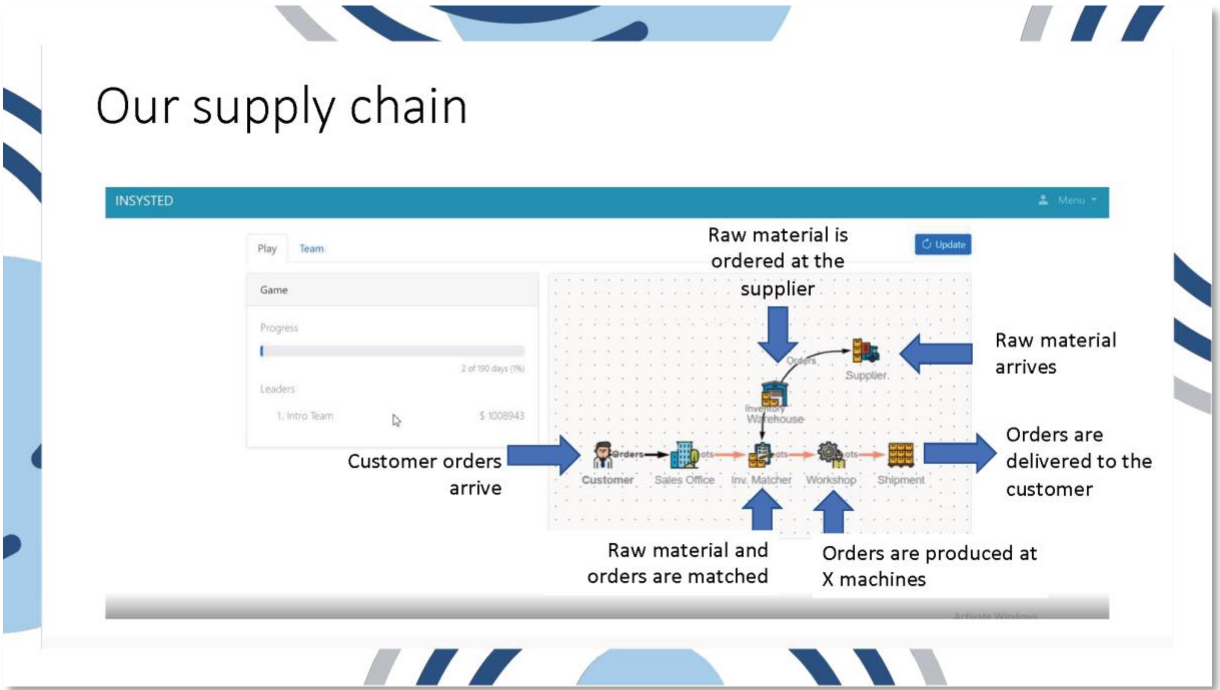
- Fast-forward possible



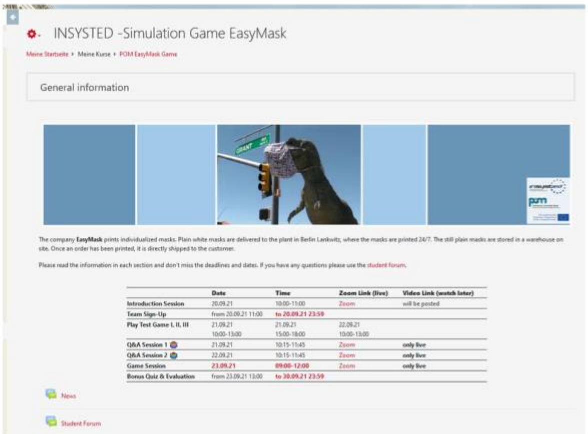
INTRODUCTION TO THE SERIOUS GAME PROTUCE FOR STUDENTS (SLIDE DESK)

(**for video tutorial click here**)





Find the additional information



TOP TIP

Use the Student Forum for all questions, probably others have the same question anyway. To communicate with your team, there is a team section in the chat function in the upper right corner.

Carefully read the task descriptions

The demand per day is normally distributed with an expected value of 50 units and standard deviation of 20 units. It takes two days for ordered units to arrive at the warehouse. The order quantity is already fixed at Q=250 units. Calculate the reorder point s required and the corresponding safety stock for an α-service level of 95%.

Here is some additional information you may need:

You have a starting capital of 1,000,000 € and already have 1 machine. The Reorder Point is initially set to 400 and can be changed. The service time is 30 minutes, and the productions is continuous throughout the day. The game period is 150 days (basically this means afterwards the world ends).

Costs:

If the delivery time of an order is less than one day, you will receive 600€. If the delivery time is longer than one day, the revenue decreases linearly up to three days delivery time." Example:

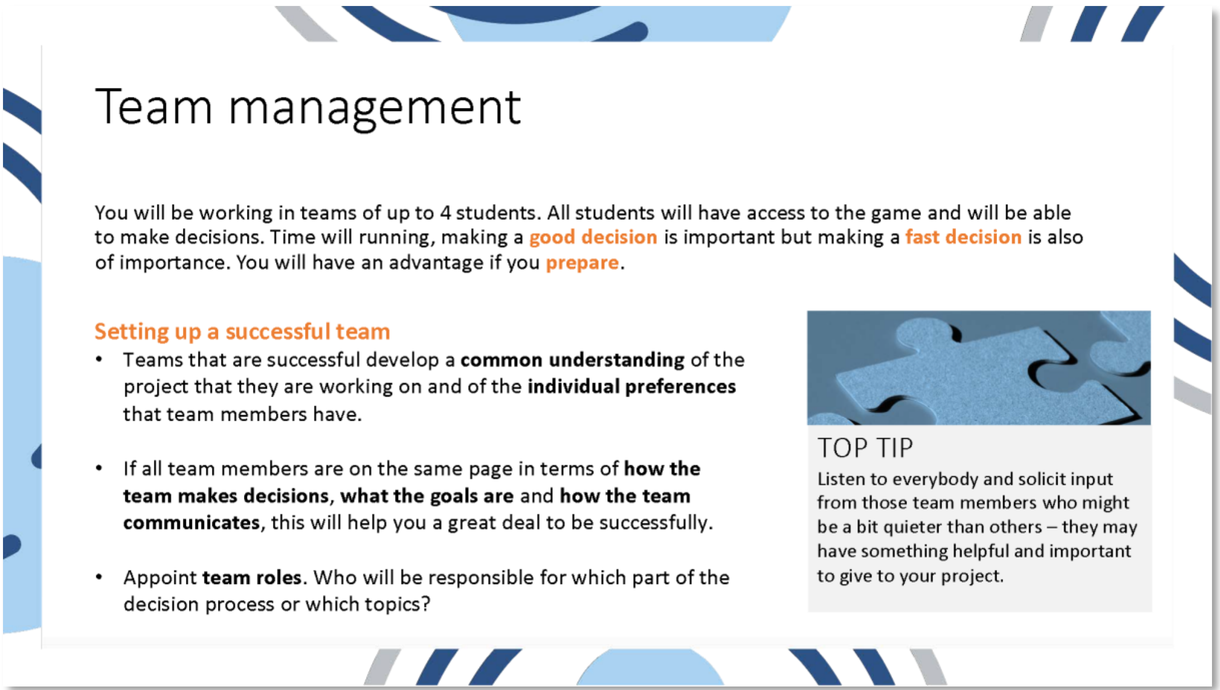
- Order 1 has a delivery time of 24 h → revenue = 600€
- Order 2 has a delivery time of 48 h → revenue = 300€
- Order 3 has a delivery time of ≥ 72 h → revenue = 0€

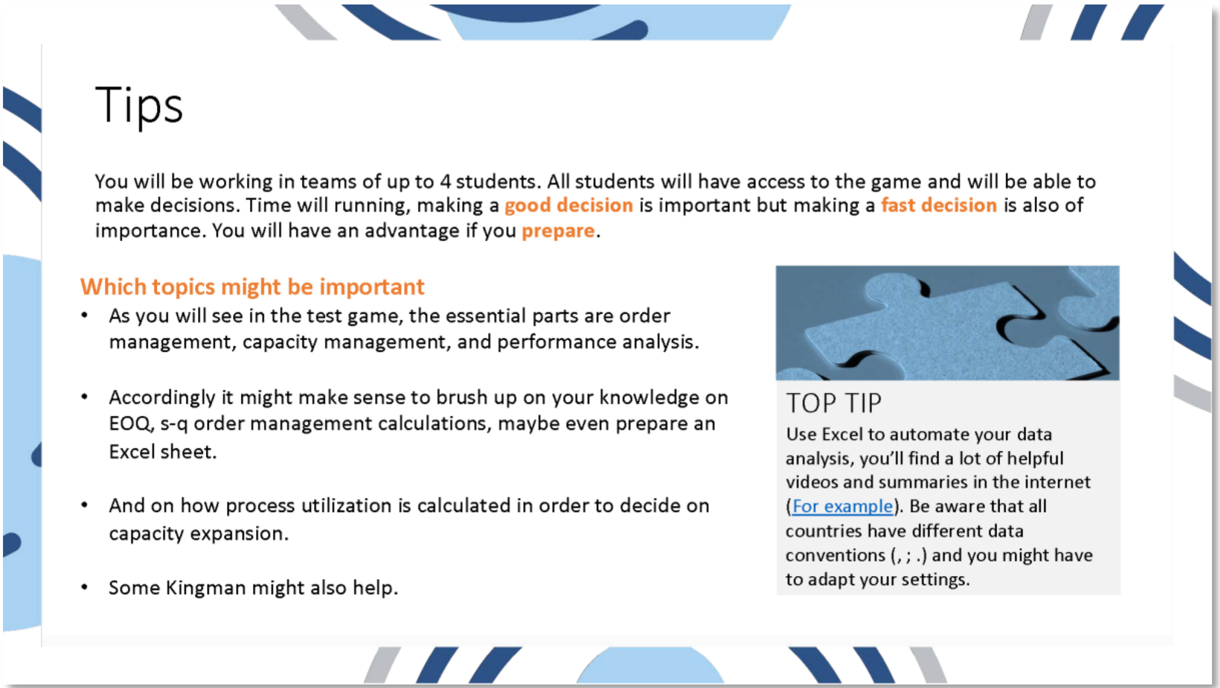
Raw material costs: 200€ per unit, The fixed shipping costs are 500€ per batch of orders. The calculated storage cost rate per unit and day is 0.80€. A new machine costs 100,000 € and can be sold at a price of 40,000 €.

OBJECTIVE: Optimise the production parameters, such as the number of machines or the reorder point to achieve the highest final cash and machine value possible.

TIPS FOR PREPARATION AND TEAM MANAGEMENT (SLIDE DESK)

(**for video tutorial click here**)




Tips
You will be working in teams of up to 4 students. All students will have access to the game and will be able to make decisions. Time will running, making a good decision is important but making a fast decision is also of importance. You will have an advantage if you prepare.
Which topics might be important
• As you will see in the test game, the essential parts are order management, capacity management, and performance analysis.
• Accordingly it might make sense to brush up on your knowledge on EOQ, s-q order management calculations, maybe even prepare an Excel sheet.
• And on how process utilization is calculated in order to decide on capacity expansion.
• Some Kingman might also help.
TOP TIP
Use Excel to automate your data analysis, you'll find a lot of helpful videos and summaries in the internet (For example). Be aware that all countries have different data conventions (, ; .) and you might have to adapt your settings.

FURTHER APPLICATION: THE SERIOUS GAME DAC

In this section, we present a second example of how to use a serious game to redesign a course into the blended-learning mode, following the frameworks set up by the INSYSTED project. In the first subsection, we start with a brief introduction of the **serious game, DAC (Detectives for Accident Courses)**, developed at Centralesupelec, Universite Paris-Saclay, France. Then in the second subsection, we present how does the course PoF (Principles of Failures) is redesigned as a blended learning course by integrating the serious game.

DESCRIPTION OF THE GAME

DAC (Detectives for Accident Courses) is a serious game designed to train the students to identify potential failure modes in a complex engineering system, and also discover the causes for major accidents of complex engineering systems. The game is designed based on real-world failures/accidents happened in the past.

The game is organized as a role-play game: the different players will play the role of designers of subsystems in a complex engineering system. A script will be provided to the players, which contain useful information regarding the subsystem he/she designed. Then, all the players will work as a team to identify the potential failures through a design review, and discover the causes of an accident through an accident investigation committee meeting. To make the game more attractive to the students, the game is designed to be competitive and similar to popular board games Wolfman and Who is the Murder, which are very popular among young generations.

Background of the game

Electrical network and railways are both very critical infrastructures for a modern society. It is, therefore, important to maintain them in a healthy and up-to-date state. The electrical and railway infrastructures in Country X, however, are neither healthy nor up-to-date. The electrical network was old and still largely relied on fossil energy, which needs urgently upgrades due to the unanimous consensus on controlling greenhouse-gas emissions. The railway infrastructure was even worse. The majority of the railway infrastructure was built over 30 years ago and was suffering a lot from various reliability problems due to aging. Both the reliability and efficiency of the railway system badly need improvements.

Four years ago, Country X launched a project aiming at modernizing the electrical and railway infrastructure. The project is very ambitious: upgrade the electrical network to include more "clean" energy like nuclear and renewables, while at same time modernize the railway infrastructure by introducing automatic train control systems to improve its reliability and transportation efficiency. Given the complexity of this plan, a group of most prominent engineers are contracted to design and implement a test system near the capital region. After years of hard-work, the system is finally close to complete and just need a few design reviews before handed over to the operators. Nearly everyone is happy and very satisfied with this new system: the railway infrastructure is brand-new and highly reliable, highly efficient, supported by a cleaner electrical infrastructure with much less CO2 emissions. No one doubts that it will have a bright and sunny future. However, on the edge of the sunny sky, some clouds are appearing: it seems that a thunder storm is coming…

Rules of the game

- This is a game for teams of four people, and it comprises of two phases.
- Each one of the team members will be given a script. According to the script, you are going to play the role of subsystem designers involved in this project. The **four roles** are:
  1. Designer of the power supply system to the railway.
  2. Designer of the DC microgrid that allows integration of renewable energy.
  3. Designer of communication system in the DC microgrid and the railway control system.
  4. Designer of the new railway system that implement automatic train control system.
  5. Some group will have an additional player: An accident investigator.
- **Phase 1:** It is a design review, where two of the four systems will be reviewed for potential failures/risks.
- Your common goal in this phase is to identify as much as possible the potential failures/risks.
- Besides, in the script, you are also given some individual tasks. You also need to finish those tasks.
- Some “evidence” will be shown by the monitor to help your reasoning.
- In phase 1, no one should hide any information from the others.
- **Phase 2** is about one afternoon when a deadly accident happens in this new railway system. You are going to be given a new script, which describes what you experienced and how your system behaves on that afternoon.
- You are asked to find out, as much as possible, what happened on that afternoon and what is the cause of the accident, based on a discussion among you and the “evidence” presented by the monitor.
- Besides, in the script, you are also given some individual tasks. You also need to finish those tasks.
- In Phase 2, there will be a “murderer”, whose system is the direct cause of this accident. Only this “murderer” is allowed to hide information/tell lies to the others, while the others must always tell the truth.

Evaluation

You score comprises of two parts:

- **Collective part:** based on the performance of this group. Decide based on:
  - Potential failures identified in phase 1;
  - How much you could reconstruct the accident timeline in phase 2
- **Individual part:**
  - Evaluated by the monitor based on your performance in the game:
    - Degree of participation.
    - Contribution to the results.
    - Etc.
  - Bonus point to: * Escaped "murderer", or
    - The others if "murderers" identified.

DESCRIPTION OF THE COURSE

The course in which the serious game will be applied is DAC (Detectives for Accident Courses). This is an elective course for third-year engineering students (master's level) in **Centralesupelec, Universite Paris-Saclay, France**. In this section, we briefly described the objectives and organization of the original version of this course, which will be redesigned in the next section by integrating the serious game and other digital elements.

Context and objectives

It was a quite evening on 6 July 1988. Under the beautiful sunset of the North Sea, 228 workers began boarding the gigantic offshore oil drilling platform, the Piper Alpha, and started their routine night shift of working. It seems to be just another causal day. The then largest offshore platform of the UK kept producing oil and gas smoothly and quietly, until roars and flames from a huge explosion broke the serenity of the night and devoured everything. The platform was destroyed completely and, 167 out of the 228 workers, did not return from their last work. The tragedy shocked the entire world, as modern offshore oil platforms like Piper Alpha have been designed with a large number of safety systems connected in a "defensive-in-depth" manner: such accidents could occur only when all these safety systems fail, which is considered to be highly unlikely, if not impossible at all.

Sadly, severe failures like this keep occurring in almost every sectors of modern society. The nuclear accidents in Fukushima in 2011, the financial crisis in 2008, the explosion of the space shuttle Columbia in 2003... We can easily go on with this list. These sophisticated human-made systems, although all designed with seemly "unbeatable" safety systems, turned out to be much vulnerable than expected. They do fail and cause substantial damages and losses. What exactly caused their failures, then? Why do the seemly well-designed systems become vulnerable? Can we find some common rules governing these failures? If yes, how can we make use of this knowledge to manage the risks and make our systems safe and resilient? In this course, we attempt to give preliminary answers to these questions.

This course aims at giving the students basic knowledge on why human-made systems fail and how to manage the risks so that they can be operated safely and reliably. More specifically, the contents of this course include:

- general theories of why systems fail (e.g., Normal Accident Theory, the logic of failures)
- common failure causes and mechanisms;
- risk sources identification (e.g., FMEA, FTA);
- risk mitigation and control (e.g., high reliability organization);
- applying the theoretical methods to solve a real-world problem.

REDESIGNING THE COURSE INTO A BLENDED LEARNING SCENARIO

As indicated in the previous outputs from the INSYSTED project, the main goal of transferring a traditional course into a blended learning one is to create a learning environment that makes it easier for students to achieve the intended learning outcomes. As a first step, the intended learning outcomes of the original PoF courses need to be clearly identified:

Disciplinary skills

- **Remember:** the representative failure examples discussed in the class
- **Understand: the major principles** that lead to failure of complex systems
- **Understand: how to use** the discussed tools (FMEA and FTA) to assist failure analysis
- **Apply:** the learned principles to analyse failure scenarios similar to the representative examples
- **Create:** integrate the different theories and tools to solve a real-world problem related to failure analysis/prediction of a complex engineering system

Soft skills

- **Communicate** and **work in teams** with group members
- **Transfer adaptably and flexible** the learned concepts to specific case
- **Self-evaluate** while reflecting on the project results
- **Think logically** and **solve problems** related to a complex system **creatively**

To better fulfil such learning objectives, a blended learning course is redesigned, integrating the serious game discussed in the first section. The three pillars of blended learning, proposed by the INSYSTED project will be the focuses of the blended learning design.

MOOC

The lectures will be designed in an "inverted classroom" manner. Before each lecture, the students will be provided with MOOC materials that cover the basic theories they are intended to understand after the lecture. The MOOC materials will include several short video lectures (10~15 minutes) each, explaining the basic principles and theories that the students need to understand, reading materials that help the students to better understand the important things, small quizzes embedded in the videos to test the understanding of the students, and other supplementary resources. The students need to finish the offline learning and the associated quizzes before each class, so that in the classroom, more detailed discussions and case studies could be designed, focusing on the important and difficult aspects of the courses, to further improve the student understanding. It is anticipated that through the combination of offline and online learning, the students could achieve the more advanced learning objectives, such as the "apply" and "create" quicker and easier.

In the new blended learning course, the first three points in the original planning, i.e., example of AF447 crash, history and background of Normal Accident Theory, and introduction of complex interactions will be given as a MOOC lesson. Short video lectures will be combined with some reading materials on the crash and the normal accident theory. Small quizzes will be designed and integrated with the video lecture to ensure the students understand the basic elements of the Normal Accident theory, especially the concept of complex interaction. Then, onsite lectures will be organized in the form of discussion sections and case studies, which covers the other parts in the original planning. Through reorganizing like this, the students could take their time to understand the simple and basic concepts and theories, while saving more time in the classroom to focus on the complex aspects of the theory and how to apply the theory in practice.

Serious game

The serious game DAC will be used as the final evaluation of this course. In this game, the students will work in groups and try to apply the learnt theories to analyse a real-world problem related to failure of a complex engineering system. The organization of the game could be summarized as follows:

- **Introduction** of the serious game: context, background, rules.
- **Round table**
  - students are requested to briefly introduce themselves to their peers (name, position, company, your company's role in this project, etc., one or two sentences per person)
- **Resilience design review of the main power supply system**
  - Related evidence: "P1_Evidence_Information of the main power supply system", could be found in the "files" of the channel "Group_X".
  - Brief introduction from the designer of the main power supply system. (~5mins)
  - Questions from the other designers and discussions. (~10mins)
  - At the end of this section, students will attend a quiz, in which they are asked:
    - Whether the main power supply system is reliable/resilient enough.
    - If their answer is no, students are requested to provide some potential risks that could damage the system.
- **Resilience design review of the block-state sensing subsystem in the railway system**
  - Related evidence: "P1_Evidence_Information of the block sensing subsystem", could be found in "files" of the channel "Group_X".
  - Brief introduction from the designer of the system. (~5mins)
  - Questions from the other designers and discussions. (~10mins)
  - At the end of this section, students will attend a quiz, in which they are asked:
    - Whether the block-state sensing subsystem is reliable/resilient enough.
    - If their answer is no, students are requested to provide some potential risks that could damage the system.
- **Reading scripts of phase 2 – instructions for students**
  - Your script is available in the Teams channel with the name of your system (not the channel of the group).
  - In this phase, two trains collide in a deadly accident, and we need to figure out which system is the cause.
  - The script describes what happens on your system that afternoon.

- Please pay special attention to the texts in red, and your tasks given at the end.
- In the next sections, you are going to use information in your script, together with some evidence to be presented to you next, to reconstruct what happened during that afternoon of accident based on logical reasoning.

- **Round table - instructions for students**
  - Explain the timeline of each person.
  - You are allowed to tell only part of your timeline, if you feel some events might be harmful to you, even though you are not allowed to "tell lies".
  - If you have any questions/doubts during someone's presentation, you can directly jump in and raise question.
  - A few hints:
    - Please manage the time well by yourself! Altogether, you have 20 minutes!
    - Take notes when necessary, especially on the occurrence time of events.
- **Reasoning and discussion based on evidence – instructions for students**
  - Evidence is available from now on the "file" section of the Teams channel of your group.
  - There are five groups of evidence:
    - Interviews with passengers in the collided trains.
    - Evidence on each one of the four systems.
    - Each group contains about 3 pieces of evidence.
    - Try to reconstruct what happened during that afternoon and which system causes the accident, by discussing and analysing this evidence.
  - Hints:
    - There are a lot of evidence. Some of the evidence might be unrelated to the analysis. So, don't expend too much time on a single piece of evidence.
    - It is suggested you start from the interview with the passengers, and then go through the evidence of each person.
    - If you suspect or have any questions on anyone, feel free to raise your questions during the discussions.
    - Please manage your time by yourself. You have until 11:10 for discussion.
    - From 11:10, you are going to do another quiz to test if your reasoning.

Online learning community

The students will be exposed to an online learning community, where they could have discussions and work in groups in some given problems. A forum in the online learning platform will be set up for students to pose questions and launch discussions. Apart from that, to attract further the students to get involved, a more modern online exchange platform, Flipgrid (**https://admin.flipgrid.com/manage/discussion**) will be also be used. Flipgrid is an online learning platform similar to Tiktok, where students could interact with his/her peers by posing short videos. The teachers will start some discussions in Flipgrid, where the students are asked to respond and potentially interact with the others by short videos.