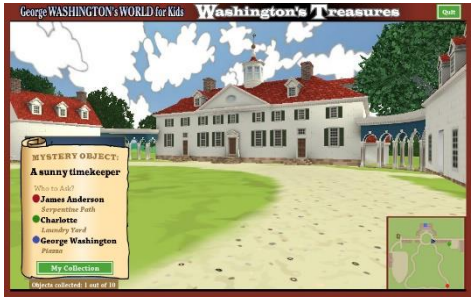
Serious Games Design
A tutorial



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Goals of the tutorial

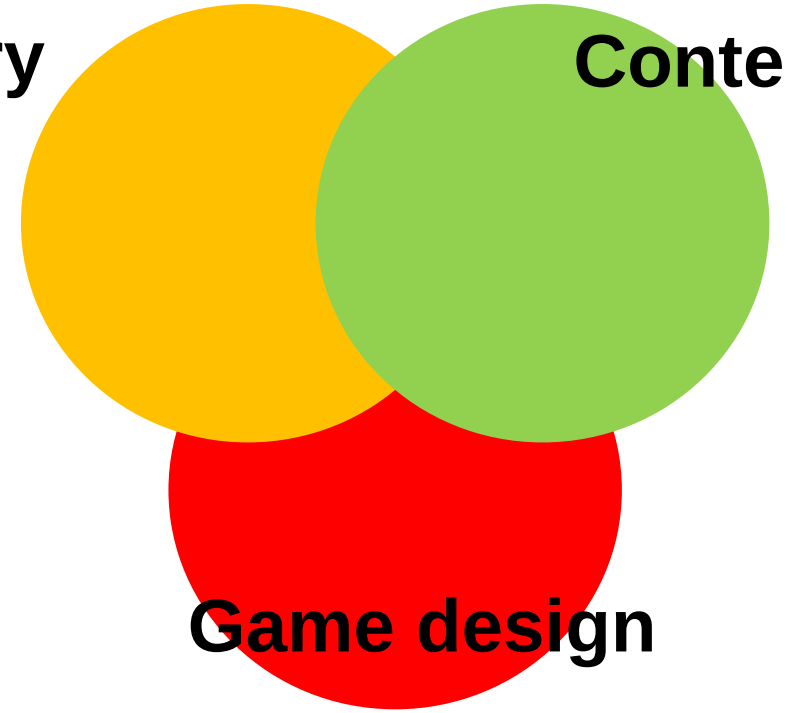
- Introduce learners to the design of educational serious games
- Allow learners to be able to prepare a proper document design for an educational serious game, given a set of specifications

- Subgoals *(and structure of this presentation)*
  - Have an idea about collection of requirements from stakeholders
  - Have an overview of pedagogical approaches that are mostly relevant for SGs
  - Understand how they can be mapped to game mechanics
    - ✓ Particular focus on items such as:assessment, feedback, collaboration, plot/story

Side information

- This tutorial is strongly related to the SG Analysis Framework that we used for SG studies
  - We exploit is a reference tool
- We propose a Top-Down approach, but it is an iterative process.
  - Not all the points should be addressed in sequence
  - Some points may be skipped
  - Some *(all, in principle)* points could be updated later

A multidisciplinary challenge



Theory

Pedagogy
Cognition
Learning
Psychology
Flow/presence
Perception
Behaviour
Learning

Contents

Museum
History
Mathematics
Science

Game design

HCI
Storytelling
AI

Goals
Rules
Levels

A/V
2D/3D graphics
Programming

Putting it all together in a meaningful whole

- Different (if not conflicting) goals
  - Pedagogy
    - ✓ Rigorous provision and verification of knolwedge
    - ✓ Determinism
    - ✓ Efficiency
    - ✓ Avoid misconceptions, guidance
    - ✓ Distinguish reality from fiction
  - Games
    - ✓ Fuzziness
    - ✓ Chance
    - ✓ Repetitiveness
    - ✓ Trial and error, free exploration
    - ✓ Suspension of dibelief
- Common aspects
  - Feedback (formative and summative)
  - Hyphen on motivation
  - Problem solving
  - Inqury-based learning

Putting it all together in a meaningful whole

- This the challenge of SG design
- All the topics/concerns related to pedagogy/contents and entertainment must be addressed together since the beginning of the design since:
  - superimposing a posteriori game mechanics over an exercise only seldom creates a fun/entertaining SG
  - inserting a posteriori cultural/curricular contents inside a game only seldom creates valid educational tools

Requirements (I)

- Collection and elicitation of the requirements
  - Interviews, questionnaires, domain analysis, field studies, literature review
- Who are the end-users?
  - Demographi aspects
  - Any relevant feature
  - Different categories? (may imply personalization or different versions)
- Who are the buyers?
  - (What is the business model?)
- Who are the stakeholders?
  - E.g., parents, educators, museum/exhibition curators, etc.
- What do they need from the game?
  - Stress in particular the learning/educational objectives
  - Collaborative?
- What do they expect from the game?
  - Consider also the entertainment goals/constraints

Requirements (II)

- What is the context of use of the game?
- Usability aspects
  - Constraints, expectation
- Constraints on costs, technologies, etc.?
- What is the novelty of the game?
  - Study the state of the art and state your main innovation
  - Be focused on particular strengths
- Merging and reconciliation of the requirements

Requirements (III)

- Prepare one or more requirement tables
  - Write in bullets to be synthetic
- Write text use cases of your game
  - If you have time…
- Your game will need to support/comply with all these requirements
- You will then need to derive the features of your SG on the basis of these requirements
- And you will need to check that your SG meets these requirements
  - Expert and user focus groups
  - Expert evaluation
  - (Field) user tests

Pedagogical requirements in detail

- What should the players learn?
  - Focus on the contents
  - Define «learning units» (for knowledge and/or skills)
    - ✓ Specify difficulty levels
    - ✓ Specify dependencies among units
      - Overall oriented graph structure (Game knowledge/skill Graph - GKSG)
      - Loops may be possible
    - ✓ Specify (additional) pre-requisites for every unit
    - ✓ Speficy the expected learning outcomes
    - ✓ Specify success conditions (the unit may be repeated?)
    - ✓ Specify how knowledge/skill acquisition could be verified
    - ✓ Time constraints?
  - (Write in bullets)

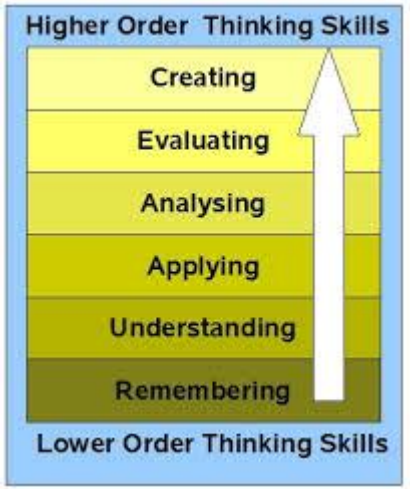
Learning theories/approaches/strategies

- Learning happens is different ways
  - Let's have a look at some established learning theories (in the SG and technology enhanced learning literature) to get inspiration
  - You do not need to follow all of them
  - You may consider just one of them

- Our selection:
  - Revised Bloom taxonomy
  - Kolb's Learning stages
  - Cognitive Load Theory
  - ARCS model
  - Personalism

Revised Bloom taxonomy

- A taxonomy of Learning goals



- Remember
  - Recall information
    - ✓ Recognize, list, describe, retrieve, name, find
- Understand
  - Explain ideas or concepts
    - ✓ Interpret, summarise, paraphrase, classify, explain
- Apply
  - Use information in another familiar situation
    - ✓ Implement, carry out, use, execute

Revised Bloom taxonomy

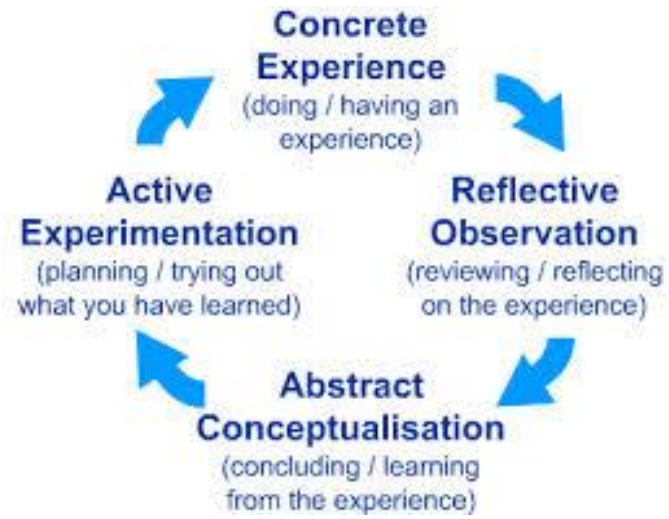
- Analyse
  - Breake info into parts to explore understanding and relationships
    - ✓ Compare, organize, deconstruct, interrogate, find
- Evaluate
  - Justify a decision or course of action
    - ✓ Check, hypotesisze, critique, experiment, judge
- Create
  - Generate new ideas, products or ways of viewing things
    - ✓ Design, construct, plan, produce, invent

- More detailed info:
  - http://www.utar.edu.my/fegt/file/Revised_Blooms_Info.pdf

How to use the Revised Bloom taxonomy?

- You should select one knowledge item/ skill and an associated learning goal type from the taxonomy
- Examples:
  - Retrieve from a list all the cities in Africa
  - Use your knolwedge on the typical african tissues to select an african cloth within a set of clothes
  - Compare a set of possible decisions and choose the most suited to achieve a goal
  - Interrogate several witnesses and identify the lier
  - Make hypothesis about the next step of a process
  - Plan the next steps to defeat the enemy or to overcome your market competitor

Kolb's learning stages



Kolb's experiential learning cycle (do, observe, think, plan)

- This cycle is particularly relevant for simulation games

- Think – The player studies a context (situation, environment, e.g., a company)
- Plan - Takes some decisions (e.g., sets parameters such as the prices of his products and the amount of production)
- Do - The simulation runs (e.g., one month of market) and the player sees the outcomes (e.g., how many products have been sold, what the revenues are, how customers are satisfied)
- Observe – The player reviews the results (e.g., graphics, historical trends, etc.) and reflects about the outcomes of his choices

How to use the Kolb's learning stages?

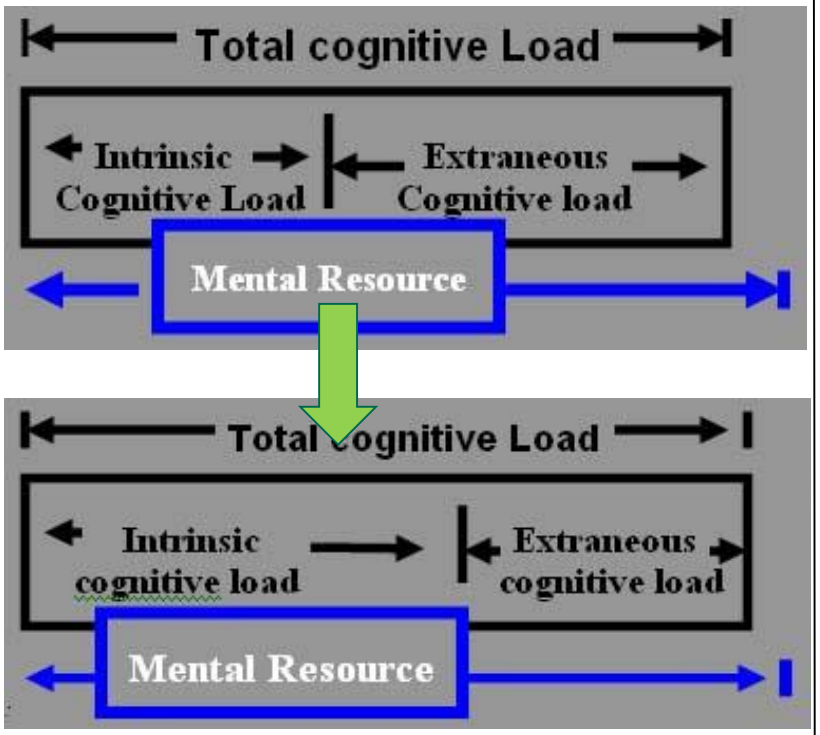
- A proper educational tool (a SG, in our case) should well support all the steps of the Kolb's experiential learning stages
- Think of SG situations, scenarios and mechanics that would trigger/support/stimulate all the steps
  - Particular attention to:
    - ✓ Allow the player to experience as well as possible all the aspects of the game scenario/situation/simulation
    - ✓ Support the player in reviewing and reflecting about his perfomance and what is happening
    - ✓ Stimulate conceptualization and conclusion making and experience
    - ✓ Allow the player to control parameters in a fair and appropriate and effective way
- Think of graduality
- Particularly suited in simulation SGs

Cognitive Load Theory

- Relies on the hypothesis that **short term memory** is limited in the number of elements it can contain simultaneously and must **not be overloaded**
- Sweller builds a theory that treats **schemas**, or combinations of elements, as the cognitive structures that make up an individual's knowledge base
- The contents of **long term memory** are "sophisticated structures that permit us to perceive, think, and solve problems,". These cognitive structures make up the knowledge base. **Schemas are acquired over a lifetime of learning**, and may have other schemas contained within themselves.
- From an instructional perspective, information contained in **instructional material must first be processed by working memory**. For **schema acquisition** to occur, instruction should be designed to **reduce working memory load**
- Cognitive load theory is concerned with techniques for **reducing working memory load in order to facilitate the changes in long term memory associated with schema acquisition.**

Cognitive Load Theory

- ***Intrinsic cognitive load***: Is the intrinsic mental effort needed to learn a certain unit of knowledge
- ***Germane load:*** Is the load that helps building new complex schema in a successive manner helping the learner to move from novice to expert. It is a self effort to learn, and memorize information learned.
- ***Extraneous cognitive load:***
  Results from the techniques in which the to-be-learned information is presented.
  Extraneous cognitive load does not contribute to learning
- **The total cognitive load** is the sum of the three above
- Modifying the instructional material to engineer a lower level of extraneous cognitive load will **facilitate learning**



Good instructional design

Guidelines for instructional design

- Eliminate the working memory load associated with having to mentally integrate several sources of information by physically integrating those sources of information.
- Eliminate the working memory load associated with unnecessarily processing repetitive information by reducing redundancy.
- Increase working memory capacity by using auditory as well as visual information under conditions where both sources of information are essential (i.e. non-redundant) to understanding

Possible supporting SG elements

- Tutorials
- Maps for better exploring the space
  - Possibly, with status information
- Objectives' list
  - Possibly, with status information
- Landmarks in 3D worlds
- Contextualized helps
  - Non-virtual characters
  - Triggered on particular conditions (when the player is in difficulty – *see also the slides on «Assessment»*)
- Bookmarks
- Animated worked examples (cut scenese)
- Graduality of levels
- User profiling to avoid useless repetitions

ARCS model

- A model based on a synthesis of existing research on psychological motivation
  - Focus on learner's motivation
- ARCS is an acronym that represents these four classes: Attention, Relevance, Confidence/Challenge, and Satisfaction/Success
- Attention
  - Goal: gain and keep the learner's attention
  - Means: sensory stimuli (alerts, use different media), inquiry arousal (raise questions, suggest missions and tasks), variability (introduce variability elements)

ARCS model

- Relevance
  - Goal: learners need to know how the activity relates to their current situation, and/or to them personally
  - Means: goal orientation (know and meet the user needs), motive matching (allow choices and responsibilities), familiarity (tie instruction with the learner's experience)
- Confidence/Challenge
  - Goal: the activity cannot be perceived as either too hard or too easy
  - Means: adaptivity, keep the flow, build a positive expectation for success, success opportunities (enhance the students' belief in their competence), personal control (awareness that success os related to personal effort and abilities)
- Satisfaction/success
  - Goal: Learners must attain some type of satisfaction or reward from the learning experience (internal or external to the learning experience)
  - Means: awareness of the achievements, awareness of the positive consequences of the newly acquired knolwedge, internal/external rewards, badges, charts, standings, earning analytics, etc.

Importance of user assessment

- For ARCS, like for other educational strategies, it is key to profile the user in order to estimate the attention status (see also the «Assessment» slides)

Personalism

- Education as a human relationship between a child (learner) and adult (teacher) who introduces to reality
- (free) questions and answers
- Focus on supporting the relationship
- Real-world hooks and references
- Augmented reality
- Mobile games
- Territorial gaming
- References to other media

Mapping to SG mechanics

- The game designer should select the above seen learning goals/activities that best match the pre-defined requirements
- Every learning goal/activity should be:
  - supported by proper content
  - mapped to concrete game situations (mechanics)
- This is a very critical point
- Every choice should be consistent and properly justified

SG mechanics/components

- Main info sources: the Game Ontology Project (GOP) and T. Hussain, "*Serious Game Design Tutorial*," Gametech *2012*

- Interface
  - mapping between the actions of the player and the manipulation of game entities
  - Receiving the feedback from the game
- Rules
  - Constrain what can and can't be done in a game
  - Determine the basic interactions that can take place within the game
- Goals
  - Objectives or conditions that define success in the game
- Entities
  - Objects in the game that the player manages/modifies/interacts with
- Entity manipulation
  - Alteration of the game made by player or in-game entity
  - Actions that can be performed by the player or in-game entity

SG mechanics/components

- *User Interface*:
  - scoreboard, screen, keyboard, charts/standings, physiological sensors, time indicator, performance meter, odometer, dashboard, cockpit, tactile output, touch-screen, stylus pen, point of view, point & click interface, cameras, bio-feedback, aural output, warning, alarm, notification, 3D, 2D, etc.
- *Rules*:
  - Bonus, checkpoint, difficulty levels, dynamic difficulty adjustment, mission, tasks, dialogues, segmentation, game ends, lives, level, narrative, spatiality,matching, social interaction, social networking, time, etc.
- *Goals*:
  - Score computation, performance record, performance metrics,rewards, gadget, learning experience etc.
- *Entity manipulation*:
  - collect, encounter, acquire, gain, etc.

- Subdivision is somehow arbitrary, and we are interested also in some (transversal) SG-specific aspects such as:
  - Assessment
  - Feedback
  - Plot/Story
  - Guidance
  - Graduality
  - Cooperation/Collaboration

Before going in detail: game genres

- You should choose a SG genre:
  - Mixed solutions are also possible
- Examples from the cultural heritage domain
  - Adventure 3D
    - ✓ Battle of Themopylae, Revolution, TiE
  - Adventure (pointand click)2D
    - ✓ TimeMesh, The Plague
  - Strategy2D
    - ✓ Expedition the game
  - Simulation2D
    - ✓ Building Detroit
  - Documentary2D
    - ✓ The catand the coupe
  - Trivia/puzzles
    - ✓ The great bible race
  - Territorial (mobile) game
    - ✓ VeGame (can be a mix of the above – the definition criterion concerns the use, not the contents/interaction, differently from the above)
  - Other?

Before: game models

- You may follow a game model
- SG Sandbox model
  - 3D context environment to be explored
  - Tasks (minigames) assigned in relevant points
- Treasure hunt
- Snakes and ladders
- Board game
- Other
- You can also think of one or more specific games

Plot/Story

- Typical story elements to be defined
  - Characters (player avatars and non-player characters), settings, voice, plot, conflicts, events, themes
- Structure:
  - Introduction
  - Breaking event
  - Climax
  - Solution
- Typical elements
  - Quest, race, competition, cooperation, surprise, affectivity, etc.
- Could be schematic at high level
  - E,g., treasure hunt
- Think of graduality and levels *(cfr the «Graduality» slides)*
- Think of interactive storytelling

Plot/Story – possible mechanics

- Introductions and conclusions
  - Why?
    - ✓ Create/stregthen the plot
    - ✓ Explain the value of the next/previous step in the game
    - ✓ Intriduce/make clear the educational value of the next/previous step
  - When?
    - ✓ At the beginning of the game
    - ✓ At the beginning of each level/task/mission
  - How?
    - ✓ Cut-scenes
    - ✓ Texts
- Dialogues with the NPCs
  - Closed dialogues
    - ✓ The player chooses among a set of predefined questions
  - Open
    - ✓ Natural language processsing. The system answers with the best-matching answer from a database of possible answers
  - Support for inquiry-based learning
- Narration/voice over
- Sound effects/jingles/motives/soundtrack

Graduality

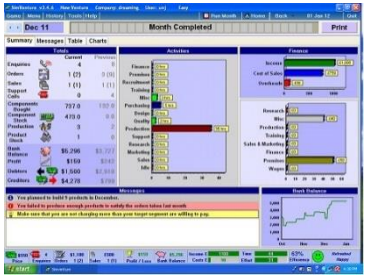
- Graduality is key for any pedagogical activity
- Scale difficulty of contents and challenges
- Graduality should be employed to pass from extrinsic motivation *(at the beginning of an educational process, where the teacher)* to intrinsic motivation *(at the end)*
  - See also next slide
- Graduality may be reflectd in games through game mechanics such as:
  - Levels
    - ✓ Define the levels
      - – Start and end conditions (time elapsed, achieved goals, etc.)
  - Personalization/adaptation
    - ✓ Define the conditions and the personalized/adapted components/items (see also next slides)
  - Other?

Graduality: the continuum from game to simulation

Combine extrinsic and intrinsic motivation

More game-like
(extrinsic motivation)

More simulation-like
(intrinsic motivation)

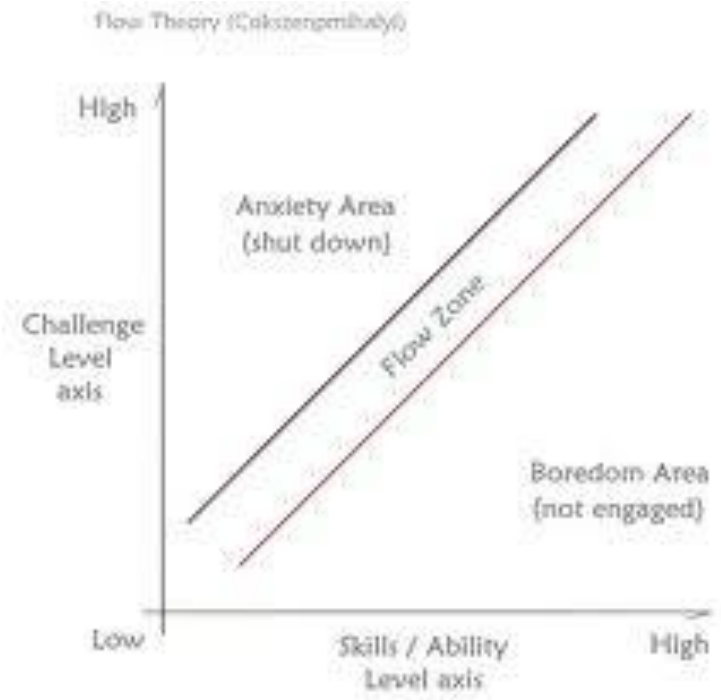


Knowledge/skill is expected to increase as time elapses

Parameters to be tuned during the transition: structure, rules, targets, timing, assessment, feedback, virtual vs. real world rewards

Adaptation

- Keep the flow
- Adapt difficulty to the user level
- Provide motivation, in particular for the weaker users
- Support weaker users *(also to increase competitiveness)*, also through score



Assessment

- Assessment is key for any pedagogical activity
- The game should continuously (or at some check points) assess the player activities according
- It is necessary to define a user profile able to capture the skill/knowledge dimensions
  - For instance, the user should be able to successfully complete the whole game knowledge/skill graph (GKSG) defined in the pedagogical requirements. This may be a data structure that could be employed
- The system should be able to update the player profile in real-time
- How is the score computed?
  - Are there different (weighted) dimensions?
- Are performance metrics defined?

Assessment

- How does the game implement all the assessment/verification items defined in the pedagogical requirements? (in order to fill the user profile)
  - Through questions? Assessment tasks (quizzes, minigames) at checkpoints? Evaluating the player actions?
- Stealth/embedded assessment should not interrupt the user experience/flow
  - Assessment by processing data from the game play
  - Possible user moves and interactions should be carefully designed to support assessment
  - You should define all the in-game actions/events/data that should be recorded and how they should be processed in order to update the user profile
- Assessment is a key enabler for feedback provision and assessment/personalization

Feedback

- Relying on proper assessment, it is necessary to provide feedback to the player
  - Precision, accuracy, tutoring
- Formative (real-time, push or on demand)
  - Consider efficacy, effiiciency, intrusiveness with respect to the flow, cognitive load
- Summative
  - (detailed) performance summary at the end
- What mechanics?
  - Learning analytics, charts and standings, (segmented) player rankings, bonuses, performance meter, performance dashboards/displays, multimedia alerts, suggestion signs on the screen, «virtual teacher» intervations, passage of level, lives, end of game, timer display, summary of state with regard to the best/ideal, others
- Consider the various pedag. strategies/theories (in particular the ARCS motivation model)

Feedback

- Learning analytics
  - Graphics showing:
    - ✓ Historical trends, (quantitative) relationship among different measured dimensions/parameters (score, precision/accuracy, time spent in a level, number of level passed, number of wrong attempts, age, sex, estimated competence in some topics, etc.)
  - Supporting learners' self-assessment to take decisions and improve learning
  - Supportig teavhers' assessment to take decisions and improve teaching

Guidance mechanics

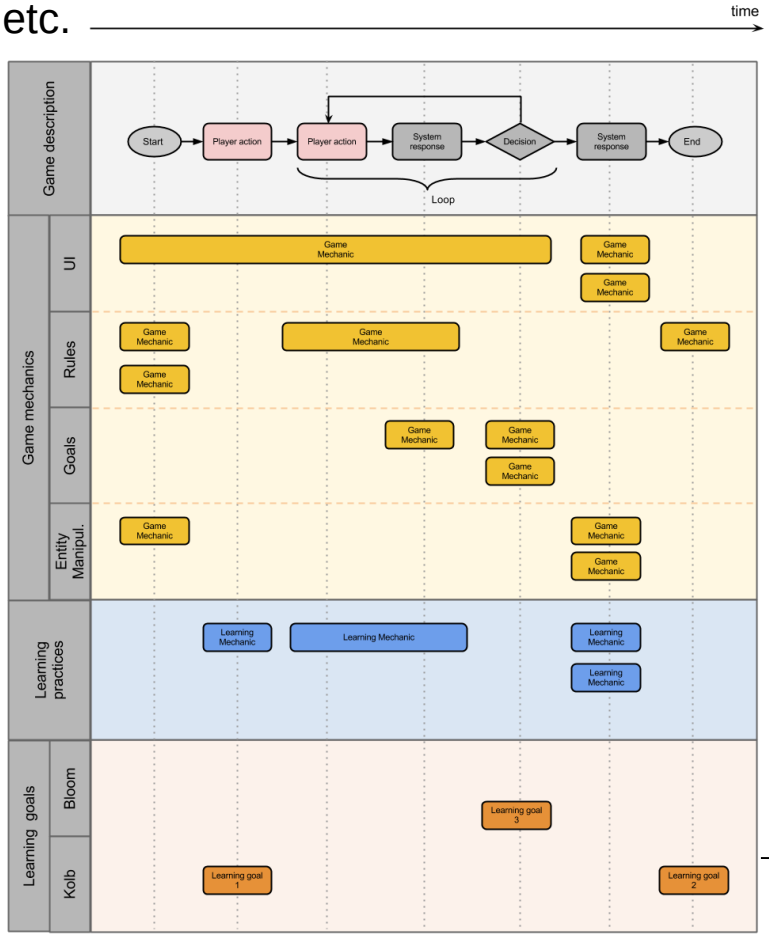
- Guidance is very important, in particular in the light of the Cognitive Load Theory
- Introductions and conclusions, dialogues with an NPC, already presented in the «Plot/Story – possible mechanics» slide
  - Explicit/implicit instructions
- Educational briefing
  - Explain the educational goals
  - Provide hints/clues that will orient/guide the player experience/quest
- Map
  - With some status information, landmarks
- Objectives' list
  - With achievements reported
- Cues and hints
  - Visual, in dialgues
- Bookmarks
- Mouse-over information
- Explicit references to more in depth info, typically on other media

Cooperation and collaboration

- Cooperation
  - Team mates cooperate when they do different tasks (without a significant interaction) to achieve a shared goal
- Collaboration
  - Team mates collaborate when they do some tasks (with a significant interaction and proper negotiation and agreement) to achieve a shared goal
- How can this be supported thorugh game mechanics?
  - Possible examples:
    - ✓ Micro-blogging
    - ✓ Chat
    - ✓ Sharing of information (through verbal, text communication) that is (or an be) available to only one of the participants but is necessary also to the others
    - ✓ Sharing of energy/resources, under what condition?
    - ✓ Bonus score for collborative behaviour
    - ✓ Joint rewards (score, badges, etc.)

SG mechanics

- Every SG mechanics/situation should have a relationship with at least one of the pedagogical elements, such as:
  - Bloom: remember, understand, apply, etc.
  - Kolb's: do, observe, think, plan
  - Etc.
- Put all together in the graphic representation in the SG Analysis and Design Framework (SGAD)
- Always explain and justify your choices



SG mechanics

- The SGDA includes:
  - A dynamic timeline, where the learning activities/goals and mechanics are specified for every level
    - ✓ In order to avoid repetitions, in the next levels only the differences with respect to the previous one are specified (e.g., increased question difficulty, reduced available time, new/missing mechanics, different modalities/weights in computing the score), assuming the rest to be the same
  - A static document (the SG description template) with a general overview of the game, also including the static elements (e.g., tutorial sections, help pages, score/performance/analytics pages, etc.)

Deployment

- How will the game be deployed?
  - At home, mobile, in a kiosk, rented device, etc.
- Context
- Role of the teacher/guide/educator/attendee

Miscellaneous suggestions

- Consider using metaphores
- Be consistent in the choices
- Make the mechanics/implementation consistent with the message/content
- Carefully consider the time factor

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The end

- Thank you for your attention!
- Questions?

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