Designing Educational Games for Project Management using the MyPMgame Canvas©

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ABSTRACT

The development and application of educational games has firmly established itself in the fields of business economics and political science, both for the purpose of vocational and further training as well as the research of complex systems and the partly dynamic structures included therein. Hitherto, this does not entirely apply to technically-oriented fields like for instance the engineering, natural or computer sciences, in which plans or endeavors are frequently realized with project orientation.

In accordance with the German Standard DIN 69901, a project is a complex, previously unknown, unique, target-oriented and temporally limited plan or initiative, collaboratively implemented either by an individual or a specific group of contributors to realize a defined quality for a specific purpose.

Interestingly enough, this definition demonstrates a notable analogy to common definitions of educational games, allowing the deduction that especially the method of educational simulation & gaming can deliver a valuable contribution to vocational and further training in project-oriented industries, potentially even serve as a forecasting or optimization tool. Currently it appears impossible to determine the specific reasons for the limited application of educational games in the technically-oriented disciplines. Nevertheless, these reasons can be expected to have historical origin or depend on subject-related issues within the culture of the profession.

In contrast to that, experience shows whilst a general interest in educational simulations and their methodology frequently exists, the necessary methodological and subject-related didactic know-how is yet unavailable.

To overcome the barriers existing to date for the application of educational simulations in the above-mentioned domains, this contribution presents a 12 stages development framework for the straightforward conceptualization and modular refinement of educational simulations with special orientation towards the project-oriented industries.

After introducing the theoretical background of the framework the game development process is presented as an example by using a wind energy project (converter platform).

INTRODUCTION

Engineers, for example, tend to work according to predefined procedures and proven examples to achieve the intended planned objectives. A deeper understanding of backgrounds and contexts will be developed only if the situation demands it. According to the PDCA-principle: PLAN – DO – CHECK – ACT. That is the reason why technically oriented professionals, who want to deal with simulation and gaming, which is indeed far away from the original profession, are often cautious to make themselves familiar with the theoretical background of the simulation and gaming method e.g. by comprehensive study of literature. Based on their culture, they prefer in general to DO and not to invest a lot of time in preparing themselves for new endeavors (usually they are learning during the action).

To overcome this challenge, it seems to be rational to support the design and the implementation of simulations and games in this field by developing a predefined, logical and easy to apply procedure which can be used without comprehensive preparatory work. This will address the "culture of doing" and enables the technically oriented professionals to design their own game right from scratch. Further, applying this procedure will motivate to gain further necessary knowledge during the game design process due to the fact that it is demanded to achieve the goal (CHECK & ACT).

As an underlying foundation for the design framework a simulation system for the project management was developed. Before presenting this, it is necessary to introduce the term *project* in brief.

A plan or initiative is called a project when it is essentially marked by the uniqueness of its conditions, e.g. clear differentiation from other plans, specific targets, temporal, financial, staff-related or other limitations, and a plan-specific organization. Apart from the uniqueness, a project is also defined by its novelty, complexity and interdisciplinarity (Schelle, 1989).

Therefore, a range of projects can be rated as novel and highly complex systems. As a consequence, it is especially the isolated consideration of individual problems within the system "project" which leads to insufficient solutions and strategies, as it frequently disregards the context of the project. According to Patzak (1989) projects are characterized by the following problem areas:

- High need for knowledge and technological innovation,
- high risk regarding the target achievement of the system realization (content, time, costs) and system usage (acceptance, function, system environment),
- substantial, partly unapparent cross-linking (multiple and reciprocal dependencies in the system and on the environment)
- considerable dynamics of environment and the basic conditions (structure of values, needs, level of knowledge),
- high degree of interdisciplinarity, accompanied by communication problems,
- long duration of realization as well as validity, long after-effect of solutions,
- high relevance regarding satisfaction of demand / corporate

success.

If the defining characteristics of projects are compared to common definitions of simulation & gaming, the potentially increased value of educational simulations and games as a teaching and learning method in this field become apparent. Based on a realistic setting with conflicts and problems, an educational simulation should motivate participants to develop specific capacities to act, aiming at the adapted, responsible and successful application of these skills in a real context (Karl, 2012).

It is especially the high risk in regard to the achievement of targets, the substantial but unapparent cross-linking and dynamics, and lastly the high degree of interdisciplinarity which cause conflicts and problems in the context. To allow a successful finalization of a project, it is necessary to consider and include these determining project characteristics. Thus, the involved parties of the project are expected to have specific skills at their disposal, which they need to adapt and employ in the according project.

These skills are influenced by numerous professional, methodological and social competencies. Precisely these competencies, necessary for the implementation of a project, are superbly covered by the simulation & gaming method: the training of combination and coordination abilities, autonomous problem-solving skills, flexibility of evaluation and decision-making, the willingness to take the lead as well as team-working ability, communicative skills and assertiveness.

Thus, it is not only the project itself which forms a complex system, but also the diversity of competencies required for the implementation thereof. As a consequence for the development of business simulations, an expedient intertwining of the technical as well as the needed didactic system becomes necessary.

A SIMULATION SYSTEM FOR THE PROJECT MANAGEMENT

According to Patzak (1989), four types of logically consecutive systems can be identified:

1. Target system: This system is oriented towards the needs in the project, i.e. it forms the sum of the targeted states and results of the activities as a planned final state. These are e.g. project aims, project definitions and the performance specification.
2. Operation system: Here, the tasks and activities required for the target achievement are recorded in accordance to content, time and resources. This includes, for instance, the project structure, the project progress, appointments and costs.
3. Stakeholder system: The stakeholders or active agents are organized in this system. This way it represents the executive unit of the operation system to satisfy the needs in the target system. Actors can be individual contributors or participants of the project, a project team or whole organizational units of the project.

Product system: This system depicts the project subject, which itself illustrates the result of the stakeholder system. The product system can display different stages of the project life cycle as well as quality or quantity of the product.

From a didactic point of view, such a project system typology is a purely content-oriented, subject-specific system.

As both educational simulations and events which are organized with their help have to be understood as multidimensional teaching and learning scenarios, more systems and subsystems need to be taken into account for the development of a project management educational game (PM game).

Due to this, more meta-systems need to be considered for the development of an educational simulation according to Karl (2013): 1) a participant-oriented system, oriented towards the desired competencies and learning outcomes, 2) a technical system, which addresses the concrete realization of the educational simulation. Following the previously introduced project system typology, these could also be regarded as independent meta-systems in the development of educational simulations.

TABLE 1
SYSTEM FOR PROJECT MANAGEMENT SIMULATION

Target system (1)	**Operation system (2)**	**Stakeholder system (3)**	**Product system (4)**
Subject-specific, content-oriented system (Cont)			
project aims	project phases, processes, activities, action risks	decision levels, functional areas, project organization & relations, project roles, risks of stakeholders or agents	project, project type, project risks and chances
Participant-oriented system (Part)			
aim of the educational game, targeted competencies, teaching and learning aims	structure of educational game, temporal proceedings, tasks in the game	participants (addressees), facilitator	competency build-up, teaching and learning results, measurement of learning success, evaluation of educational simulation
Technical system (Tec)			
physical specifications of the educational game (e.g. haptic, EDP - supported, i.e. on site, online or hybrid)	temporal or financial resources for development and implementation, time frame for execution, communication methods, random elements	human resources for the development and implementation (e.g. in-house or external development)	educational game as final product, product and process quality

The compilation of these three systems results in a multidimensional system for educational simulations of project management (table 1).

However, this structure is not sufficient for the practical development of a PM game. Just like in any complex system, dependencies and reciprocal influences are equally relevant and need to be modelled in detail.

The basis for the development of an educational game is the specification of addressees and the aim of the game (Part3, Part1). This predefinition is directly dependent on the illustrated level of project decisions respectively the functional area (Cont3). Once the basis has been set, the project start (Cont4) and the project phases which are to be included (Cont2) can be defined. This results in the project aims which are to be defined in the educational game (Cont1) and the accompanying risks (Cont4).

In parallel, the aforementioned basis of the educational game development defines the competencies addressed by the game as a whole (Part4), which in turn lead to the setting of the teaching and learning aims.

These subject-related as well as didactic settings find their way into the selected processes of the project and their activities (Cont2). The subject-related considerations (type of project, phases thereof etc.) lead to the definition of the project management areas and the according roles (Cont3), being indispensable elements of the educational game. Then, they are combined with the processes and activities, forming a model of the project organization and the relations therein.

Furthermore, it has to be decided which processes and activities need to be integrated, as they will result in specific tasks for the participants, who in turn influence the implementation of the educational simulation decisively (Tec 1-4). This again is reciprocally affected by the methods which should be employed for the measurement of the learning success and the evaluation (Part4). Then again, the latter are defined by the teaching and learning aims.

It becomes apparent that the illustration of such a dependency structure is everything else but comfortable for the practical development of an educational simulation – especially in view of the fact that the level of detail increases during the development itself. Thus it appears reasonable to select a form of illustration which offers a straightforward presentation of the project management game system and simultaneously allows the conceptualization respectively modular development of an educational game.

The “Business Model Canvas” (BMC) according to Osterwalder & Pigneur (2010) is an established method for the development and testing of models. The BMC primarily addresses business models and start-up ventures. Here, all elements of a successful business model are visually depicted on a canvas, so developments do not only take place linearly, but also in parallel and recursively. Additionally, variants can be compared and existing business models can quickly be refined.

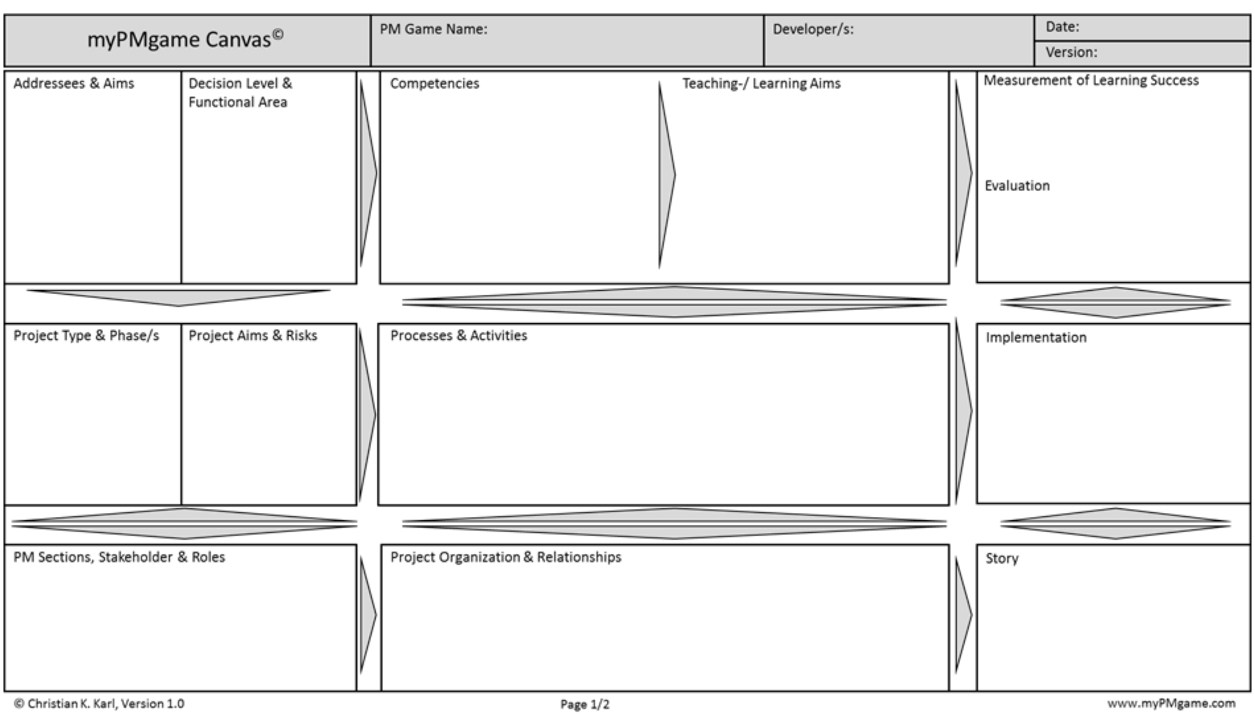
This comparably basic principle seems advantageous for the development of educational games, as the visual display on the canvas offers direct access to the game system. This development on a canvas is especially suitable for persons with a general interest in the educational game method, but a lack of methodological or subject-specific didactic experience.

As a consequence, the project management educational simulation system including the contained, diagrammed dependencies are developed further into a game design framework named “myPMgame Canvas©”.

On the basis of the BMC, the myPMgame Canvas© allows an immediate start of the game design process with very little preliminary work (figure 1). Thus, the canvas is not only for the illustration of the above-mentioned subsystems, but is also intended as practical aid in the process.

Furthermore, the canvas offers the possibility to develop an educational game not only as a single person, but also as a group. For instance, the myPMgame Canvas© enables the realization of a simultaneous and synergetic development with one contributor per subsystem (subject-related, didactic,

FIGURE 1
MYPMGAME CANVAS© (PAGE 1)



technical). One immediate advantage of this is the direct addressing and solving of conflicts which emerge during the design process.

Figure 2 displays the second page of myPMgame Canvas©. It offers further sensible and practical aids to support the continuation of the creative process during the design phase (this second page should simply be put up next to the first one on a wall).

EXEMPLARY DEVELOPMENT

Below, the 12 development stages (blocks) of the myPMgame Canvas© are introduced with the help of an example taken from the own project respectively consulting practice. Even though the blocks are listed in a specific order in the following chapters, they do not have to be processed in the given sequence.

As the application of the introduced development framework aims both at a straightforward and creative development of a PM game, the jumping or switching between the different blocks is explicitly invited and encouraged. Beyond this, the switching promotes the systematic thinking of the project contributors and agents, as their actions and reciprocal influences become ascertainable.

BLOCK 1: ADDRESSEES AND AIMS OF THE EDUCATIONAL SIMULATION

At the beginning of the development, it is especially relevant to determine for whom and with which aim the PM game should be developed. Potential addressees can be for instance pupils, students, job starters/young professionals or executives.

The aims of the PM game can be defined with the help of the following operation fields:

FIGURE 2
MYPMGAME CANVAS© (PAGE 2)

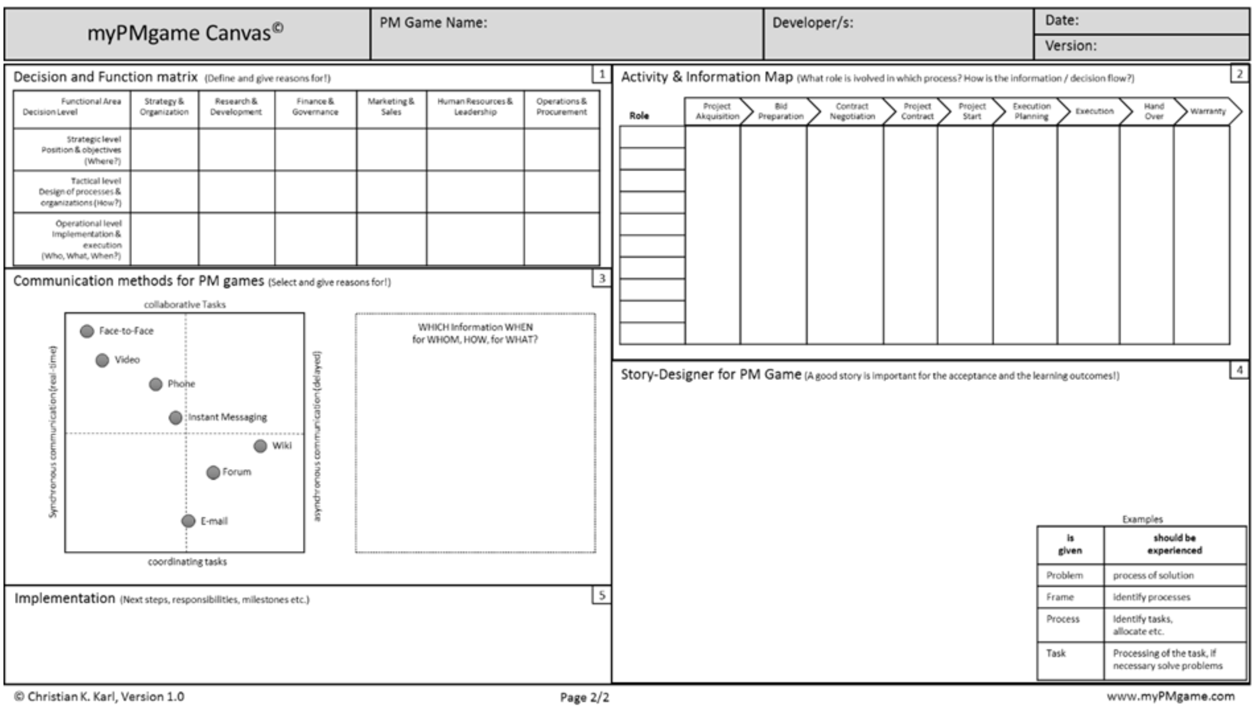


FIGURE 3
DECISION AND FUNCTION MATRIX ACCORDING TO KARL (2014)

Function level Decision level	Strategy & Organization	Research & Development	Finance & Governance	Marketing & Sales	Human Resources & Leadership	Operations & Procurement
Strategic level Position & objectives (Where?)						
Tactical level Design of processes & organizations (How?)						
Operational level Implementation & execution (Who, What, When?)			students and young profes-sionals			students and young profes-sionals

1. Project organization,
2. Project coordination,
3. Project documentation.

Depending on purpose and target group, an isolated field or an intersection of several operation fields is feasible and can be considered.

A major proportion of problems occurring during projects can be traced back to a lack of communication or cooperation or a failed distribution of essential information. Here, fundamental causes for these problems can be found on a technical or personal level. Especially the latter aspect is in the scope of the described example, as it aims to demonstrate that a PM game should increase the awareness of the necessity of collaboration and transparent project implementation. This implies that all three operation fields of the project management are involved.

The target groups of the given example are students in the final phase of their studies and young professionals.

BLOCK 2: DECISION LEVEL & FUNCTIONAL AREA

Block 2 contains the determination of the decision level and the functional area which should be represented in the PM game. As the example aims to improve the participant's awareness of the need for collaboration and transparency, this PM game will explicitly depict the operative decision level of a project (who, what, when).

The illustration of this decision area has another advantage. As, at the beginning of their professional career, the target group defined in block 1 will also be working in the operative business of an organization or enterprise, experience derived from the PM game can immediately be transferred into practice to improve future employability.

As the existing financial and temporal restrictions form a major part of the problem settings in the operative project implementation, the functional areas finance & governance as well as operations & procurement need to be included in the educational simulation (figure 3).

BLOCK 3: DEFINITION OF PROJECT TYPE AND PHASE

Block 3 raises the general question, whether a detailed and real project is necessarily the basis for the PM game or if a fictitious project, completely unknown to the target group, should be preferred.

Both variants offer valid advantages. On the one hand, a project which is closely oriented towards reality supports the learning of technically relevant background knowledge and the experiencing and practice of realistic workflow and its processes. Furthermore, this realistic project model increases the acceptance of the PM game and thereby promotes the motivation of the participants.

On the other hand, a fictitious project model, completely outside the scope of the previous experience and professional activities of the target group, can help to get a distance to the own working environment, known and routinely followed workflow processes and the repeated habits therein. Thematic areas for rather fictitious projects could be space missions, environmental disasters, journeys round the world, development of novel devices or machinery etc. (fictitious only if the target group is not familiar with these areas).

Thus, one decision to take in block 3 is the evaluation whether identification with the project is indispensable or, respectively, which level of realism is required to encourage and allow acceptance of the PM game.

A realistic project model is chosen for the example given here, as – in addition to the aims defined in block 1 – the target group should also be confronted with technical aspects like current technological developments. This project is to take place in the context of renewable energies, because many countries currently stage a massive expansion and therefore this area will more and more be part of future professional activities of the target group. In this context, especially offshore energy facilities for low-loss energy transmission are among the innovative projects with a highly challenging implementation.

These projects dealing with high-voltage direct current transmission (HVDC) are employed to cover greater distances outside the 12 nautical mile zone between the offshore wind parks (OWP) and the mainland. To introduce the HVDC technology to the target group of the educational simulation, such a facility is defined as the project item. The detailed illustration of the technical background is omitted here; instead it is referred to the according information made available by the manufacturers of such facilities and installations (e.g. Alstom, Asea Brown Boweri (ABB) and Siemens).

After the type of project has been set, it has to be decided which phases need to be depicted in the PM game. As the teaching success of an educational simulation is highly

TABLE 2
CONTRARY, RESPECTIVELY CONFLICT-RIDDEN, ANTAGONISTIC FACTORS IN PROJECT MANAGEMENT

Project phase	Examples of antagonistic factors
Development	Location, project idea, budget
Implementation	Increase in production, cost reduction, job preservation
Use	Profitability, flexibility of use, social and environmental acceptability

FIGURE 4
DETAILED MODEL OF PROJECT PHASES

dependent on the definition of the problem setting, the identification of contrary, conflict-ridden or antagonistic elements is of crucial importance. These can be identified on the basis of three fundamental project phases (table 2).

These fundamental phases can be further specified (figure 4). Depending on the respective aim and the participants, it is not always necessary to depict all project phases.

If the educational game is supposed to focus on the improvement of cooperation on the planning level, it is fully legitimate to reduce the details of the implementation phase (and the phases thereafter) to a more basic level or even omit them as a whole. This is valid for the negotiation phase, too. Nevertheless, the phases of offer processing and execution planning would still need detailed modelling – on condition that both of them are supposed to be included.

In the example "Realization of an offshore converter platform", the phase of project realization should be illustrated, i.e. the period from the project contract to the project hand over.

BLOCK 4: IDENTIFICAION OF PROJECT AIMS & RISKS

The aims which are to be reached in the educational game can be differentiated with the help of the main aims for the project management:

1. Assurance of qualities and quantities,
2. Compliance with the prognosticated costs and project budget,
3. Keeping of deadlines and
4. the reasonable disposition of resources (according to Mishra et. al. (2009): money, people, materials, energy, space, provisions, communication, motivation, etc.).

As already mentioned in block 3, a problem-ridden situation is mandatory for the educational game. Such a situation can easily be created by identifying the risks which endanger or hamper the previously defined project aims.

In accordance with the already introduced PM game system (table 1), these risks can be categorized in operational risks, stakeholder risks and product risks.

A risk is defined as the danger which can cause an activity to fail altogether or at least fail to deliver the expected success (Bauer, 2007) and thus a risk can be interpreted as a negative deviation from the targeted aim (Haller 1978). Risks can generally be derived from the above-mentioned project management aims. For instance: quality risks, quantity risks, cost risks, scheduling risks, contractual risks and technical risks.

To address specific, realistic risks in the educational game, the developers of the game should have according experience in the project context or at least refer to relevant technical literature.

The chosen example "Realization of an offshore converter platform" stems from the field of construction management. Therefore, specific risk areas and their sub-categorizations can be taken from Schnorrenberg & Goebels (1997), Jacob, Winter & Stuhr (2002), Drees & Paul (2002) and Girmscheid (2005), for instance. The risks can be arranged in the following groups: a) performance-related risks (risks of the construction itself), b) internal risks (management and organization), c) fiscal risks and d) external risks (political changes, force of nature, changes of economic circumstances and conditions).

As the example is supposed to contain the phases from the project contract to the project hand over, the potential risk areas and risks in accordance with Bauer (2007) are identified and assigned to the project phases (table 3).

This qualitative structuring can be used together with the defined project aims to derive numerous relevant aspects. These may be potentially occurring conflicts, which challenges should be mastered by the participants and what could be corresponding actions or interventions.

Apart from this qualitative perspective, the quantitative perspective is equally necessary for the illustration of the project risks. A straightforward method is the separate evaluation of each risk in dependence on the probability of its occurrence (in percent) and its potential damage extent (usually in currency units). The resulting mathematical product of both is labelled *risk*.

As a consequence, it becomes necessary to define concrete risks for the given example. These risks need to be specified in dependence on the settings which already exist at this stage of planning, i.e. those risks which are grounded in the phase of project realization and influence the functional areas finances &

TABLE 3
POTENTIAL RISK AREAS IN THE SELECTED PROJECT PHASES

Project Start	Execution Planning	Execution	Hand Over
• Changes and concessions to preceding phases	• Technical processing • Preparation of operations	• Production • Advance of the principal builder • Performance of subcontractors • Approval risk of subcontractor performance • Obstruction or interruption of operations • Organization, coordination and quality monitoring • Weather effects • Technical and construction site-related obstacles • Construction materials	• Contractual requirements • Legal requirements

management as well as operations & acquisition.

The central project aims given in the example are compliance with the prognosticated costs and the project budget as well as the keeping of deadlines. Therefore, corresponding risks need to be considered during the project development; those risks which exert an influence on costs and target dates. In this case, the risk is seen as additional costs and extra time. The risk areas selected from table 3 for the PM game are modelled further and refined, then concrete values are allocated to them (amounts or shares of original values). It has to be taken into account that not every risk needs to exert an influence on both costs and time – influencing one of these areas is sufficient.

Within this framework, a diversity of problem-ridden situations can be created for the participants. Here it is the decision of the game development, whether the risks a) are completely known from the start, b) gradually emerge in form of events during gameplay or c) are to be identified and rated by the participants at the start of the game (e.g. on the basis of a risk analysis according to Locher & Cie AG (1980), Busch (2003) or Fischer, Maronde & Schwiers (2007)). All above-mentioned alternatives are useful, depending on the according teaching or learning contexts.

The quantification both of the probability of occurrence and the damage extent underlies the experience of the game developers. For this, it has to be decided whether an explicitly realistic determination is indispensable. For the mere transfer of specific risks occurring during a project, thereby solely aiming at the sensitization of the participants, a rather rudimentary modelling of the quantitative basis can be sufficient. On the contrary, a more experienced target group taking part in further training requires a quantitative basis which conforms much more to reality. Otherwise, the educational simulation and the success of the event may be questioned by the participants.

BLOCK 5: PM SECTIONS, STAKEHOLDERS & ROLES

Following the identification of the project type, the phases to be depicted and the potential risks, block 5 contains the identification of the involved sections of the project management as well as the stakeholders and roles therein (a detailed description of the project management sections is omitted here, instead it is referred to relevant literature).

It was already decided in block 1 to take all three operational areas of project management into account (organization, coordination, documentation). Thus, the relevant project management sections which have to be included in the future simulation can be selected. At this time a first definition of the relevance of the individual sections for the educational game is reasonable (table 4). Furthermore, the reasons for this selection need to be documented, i.e. especially signification and purpose of the choice for both the technical and the didactic level of the educational game. This proceeding supports the targeted interrelation with the desired teaching and learning aims, thereby allowing a first plausibility check.

As the awareness of the necessity of collaboration and transparent project implementation has been set as central aim for the PM game, the project organization will be allocated the highest relevance. Due to the fact that especial interest is directed towards communication, cooperation and the distribution of important information (block 1), the section document management will be granted an important share in the game. The primary project aims of compliance with prognosticated costs and the project budget as well as keeping of deadlines (block 4) result in an equally important rating of the sections schedule management and project controlling. Even though block 4 identified specific risks for the educational simulation design, the participants are not supposed to explicitly handle the content of the risk management. The same is true for the contractual management and the quality management. These sections are mentioned in the game, but do not require explicit activities of the participants. Therefore, these sections are rated as less important. Even though the sections operational safety and environmental management are not less important aspects of project management in general, they are neglected in the given example because they do not have direct links to the above-mentioned aims.

After the sections which have to be included in the PM game have been identified, the related stakeholders need to be determined. Apart from the approval and building supervisory authorities, other involved parties of the project can be arranged in six groups of service providers according to Führer & Grief (1997):

- Owner (contracting entity or authority, customer),
- Project manager / project controller,
- Architect / planner,

TABLE 4
SELECTED SECTIONS OF PROJECT MANAGEMENT

PM section	Relevance
Project organization	3
Schedule management	2
Project controlling	2
Contractual management	1
Risk management	1
Document management	2
Quality management	1
Operational safety	0
Environmental management	0

Relevance value: 0 = unimportant, 1 = less important, 2 = important, 3 = very important

- Specialist planners and assessors,
- Construction manager (object supervision) and
- Contracting companies for building shell and interior completion (contractors).

As the chosen project is the construction of a converter platform outside the 12 nautical mile zone, more than just the two common and mandatory stakeholders - contracting authority or entity (electricity grid operator) and contractor (as prime contractor) – are involved. In this case, these additional involved parties are the approving and construction supervisory authority (in Germany the Federal Maritime and Hydrographic Agency or Bundesamt für Seeschifffahrt und Hydrographie, BSH) as well as certifiers or registered inspectors. As the contractor is usually the general contractor, at least one subcontractor is involved, e.g. for the construction of the steelworks of the facility.

Once the required agents or stakeholders have been identified, the next step is the potential assignment of the different roles to the participants of the PM game.

In the present example, the management of the PM game also assumes the role of the electricity grid operator. This agent introduces the project in the phase of project transfer resp. contracting and becomes active at specific points of time. Depending on the design of the educational game, this role can also be taken by (at least) one of the participants. It is important to keep in mind, however, that especially the role of the owner or contracting entity is prone to conflicts and can be seen as extremely contrary to their own aims. If such conflicts are generated in the PM game and transferred into the real world existence of the participants, the mediation and negotiation skills of the PM game facilitator will become very important.

In general, the contractor could be represented with these 12 roles:

1. Project manager
2. Deputy project manager
3. Contract manager
4. Controller

TABLE 5
EXAMPLE OF A ROLE DESCRIPTION

Role card		
Name of PM game: "Realization of an offshore converter platform"		
Role: Control systems engineer		
A.	**General properties**	
1.	Group of service providers	contracting authority (general contractor)
2.	Department	engineering
3.	Position in company	control systems engineer
4.	Experience in company	1 year
5.	Job description	planning of HVDC technology and continually ensuring the proper functioning of components, integration of changes under consideration of the system areas hardware, software, cyber security and safety
6.	Superordinate role	lead engineer
7.	Role on same level	mechanical engineer, electrical engineer, piping engineer
8.	Subordinate role	none
9.	Necessary communication & exchange of information	Continuous communication with lead engineer, mechanical engineer, electrical engineer und piping engineer
B.	**Personal properties**	
1.	Professional aims:	promotion to lead engineer
2.	Relationship to superordinate roles:	takes directives rather critically, questions situations, finally implements and realizes his tasks quickly
3.	Relationship to roles on same level:	as the HVDC technology is the primary system of the platform and the other engineers work with the secondary systems needed for the operation, the control systems engineer expects the others to follow his lead and listen to his directives
4.	Relationship to subordinate roles:	no information
5.	Mode of operation:	creative chaotic
6.	Communication skills:	Frequent occurrence of unidirectional communication, takes most input critically, rather passes instructions to other engineers than adjust his own design
7.	Personal challenges:	keeping order
8.	Motivation level:	Highly motivated in his own area of work

5. Time scheduler
6. Lead engineer
7. Mechanical engineer
8. Electrical engineer
9. Piping engineer
10. Control systems engineer
11. Document control manager
12. Site manager

Beyond this, further roles are possible in accordance with a real project of this type and in dependence on aim and purpose of the educational simulation. These roles could be based on the above-mentioned roles and either represent the subordinate organizational or working levels in more detail or even include further areas like the support section (e.g. the supply manager or the quality manager). Similarly, it could be reasonable to include the commissioning manager.

The subcontractor could generally be represented by these 8 roles:

1. Project manager
2. Controller
3. Time scheduler
4. Structural engineer
5. Systems engineer
6. Document control manager
7. Site manager

The certifier can be represented by at least one person (as claim handler or office clerk).

The finalizing step of this block is the description of the selected roles. To emulate the problem setting and practice situation in a realistic manner, on the one hand the characters of the individual roles need to be determined and described as precisely as possible. On the other hand, a too detailed description can hamper the participants in their roleplaying and restrict the possibility to immerse themselves into the educational simulation with their own personality. Generally speaking, the degree of detail selected for the description of the involved roles is dependent on the aims of the educational game and should be defined accordingly by the game designer.

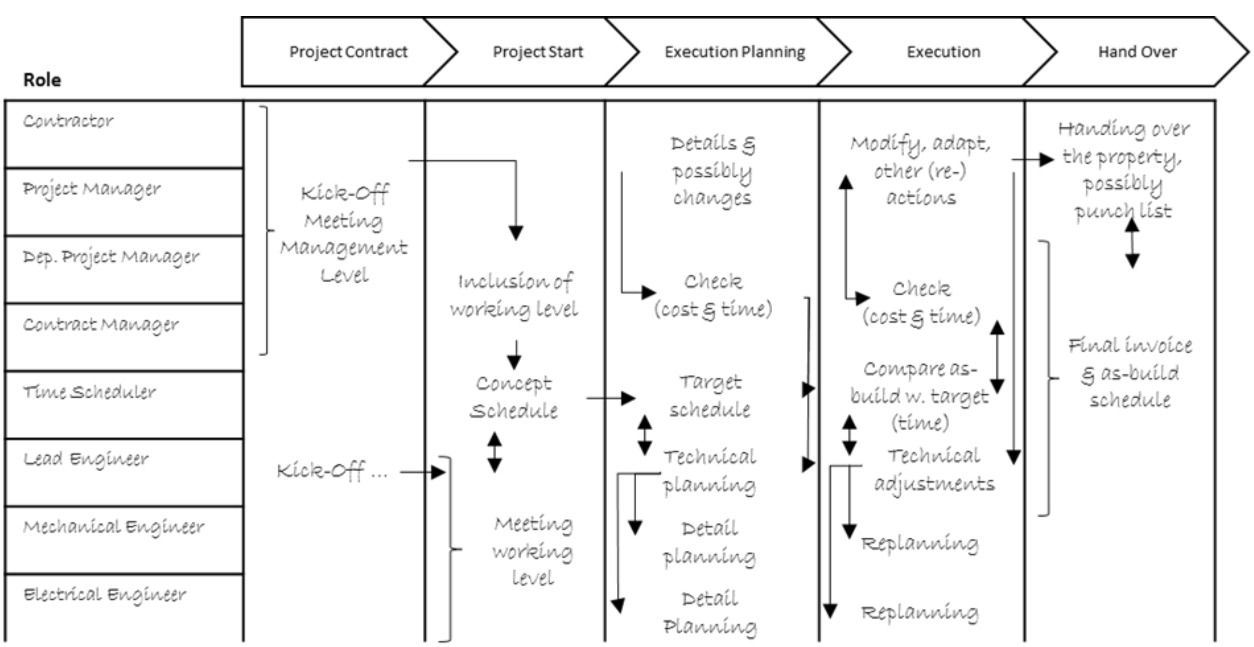
The role description should include personal attributes (Neumann & Heß, 2005) as well as the individual aims. The use of role cards is recommended, as these can either be used again in future game expansions or for new game developments. Table 5 shows an exemplary, fictitious role description for the control systems engineer. It is just a suggested selection of potentially relevant aspects for this person; one can either leave out some of the listed aspects or even include other aspects which are not listed yet. In any case, the role cards need to be adjusted in accordance with the respective scenario of the educational simulation and the corresponding role. After processing blocks 6 and 7, the role cards need to be validated again and supplemented if necessary. Finally, the role cards need to be aligned with the teaching and learning aims of the simulation at the end of the whole development process of the PM game; then adjusted one more time in case of need.

This exemplary role description illustrates the inevitable conflict potential of accordingly arranged roles. Especially the creative chaotic mode of operation, combined with the personal problem to keep order, will have substantial impact on the systematic filing of the documentation and therefore determine the cooperation with others. In addition to that, the relationship to colleagues and the communication patterns can also be seen as critical.

This constellation addresses the central aim of the educational simulation, the increasing awareness of the necessity of collaboration and a transparent project implementation.

Due to the fact that the personal attributes or properties of this role are supposed to be a challenge for the other participants, the role cards of the PM game should not be made available to the other participants from the start on. Consequently, it appears reasonable to hand out the role cards to the respective individual players only and keep the other participants unaware in regard to the character of the involved persons – the latter should be discovered by the participants during the gameplay, forcing them to learn how to deal with it.

FIGURE 5
EXEMPLARY ACTIVITY & INFORMATION MAP (AIM)



As the devising of the participating roles to be involved in the PM game demonstrates already, communication, cooperation and the distribution of important information pose a challenge. A further refinement takes place in blocks 6 and 7.

BLOCK 6: PROCESSES & ACTIVITIES

In accordance with DIN 69901, project management comprises all management tasks, management organizations, leadership techniques and managerial instruments for the execution of a project. For the detailed compilation of the above -mentioned aspects it is necessary to identify the significant processes and activities of the respective project. A basis for this offers the interlacing of the project phases selected in block 3 (project contract to project hand over) with the roles involved in the PM game scenario as defined in block 5 (refer to previous chapter).

The processes, activities and information flow of the individual phases can be visualized for each role with the help of the Activity & Information Map (AIM) (figure 5). The AIM serves as basis for the following block 7 in which the project organization is determined and the reciprocal relationships are further concretized.

The potential scope of action of the individual participants plays a major role in the visualization of the activities which are necessary for the PM game. The following three variants with increasing realism can be distinguished:

a) Pure experiencing of a fully pre-defined project.
b) Like a), but with the difference that single elements of the game need to be adjusted by the participants during the gameplay.
c) Completely open educational simulation, in which only a very limited and fundamental framework of conditions is set and the participants or players are required to define the project and the project phases of the PM game on their own.

The commitment to one of the three possibilities is dependent on the aim as well as the addressees of the educational game. Variant a) is the preferable option if, for instance, the game is supposed to teach basics of project management to a relatively inexperienced group of participants, thereby sensitizing them both for the content of the project management and the potential challenges included therein. If an experienced group of participants should develop action alternatives for the project implementation, the alternative variants b) or c) would be the right choice.

Additionally, it may make sense to offer the available information and allow its distribution only incrementally during the progress of the game. Alternatively, even limit its availability in dependence of time, so that the relevance of communication and transparency within a project becomes more perceptible.

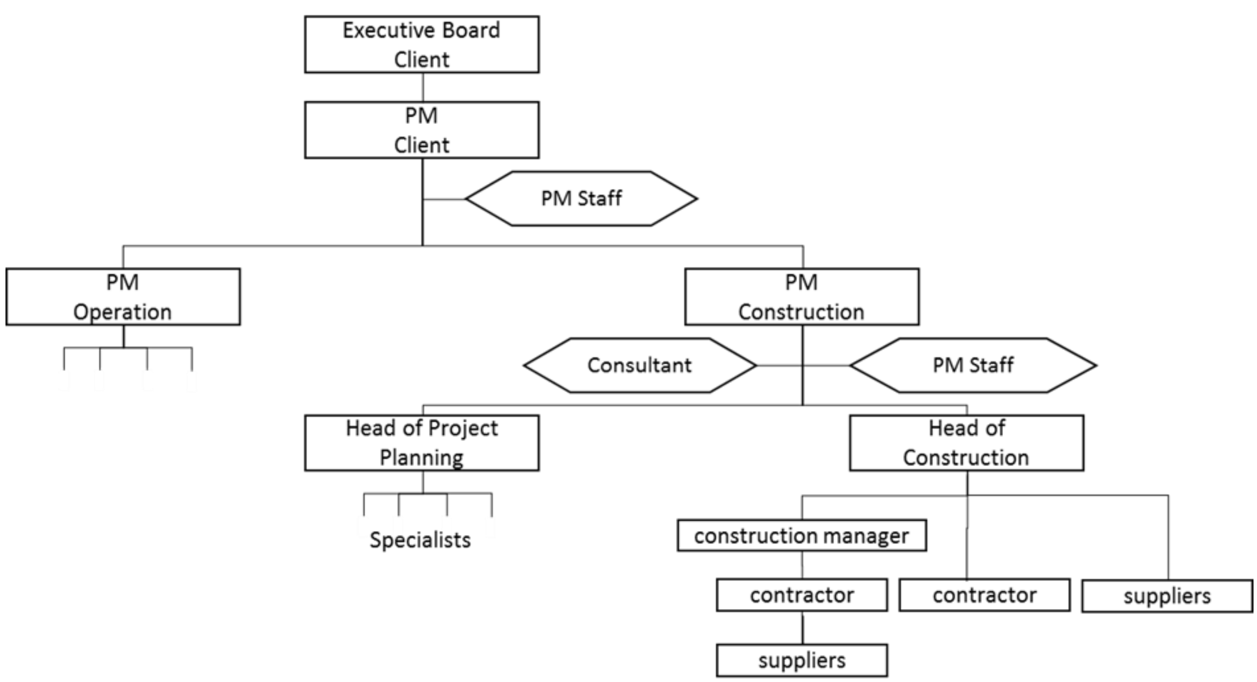
BLOCK 7: PROJECT ORGANIZATION AND RELATIONSHIPS

Each business or enterprise has a structure which is adapted to suit its needs and tasks, mirrored in the company organization (Girmscheid, 2006). As an advantage of this proceeding, the pending tasks can be handled according to their complexity and accomplished by specialized departments and specialists (Girmscheid & Motzko, 2007).

Such an organizational structure and the relationships between the individual agents and stakeholders are defined as follows, on basis of the AIM. In general, a project organization can be developed in accordance with the model of Brandenberger & Rousch (1985) (figure 6).

Including the defined stakeholders or agents from block 5 can lead to a diversity of organizational structures. Figure 7 depicts an exemplary structure for the contractor with several staff positions, which is supposed to be applied in the example.

FIGURE 6
PROJECT ORGANIZATION IN THE PROJECT EXECUTION ACCORDING TO BRANDENBERGER & ROUSCH (1985)



As the PM game aims to increase awareness of the need for collaboration and transparent project implementation, the devising of the project communication is equally important to the definition of the organizational structure. For this, the following central questions need to be answered by the educational game development: Which information is passed on when, by whom, how and for which purpose? How is information dealt with during the progress of the simulation? Is each piece of information transparent? If not, are there good reasons for it? In accordance with the real project handling, corresponding communication methods (synchronous, asynchronous) can be modelled in regard to their tasks or purposes (coordinating, collaborating) in the PM game (figure 8).

As the ample diversity of information which exists in the project as well as their (potentially changing) paths through the project are of particular importance, the information quantity and its flow can be expanded or restricted if necessary:

- by the supervisor of the game (Attention: Mind potential problems of acceptance by the participants!),
- by random elements (e.g. event cards or dice),
- by the participants themselves.

The latter lends itself as an option, if the experience and autonomous solving of conflicts in the project information flow is defined as an explicit teaching and learning aim.

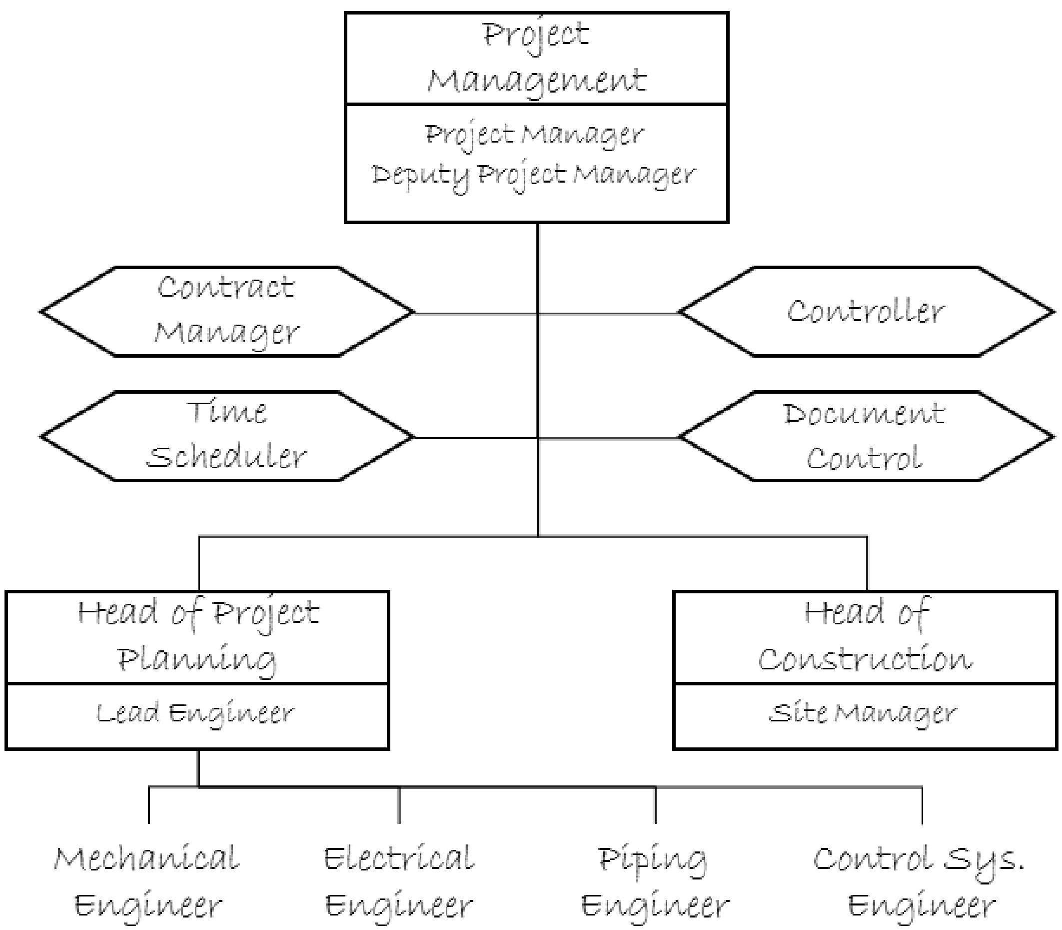
Here it needs to be decided whether the form of the organization should be a rigid and unchangeable structure during the game or, on the other hand, whether the participants should have the possibility to try themselves out in different organizational forms and learn about the advantages and disadvantages from the consequences.

This is similarly true for the style of leadership which can be depicted within the PM game. Even though the success of a project is largely dependent on the skills and abilities of the involved parties, quality and style of leadership are also influential factors, as the latter exert an influence on the relations between the different parties involved in the project. Therefore, the style of leadership should be adapted to the composition of the project team and the individual personalities and characteristics of the team members. Consequently, a PM game could also involve different leadership styles (authoritarian, democratic, bureaucratic or laissez-faire) for the practical evaluation and testing of the participants.

BLOCK 8/9: COMPETENCIES & TEACHING/ LEARNING AIMS

As previously mentioned, the blocks of myPMgame Canvas© follow a certain order in this contribution. This order, however, is not mandatory for the actual development of an educational simulation. Hence, the development of an educational game could also start with the blocks 1 and 2,

FIGURE 7
EXEMPLARY PROJECT ORGANIZATION FOR THE CONTRACTOR



directly followed by the blocks 8 and 9. In block 8 the competencies and qualifications of the target group (block 1) are determined which are demanded for the selected decision levels/function areas (block 2). For the example "Realization of an offshore converter platform", the following competencies apply:

1. Capacity for teamwork
2. Communication skills
3. Problem-solving skills
4. Decision-making ability
5. Assertiveness
6. Expertise in energy plant construction

Based on this, competency-oriented teaching and learning aims are set for the PM game. The teaching and learning aims for the given example are:

1. Collaboratively and successfully reaching of project aims
2. Experiencing the need for collaboration during the project implementation
3. Experiencing the benefit of a transparent project handling
4. Awareness of project risks and their consequences
5. Development of strategies for problem solution
6. Implementation of strategies for the enforcement of decisions
7. Capability to comprehend financial aspects of a project and observe them
8. Experiencing of interhuman difficulties and tensions
9. Increased understanding of technical relationships in construction of energy plants

In this context it has to be questioned critically whether the teaching and learning aims can be reached in the setting, which the PM game will eventually take place in. Furthermore, it should be clarified, if further teaching and learning methods should additionally be involved in parallel to the PM game (methodology mix) to facilitate or support the reaching of the teaching and learning aims.

BLOCK 10: MEASUREMENT OF LEARNING SUCCESS & EVALUATION

The debriefing is regarded as a decisive element for the measurement of learning success in educational games. This promotes the teaching and learning process (Crookall, 2010) as it addresses and involves the experience of the participants (Lederman, 1992). This debriefing offers the participants an opportunity to recapitulate what happened during the game, enabling them to gain a deeper understanding thereof and reflect upon their learning experience (Hill & Lance, 2002; Peters & Vissers, 2004; Kriz, 2010).

Beyond this, the debriefing can be of extraordinary importance to gain insights into decision-making processes. In this context, the choice of the debriefing method should consider both the learning process and the decision-making process on the basis of the participants' experience.

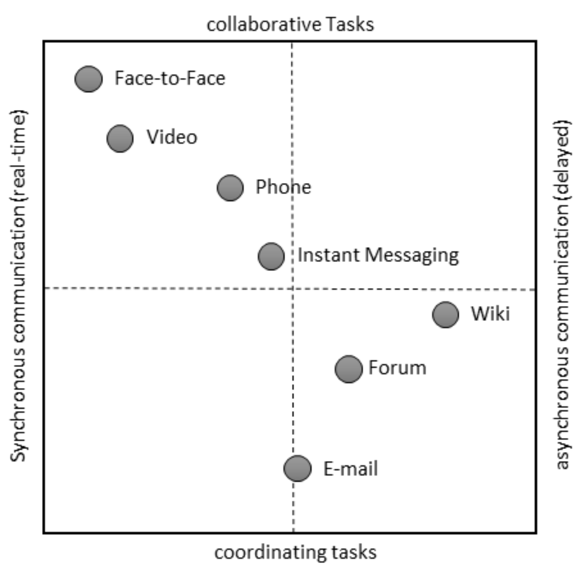
The following elements can be part of the debriefing: a) self-assessment (e.g. standardized questionnaire for the participants before and after the educational game), b) separate debriefing with each group (on condition that groups were part of the gameplay), c) evaluation of the product results (time, cost, quality, processes, technique etc.), d) evaluation of quality of educational game and the game supervision itself, e) overall debriefing with all participants.

In the given example, the successful reaching of the teaching and learning aims as well as the quality of the implemented project are in the focus of interest. To be able to assess the latter, the participants are additionally required to have understood the technical cause-effect relationships within the project. Therefore, both specific questionnaires and interview guidelines are employed in the debriefing process.

To verify the realization of teaching and learning objectives as well as the recording and measurement of competencies by monitoring and analyzing the progress of competency developments over time, pre- and post-self-assessments are employed (Karl, 2013).

In accordance with Karl (2015), the 5EQ method (5 essential questions) can be used for a basic survey of the simulation quality: 1. What was the best element of the educational game? 2. What was the least effective element within the game? 3. What was the biggest surprise in the game? 4. What was the most considerable benefit to be drawn from the game? 5. Which is the most important question remaining

FIGURE 8
COMMUNICATION METHODS FOR PM GAMES



unanswered?

Finally, the results of the different debriefing elements are discussed with all the participants.

BLOCK 11: STORY DESIGN

A distinct and realistic project definition is indispensable for the acceptance of the educational simulation and the identification with the individual roles. For this reason, the wording of the project charter as part of the game story is of essential importance.

Additionally, the fixing of a given situation has substantial influence on the experience which the participants can gain during the gameplay. A predetermined specific problem, for instance, can require the development of a solution process. If only a rudimentary framework is given, the task can be to locate processes within this frame and learn how to handle them.

If concrete processes are part of the predetermined situation, the identification of tasks and their reasonable assignment to individual participants or teams can be the logical consequence and follow-up. Furthermore, if the tasks are also already set in detail, the participants will need to focus on the task-handling respectively the solution of problems occurring during the proceedings. The story of the exemplary PM game “Realization of an offshore converter platform” defines different tasks; an excerpt of it is displayed in figure 9.

Both the general project aim and the bundle of individual targets to be realized in the project should be made available to the participants in a project manual. Depending on the aim and purpose of the educational game, it has to be observed that the solution method is not revealed. As the comparison of the project aim with the project result is the final step at the end of the project, it should as well be defined as a task for the participants.

BLOCK 12: IMPLEMENTATION

The following general questions should be considered during the implementation of an educational game concept:

- What should the participants experience and why?
- Which possibilities of implementation exist and how should the PM game be implemented (haptic, EDP-supported (local or online), hybrid)?
- Which are the concrete reasons for the chosen implementation possibility?
- Are the desired tasks and communication methods feasible with the selected form?
- Can the measurement of learning success and the evaluation be properly considered in the chosen implementation concept?
- Which resources are available for the development and as well for the implementation? Do they correspond with the selected form of implementation?
- Which duration can be targeted for the development, respectively the execution of the PM game? Are development and execution realistic in this form?

To make the joint creation of a product perceptible, the presented PM game “Realization of an offshore converter platform” should be implemented as a simulation with haptic orientation. For this, real building elements like technical components of the facility (transformers, converters, the control room, the crew’s quarters, a helicopter deck, main cables etc.) are visualized and represented with mini-scale models. This is implemented with the help of LEGO® elements, configured according to the given project with the LEGO® Digital Designer 4.3.

Depending on the desired teaching and learning aim, it can be decided during the later execution whether all participants should reside in the same room (and therefore continuously have the current construction status of the platform in view) or whether certain groups are to stay in neighboring rooms and solely receive the information, process it and deliver feedback. This setting is comparable to the real situation in which the site team is in the shipyard (assembly or construction of the platform) or later on the platform itself (set-up and final installation of the platform offshore). In contrast to that, the other involved parties reside in offices, e.g. the office of the contracting authority or the main contractor.

As the awareness of risks and the appropriate handling of them is a crucial element of project management training, the definition of the setting may not be enough – risk elements should be depicted, too. Just as mentioned before, the risk depends on its probability of occurrence but also on its damage

FIGURE 9
EXCERPT OF THE STORY FOR THE PM GAME
“REALIZATION OF AN OFFSHORE CONVERTER PLATFORM”

The internationally-active energy provider “Nea Energeia” wants to realize the project “Aiolos 1” in the Mediterranean as a contracting authority (see map in appendix A). This project consists of four parts: 1. Offshore converter platform “Aiolos Alpha” (linked to the four wind farms “Zephyros”, “Boreas”, “Notos” and “Euros”), 2. Onshore converter facility “Iris”, 3. HVDC submarine cable link (from “Aiolos Alpha” to mainland), 4. Land cable link (from terminal point of submarine cable to “Iris”). You are the general contractor and receive the order to realize the partial project 1 “Aiolos Alpha” from the project contract until the project hand over. Your tasks are: 1. Structuring of the project under consideration of all contractual and technical aspects (see appendix B and C). 2. Determination of the budget, taking into account the costs and payment milestones (appendix D). [...]
The following team is at your disposal (for further details refer to appendix H): 1. Project manager, 2. Deputy project manager, 3. Contract manager [...]

extent. In the PM game, this damage extent is measured in currency units and already determined by the game design. The probability of occurrence, however, should be generated by chance during the gameplay itself. The three most basic methods for this are a) tossing a coin, b) drawing of a card, c) throwing the dice. The immediate advantage of these three methods is that they are carried out by the participants themselves. Thus, the game facilitator is excluded from this step and minimizes the impression to be able to influence the gameplay in its progress.

Depending on the chosen method, different probability values can be generated. The easiest method, tossing the coin, regularly produces a probability value of 50%. Choosing the cards changes the probabilities significantly, as a deck of cards with 32 cards results in the following possibilities:

- One event in 32 cards (1/32) = probability 3,13%. If the drawn card is mixed in again, the probability remains identical.
- The previously drawn card is not put back into the deck, i.e. the probability increases during the later gameplay (1/31 = 3,23%; 1/30 = 3,33%; …; 1/10 = 10% etc.)
- Extra: If one further (new) card is added together with each drawn card, the probability decreases incrementally (1/33 = 3,03 %, 1/34 = 2,94%).

A steady distribution of probability can be achieved with so -called fair, ideal respectively real dice (Laplace dice). These dice are characterized by an ideal shape, i.e. the areas (faces) on the dice all have the identical form and size. The overall quantity of the faces is responsible for the name of the dice. Thus, for instance, the dice frequently used in board games with six faces is called D6. Combining the quantity of faces with the engraved or imprinted numbers yields a multitude of probability values for the occurrence of one individual random result (table 6).

With the help of the above-mentioned possibilities, a multitude of probability values can be calculated and assigned to the real values of risk occurrence. This realistic modelling increases learning effects and the acceptance of the model alike – especially in the case of more experienced participants of the simulation.

SUMMARY

This contribution introduced the myPMgame Canvas© as a development framework for a straightforward conceptualization and modular refinement of PM simulations. The implementation of the development framework was demonstrated with the help of an exemplary project taken from the wind energy sector.

The application of the introduced method displays the following advantages:

1. The myPMgame Canvas© is a low-threshold approach for the practical development of individual PM game projects.
2. Due to its universal character, it is equally employable for educational simulations in the academic context as well as in vocational training and further education.
3. The holistic view on the section of simulated and depicted reality is promoted.
4. Reciprocal interactions between different elements of the system and their results are considered.
5. The canvas can easily be fixed to a wall.
6. It grants immediate access to the development and initiates prompt discussion in a developer team.
7. At the end of the design, the canvas can represent a solid basis for the definition of specifications for external developers of educational simulations.
8. The definition and assessment of requirements specification for the solution of the above-mentioned development problem is facilitated.
9. Simplifies classification and evaluation of already existing educational game concepts and therefore can serve as an

TABLE 6
PROBABILITY VALUES WITH DIFFERENT TYPES OF DICE

Table 6: Probability values with different types of dice

Dice	Number	Probability
D6	1 – 2	50,00%
D6	1 – 3	33,33%
D8	1 – 4	25,00%
D6	1 – 6	16,66%
D8	1 – 8	12,50%
D9	1 – 9	11,11%
D20	1 - 10	10,00%
D12	1 - 12	8,33%
D30	1 - 15	6,66%
D48	1 - 48	2,08%
D100*	00 - 90 & 1 - 10	1,00%
*two dice: D10 with numbers 00 – 90 & D10 with numbers 1 – 10		

instrument for the selection of existing PM games.

10. Represents a method which promotes the transfer of individual knowledge and experience between the participants.

Educational simulations based on the myPMgame Canvas© can contribute to an interdisciplinary training which focuses on decisions and actions. Especially the activity-orientation, which is linked to the project aims, offers a deeper understanding of the relevance of cooperation and collaboration in projects and thus promotes the individual motivation to collaboratively lead projects to a success.

Apart from the fact that educational simulations are frequently employed in further training, academic education respectively for the general knowledge building (Wolfe & Bruton, 1994; Klabbers, 2001; Rafaeli et. al., 2003), the myPMgame Canvas© can also be applied as a tool for the analysis and optimization of real projects – independent of an educational game development – in the sense of a forensic investigation method.

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