

# GAMIFIED PRODUCT DEVELOPMENT IN INTERNATIONAL COLLABORATIVE ENGINEERING DESIGN COURSES

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## ABSTRACT

Design thinking, a framework for structured innovation, is crucial in engineering design. Teaching this methodology demands innovative pedagogy. This study delves into the "Collaborative Product Development in Automotive Engineering" (CoPro) course, a partnership between the University of Wuppertal, RWTH Aachen in Germany, and Hongik University in Seoul. CoPro, comprising five multidisciplinary teams from German and Korean universities, focuses on mechanical engineering and product design. In cooperation with a German OEM, it integrates cross-cultural dynamics and design thinking into authentic challenges.

This paper explores the integration of gamification into the 2022 CoPro course. One team used gamification to introduce novel product features, resulting in a transformative shift. Gamification proved instrumental in conceiving innovative solutions that outperformed other teams. The research emphasizes the transformative impact of integrating gamification in early product development phases, applicable in education and industry. CoPro 2022 showcases the synergy between these elements, offering insights for educators, students, and industry practitioners, reinforcing the value of interdisciplinary collaboration in addressing complex challenges in automotive engineering.

*Keywords: Product development, product design, gamification, automotive engineering, international collaborative course*

## 1 INTRODUCTION

The course *Collaborative Product Development in Automotive Engineering* is an international, interdisciplinary course that takes place annually in cooperation between the University of Wuppertal and RWTH Aachen University in Germany and Hongik University in Seoul, South Korea. The course, which takes the form of lectures and teamwork phases, is largely held digitally. In May and June, however, there will be two-week reciprocal visits to Seoul and Wuppertal/Aachen respectively, which are characterized by a high work and performance density.

The aim of the course is to teach agile working methods at the interface between design and engineering, as well as to simulate a real project situation in which students have to work under time and performance pressure. An elementary challenge for the students is posed by the different forms of work between engineers (generally detail-oriented) and designers (generally concept-oriented), but also by cultural differences in working methods (Korea-Germany), the necessary bridging of time zones and language barriers and the organization of teamwork in the form of communication and project data management. The annually changing tasks of the course are provided by a partner from the automotive industry to ensure practical relevance. In 2022, two German OEMs were acquired as joint industrial partners. In most cases, the subject matter focuses on current topics from the automotive industry, e.g. sensor technology concepts, safety aspects, sustainable vehicles or mobility in metropolitan areas.

Within the course, students are divided into five teams of six students each, with each team consisting of two German and two Korean engineering students and two Korean design students. The teams work largely independently but with regular feedback from scientific staff as well as the OEM partners and base their regular design reviews on the design thinking process phases. The teams are parallel supervised by one professor in Germany and two professors in Korea. The results of the teamwork are vehicle concepts that include technical designs and CAD models on the one hand and renderings of the

design drafts on the other. In addition, physical mock-ups and prototypes for initial ergonomics and design studies are built during the on-site work phases.

The focus of the course lies particularly in the identification of a relevant problem and a creative and consistent conception of ideas.

Due to the special structure of the course and the high work intensity, the students' results are usually above average compared to other courses from experience of the supervising professors from Korea and Germany. The results are presented to the industry partners by the students in a final presentation.

## **2 PROBLEM AND SOLUTION STATEMENT**

CoPro's annually changing tasks are developed in cooperation with the industrial partners to ensure practical relevance. This year's topic was the development of fully automated mobility solutions for the transportation and delivery of parcels in the B2C (business-to-customer) sector.

Due to its practical relevance to the automotive industry and the simulation of real working conditions in interdisciplinary, international teams, the course offers excellent conditions for evaluating disruptive development methods that are potentially relevant for industrial application.

The five teams in 2022 made comparable progress to previous years and developed innovative approaches to solving the task.

Only one team struggled in comparison, as it had difficulties developing a consistent concept with recognizable added value up to this point.

The team's basic concept was automated parcel delivery via large autonomous freight vehicles that drop off smaller moving parcel boxes at relevant points, which users can then interact with. The aim was to make parcel delivery more efficient, sustainable and user-friendly.

To support this team, it was decided to conduct a guided workshop on user-centred design. In this case, the use of gamification as an innovative method should support user-centricity in concept development and to develop innovative product features.

The integration of a gamification workshop for just one team offers the opportunity to conduct a comparative study and evaluate whether gamification can be permanently integrated into the course concept as a supporting creativity method.

## **3 THEORETICAL BACKGROUND**

Gamification is described as „the use of game design elements in non-game contexts” [1] is a modern approach in motivational and interaction design and offers different tools and methods to analyse and influence human behavior. Hence, it also offers a method to analyse usage behavior and design product features fitting to the user requirements [2]. Gamification follows structured processes during development, such as the *How to design Gamification* (HTDG) process according to Morschheuser et al.

[3]. This process follows the seven consecutive phases of *preparation, analysis, ideation, design, implementation, evaluation and monitoring* and is therefore structurally close to the design thinking process.

Various methods can be used in the phases, such as *Octalysis* according to Chou, which describes motivation through the degree of fulfilment of the eight different Core Drives *Epic Meaning and Calling, Development and Accomplishment, Empowerment of Creativity and Feedback, Ownership and Possession, Social Influence and Relatedness, Scarcity and Impatience, Unpredictability and Curiosity and Avoidance of Loss* and thus allows a detailed characterization of the motivational states of people in a particular situation (see fig. 1) [4].

Marczewski describes a similar analysis tool with the six *User Types Hexad* (*Socializer, Achiever, Free Spirit, Philanthropist, Player, Disruptor*) and, with the *Periodic Table of Gamification Elements*, offers an associated collection of 52 game elements that provide solutions for gamification concepts (see fig. 1) [5].

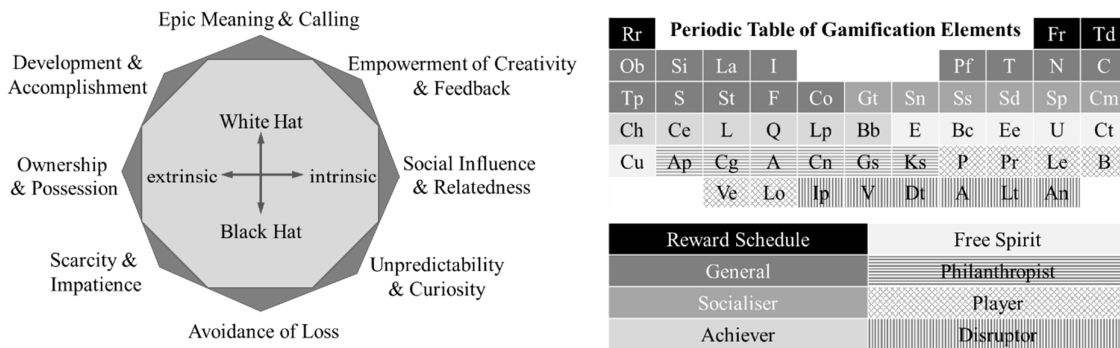


Figure 1. Left: Octalysis Core Drives acc. to Chou [4], Right: Periodic Table of Gamification Elements acc. to Marczewski [5]

#### 4 RELATED RESEARCH ON GAMIFICATION IN INNOVATION

The literature review Gamification-as-innovation of AlSaad and Durugbo explores the role of gamification as an innovation tool in organizational processes [6]. Gamification aims to promote collaborative behavior, process enhancement, innovativeness, and contests with rewards. However, integrating gamification into organizational processes can be challenging, especially when core capabilities are not known in the early phases. The review identifies three perspectives on gamification as innovation: intervention, induction, and investigation. Additionally, three themes are highlighted: multi-level modeling and learning, strategic initiatives and transformation, and digital platforms and processes. The text suggests that future research should explore innovative network models to enhance creativity and problem-solving. It emphasizes the need for a comprehensive examination of the experiential and inclusive nature of gamification. In conclusion, the review provides theoretical frameworks for innovation and technology management studies on gamification. It also offers practical considerations for businesses to incorporate gamification into strategic planning, promoting "adult recess" and "adult-style playtime" for engagement, involvement, and inclusivity. Overall, the review aims to advance discourse and scholarship on novel gamification constructs, conundrums, and conditions.

Based on the current state of scientific knowledge, it can be concluded that gamification in connection with innovation is only used at a human level to increase motivation or commitment in the existing innovation process or to adapt the innovation process. The application at product level, i.e. to improve products through an increased understanding of customer behavior and the subsequent application of game elements, does not appear to be part of the scientific discourse.

#### 5 RESULTS

As the elements of the HTDG process had to fit into a workshop, some phases were simplified. Phase 1 (preparation) had already been completed, as the framework conditions were defined by the clear task and the product is a mobility concept that interacts directly with people. The use of gamification is therefore considered to be fundamentally applicable and sensible.

The analysis in phase 2 of the interacting people for motivation profiling normally takes place in extensive qualitative and quantitative research using questionnaires or interviews. A less extensive method was chosen for the transfer to the workshop framework. At the beginning of the workshop, a fictitious persona of the potential target group was created for the group's vehicle concept. Based on this persona, the three most important core drives according to Chou were selected, which potentially represent the target group the most. The following were selected:

1. Epic Meaning and Calling (due to the importance of sustainability for society as a whole) and
2. Empowerment of Creativity and Feedback (by independently designing the interaction with the vehicle).

For phase 3 (ideation), the team selected the four most promising game elements for each core drive. The criteria for the selection were the meaningfulness in the thematic context of the overall concept and the intuitive possibility of integration. Both the elements collected by Chou and Marczewski's *Periodic Table of Gamification Elements* were used as the basis for the selection. After careful consideration, discussion and a simple dot rating, the following game elements were selected:

- Epic Meaning: Narrative, Free Lunch, Elitism
- Empowerment: Milestones

Figure 2 shows a scene from the ideation discussion during the workshop.



Figure 2. Scene of the workshop

The four selected game elements were then developed further as part of phase 4 (design). The Rotating Brainwriting method was used to encourage creative ideas. During the workshop, the conception was limited to the brief formulation of ideas and small drawings. The results can be described as follows:

- Elitism: Sense of belonging to a group through badges that are awarded according to time. Nature conservation as a possible additional topic.
- Free Lunch: After a certain number of uses, users receive free use. Partial distribution before the launch encourages interest in the product.
- Milestones: Achieved sustainability goals are visualized in the form of a growing tree in the app
- Narrative: Story of the Baby (parcel vehicle) and Motherships (freight wagon)

The so-called *NUF test* was carried out as a method for selecting the concept to be implemented in phase 5 (implementation). The ideas developed are rated by the entire team on a scale of 0 to 10 according to the categories New, Useful and Feasible. The results are shown below:

Table 1. NUF-Test results

	<i>New?</i>	<i>Useful?</i>	<i>Feasible?</i>	<b>Total Points</b>
<b>Elitism</b>	5	8	8	<b>21</b>
<b>Free Lunch</b>	1	9	9	<b>19</b>
<b>Milestones</b>	6	3	10	<b>19</b>
<b>Narrative</b>	7	3	10	<b>20</b>

After the workshop, the idea of a badge concept for the use of the parcel delivery service based on the gamification element Elitism was the most promising concept. However, the group was also encouraged to use the other ideas as a basis for feature development during the course.

In fact, following the workshop, the team decided to include the narrative around the mother-baby relationship of big freight vehicles which drop off small delivery vehicles for user interaction as a product feature in their concept because they gave the *New* category a higher weighting with a similar overall rating. This shows that the use of a structured gamification design process makes the complexity of the original task manageable and supports the making of conscious decisions at critical points. The team's final presentation to the lecturers of the course and the industrial partner companies specifically

addressed the mothership-baby narrative and was consistently perceived as an inherent product feature of the concept. Some slides from the presentation are shown in figure 3 as examples:

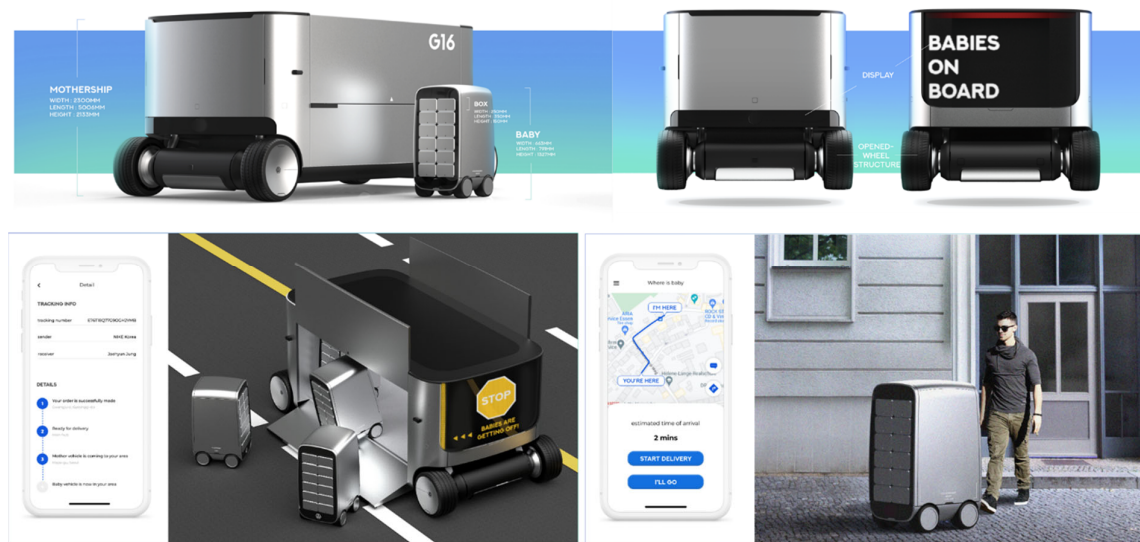


Figure 3. Implementation of the narrative in the team's final presentation

In order to evaluate the influence of the workshop and the resulting product feature (phase 6 – evaluation), a survey was conducted with the OEM partners and the supervising scientific staff from both universities following the final presentation (n=5).

The questionnaire focused in particular on the quality and development of the team results (also in relation to the other teams) and the evaluation of the mothership-baby narrative as a product feature.

The questions had to be answered on a 5-point Likert scale (strongly agree (score 4) to strongly disagree (score 0), with an additional no answer option). The questions and the evaluated results are shown in Table 2:

Table 2. Results of the evaluation questionnaire (n=5, fully agree=4, agree=3, neither agree nor disagree=2, disagree=1, strongly disagree=0)

#		0	1	2	3	4
1	Team X's final concept was good.				●	
2	Team X's final concept was above average compared to the final concepts of the other teams.			●		
3	Since the last Design Review, Team X has developed its concept much further than the other teams.			●		
4	I recognized the "mothership baby" narrative in Team X's final design review.				●	
5	The "mothership baby" narrative fits well with the final concept of Team X.				●	
6	I've noticed a stronger focus on the "mothership baby" narrative in Team X since the last Design Review.			●		
7	Team X's "mothership baby" narrative would be of great benefit to the success of the concept in reality.				●	

## 6 DISCUSSION

The results confirm that the workshop had a very positive influence on the team's final concept. Overall, it was rated as very good (question 1) and above average compared to the results of the other teams (question 2). The general further development of the team concept was assessed as comparable to the other teams (question 3).

The Mothership Baby narrative was explicitly perceived as a very good product feature and very present in comparison to earlier intermediate states of the team concept (questions 4 to 6). A possible influence on product success in the fictitious case of a real implementation of the concept was also rated very positively (question 7).

Given that the team had problems with clearly defining a consistent concept before the workshop, the workshop and the application of the systematic gamification design process had a clearly positive influence on the team result.

Hence, the implications for the next years of the CoPro course are to extend the workshop to all teams in order to support the overall creativity and quality of the course results.

Even if the results are very positive, some limitations of the study must be pointed out. For example, no comparative survey was conducted before the workshop was applied in order to measure direct differences. With five responses, the significance of the results can only be interpreted as a rough estimate but is limited by the number of OEM partners and the supervising scientific staff. Due to the limited time in the workshop format, the phases of the HTDG process could not be dealt with in detail, so a survey with potential users would be more significant than the subjective assessment of the team.

## 7 CONCLUSION

This study describes the application of gamification to support the user-centred design of innovative product features in the context of an international, team-based university course in workshop form.

Prior to the workshop, the selected team was struggling to keep up with the performance of the other teams.

The workshop enabled the team to identify user preferences of their concept in a structured way and then design suitable product features in the form of a detailed product narrative. The survey of the OEM partners and the supervising scientific staff after the presentation of the results showed a major increase in performance and quality compared to the other teams.

Gamification thus offers a new approach to increasing the creativity of students in product design courses on the one hand and a disruptive approach to analysing user behaviour and designing innovative product features in industrial practice on the other.

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