

# From Traditional to Challenge-Based Learning: A Case Study

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**Abstract:** The rapid evolution of the information technology sector necessitates innovative educational methods not only addressing current industry needs but also anticipating future challenges. This study aims to explore the transition from traditional pedagogical approaches to challenge-based learning (CBL) within the context of an undergraduate course, "Ethical, Social and Professional Aspects of IT" (120 participants). It investigates how this methodological shift influences the development strategies of the course and the pedagogical outcomes for students, particularly first-year IT administration and development students engaging in practical group work. Employing a mixed research design, the study gathers data through reflections of the course staff, empirical study with students and analysis of the didactic changes within the course. It evaluates the effectiveness of problem-based learning (PBL) and CBL methodologies in addressing real-world IT ethics, social, and professional challenges with a focus on fostering creativity, problem-solving skills, and interdisciplinary collaboration. Preliminary findings suggest that CBL not only enhances students' engagement and learning outcomes but also bridges the gap between academic knowledge and practical application in the IT sector. The collaboration students provided insights into real-world challenges, improving students' learning and administrative experiences at the university. Furthermore, the study highlights the advantages of integrating both PBL and CBL to cultivate a more dynamic and responsive educational environment. The shift towards CBL in the "Ethical, Social and Professional Aspects of IT" course at Tallinn University of Technology represents a significant step forward in aligning educational practices with the needs of the contemporary and future IT industry, preparing students for the complexities of the modern workforce, and contributing to a sustainable, innovative, and resilient economy. Further research is needed to fully understand the long-term impacts of this pedagogical shift and to refine the methodologies for broader application.

**Keywords:** Challenge-Based learning, Problem-Based learning, IT ethics, Pedagogical transformation, Course development strategies, Educational innovation

## 1. Background

Information technology (IT) is a fast-changing field that offers educational techniques both new opportunities and problems. Though fundamental, traditional educational approaches are increasingly being complemented with newer teaching strategies that predict the industry's future direction and respond to its changing needs. Challenge-Based Learning (CBL) is one such approach that has drawn interest due to its potential to completely transform processes in higher education (see Table 1 for a comparison).

**Table 1: The Comparison of PBL (based on Wijnia, 2024) and CBL (based on Membrillo-Hernández, 2021)**

Aspect	Problem-Based Learning (PBL)	Challenge-Based Learning (CBL)
<b>Definition</b>	A student-centered pedagogy in which students learn about a subject through the experience of solving an open-ended problem.	An educational approach where learners use technology and inquiry to engage with real-world problems, developing solutions that make a difference in their community.
<b>Advantages</b>	Encourages deep understanding through problem-solving. Develops self-directed learning skills; Promotes collaborative skills.	Fosters engagement with real-world issues. Enhances critical thinking and creativity. Encourages practical application of knowledge.
<b>Disadvantages</b>	Can be time-consuming to implement. Requires significant facilitator expertise. Assessment can be challenging.	Can be challenging to align with curriculum standards. Requires careful planning to ensure relevance.
<b>Effect on Motivation</b>	Generally, has a positive effect on students' motivation, particularly in healthcare and STEM fields.	Motivates students by providing a sense of purpose and relevance, though research on its specific effects on motivation is less extensive.
<b>Implementation</b>	Often used in medical and health sciences education. Can be applied at both course and curriculum levels.	Commonly implemented in engineering and technology programs. Can be integrated with project-based and case-based learning.

According to Leijon (2022), it is important to understand that, compared to traditional ways, CBL has considerably enhanced student engagement, showing this method to be more participative and responsive to learners' needs. At the same time CBL also is harder to be implemented in academic settings due to enormous freedoms from students aside. This means with the flexibility it needs to arise also raise responsibilities. If there is no room to fail, then CBL might not be best to be used in traditional settings.

The course we use as an example, the Ethical, Social and Professional Aspects of IT, dates to 2001 and has since gone through several changes and additions (including course formats and languages). A pure background knowledge course for future IT professionals, its topics range from tech history to psychology to cyberculture to legal and business aspects. Its secondary aim has always been to foster the students' communication skills (depending on the course format, the emphasis can be on speaking/presenting or writing). The main goal is to provide students with the range of knowledge that often distinguishes a professional from a mere practitioner.

Regardless of the changes, the course has always had the exploratory, 'playful cleverness' spirit of classical hackerdom (as described by Himanen (2002) and several others). On a conceptual level, it is close to the concepts of the Flow and autotelic experience (originally by Csikszentmihalyi (1990), later expanded by both him and many others). The approach has also been studied in the educational contexts by e.g. Dermott et al (2016) and Oliveira et al (2023). The main tenets of the Flow - balance of challenge and skill, well-defined tasks, and immediate feedback - have been especially evident in the distance (e-learning) version of the course (surplus in the point system allowing choice, weekly feedback letter). While the connection in the earlier contact version was not this evident (it was there, though) since the last readjustment of the course in 2023 our aim has been to bring the Flow more to the surface by reviewing the task system to match the CBL approach.

Our findings also seem to confirm the conclusions from the systematic review by Doulougeri et al (2024) that while CBL is an effective approach, it requires relevant training for educators as well as sufficient time to familiarize both educators and students with the process.

The paper discusses the results of the 2023 course, but there will be significant modifications in 2024 that aim to use the models that have been learned, as well as employ even more interactive and cooperative CBL methodology and AI generative tools next year. This is just the first step; in 2024, the course will further incorporate AI tools and shift the lecture portion into automated and more asynchronous learning opportunities. This year we also want to bring in real-world panel experts from academia and industry will also engage in debates with students.

## **2. Methods**

This study used a mixed (qualitative and quantitative) research design to investigate how challenge-based learning (CBL) has replaced traditional teaching methods in an undergraduate IT course called "Ethical, Social, and Professional Aspects of IT." There were 120 students in the course, most of whom being first-year IT administration and development majors. To evaluate the immediate effects of the new pedagogical approach in the early phase of their academic careers, the study concentrated on first-year students. We also wanted to test out some generative AI tools to complement the teaching and gather ideas on how to shift the course towards that direction in the coming years.

A variety of methods were used to gather data to examine the educational shift:

- To gather their perspectives and experiences about CBL, the teachers and facilitators provided qualitative comments over exercises used to facilitate the course. In this study the main interventions were a) Pecha Kucha and Belbin-based personal introduction to profile the students' interests; b) choosing one of the AI-generated topics for the project; c) developing personas and pilot with a real focus group (or in some cases, generative AI), d) reviews of the presentations; and e) the final exam where generative AI was used to develop the test based on lectures (which had a large variety of information society related topics).
- We also studied the reports written by students about their projects which offered in-depth insights into the students' cooperation and work process at the chosen topic. We also looked at the students' descriptive comments and reviews of each other's presentations (2), so in total, 1153 unique units of feedback were analysed for the paper.

- Finally, we studied the general end-of-the-course feedback given by the students about the course (tasks, facilitating etc).

The analysis focused on several major themes: in comparison to conventional teaching approaches, the study evaluated the effects of CBL on student engagement levels and learning outcomes. Using a focus on creativity, we assessed problem-solving abilities, potential uses of generative AI and the handling of ethical issues in professional settings, as well as effectiveness of CBL in bridging the gap between academic theories and real-world IT challenges.

### 3. Results

The results of the course are covered below by the stages as they occurred.

#### 3.1 Profiling Students' Interests and Skills - Pecha Kucha Meets Belbin

At PBL courses, the team members are usually either chosen randomly, appointed by teacher, or the teams are formed by participants. The CBL approach is to allow everyone to present themselves to form a versatile team. Different methods can be used, an example is the brain dominance test developed by Ned Hermann (1987).

At this course, the initial one-hour profiling event (named the Team Member Exchange, or TME in short) involved a Pecha Kucha (McBrain, 2016) personal introduction with a one-pager document about themselves. In this, the students had to state their interests, possible traits, and their desired role in the team, according to the Belbin Team Inventory (Belbin, 1981). Team leaders were chosen among those who had opted for the leadership role - these students then had to use the remaining TME time to create a team that included as many different roles and additional qualities as possible (see Figure 1).

#### Example: Birgy Lorenz

Is: extravert

Takes responsibilities: Leadership, Team support, Presenter

Belbin: Implementer, Plant, Shaper

Other needed:

- I can conduct research, organize cyber security competitions
- I have created various educational card games, textbooks in informatics
- people come to me to find different contacts to solve their problems
- love to cook and receive guests



**Figure 1: A sample one-pager from the profile**

The feedback from students about the TME was that it made understanding the potential of each person easier, and in turn, it made everyone understand their role and responsibility in their team. At that time, they did not know the topic yet, so they could only strive to gather the best team for any possible situation. They also found it interesting that friends did not become the first choice anymore, as they were familiar, both in their potential and limitations - the students realized that this was not the best way of team building. The students claimed to have learned a lot about themselves, but also about how to hire people, present themselves, explain their values, or show themselves as trustworthy leaders to others.

#### 3.2 Using AI for the Project Topics

The next step was providing the participants with topics based on the main content of the course - the areas included ICT history, information society, new media and social software, legal aspects of IT (intellectual property issues, patents, copyright, software licensing etc, free and open-source software, professionalism in IT, online communication, information security, privacy, censorship HCI (including assistive technology) and IT ethics.

While the role of the customer can be optional at PBL projects, it is needed for CBL. When using CBL as a methodology it is often discussed whether the customer should be present to develop the challenge or not. We decided to use a surplus of AI-generated challenges - this allowed them to interact with several customers and develop their own solution that can a) help the customer directly, b) provide the customer with a usable

service, or c) start to compete with the customer. This gave the students more freedom to develop their ideas and original solutions.

The 120 challenges were created with generative AI (Chat GPT 4.0, paid version) from which we chose 60 to be shared with the students. We found it interesting that actual, usable challenges were created by the AI within minutes using a rather simple prompt: "create a list of challenges on [topic list] for university BA level IT developers and administrators for the course [course name] using the CBL method. The idea should be possible to implement by groups of 6 in 2 months". According to our experience so far, lecturers develop these lists of ideas by themselves, and it will take 1-2 days of work to come up with versatile challenges.

After that, the newly formed groups of students had a chance to review them and choose four most interesting ones. If the same choice was made by more than one group, the competing teams had to debate each other to find out which group was better equipped to implement the topic.

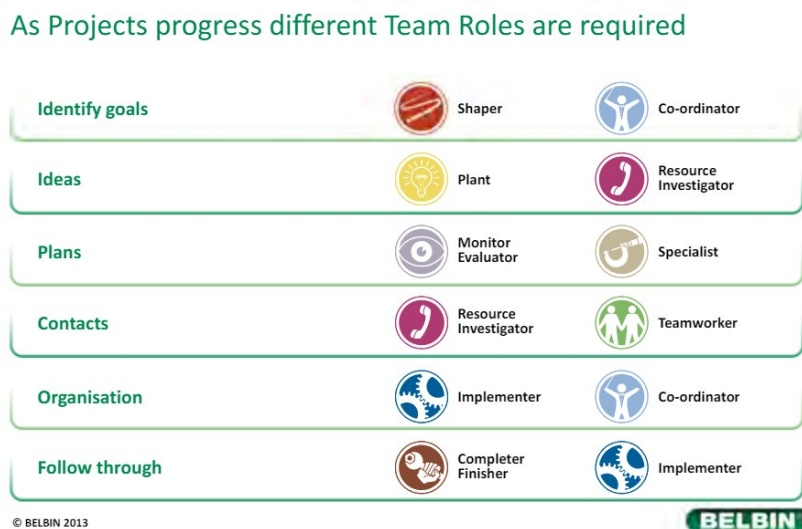
Some examples of challenges:

- How can we improve the user interfaces and user experience of autonomous vehicles to make them easier and more reliable to use?
- How can we increase the awareness of IT professionals and the public about the importance and possibilities of green IT to promote the green revolution?
- How can we effectively integrate the various IT systems and platforms used within TalTech so that they can communicate and share information effectively?

### 3.3 Personas and Piloting the Idea with Real Audience

These were three separate parts of a compound exercise with the same focus group. The student group needed to investigate who their product customer was and have a meeting. For developing personas, we provided some basic training and helped them develop academically sound and ethical surveys. We directed them towards developing a real product or at least a demo. The personas and piloting were using common business development tools, but the added value was in how the teams used their Belbin roles and responsibilities.

In our case, we made the transfer from traditional to CBL rather abruptly, therefore it was not clear whether a) the approach suits the first-year IT students at all, b) the students accept the Belbin roles (or will they prefer people they know, regardless of their skills and contribution) (see Figure 2). However, the project was successful - only one group out of 20 was afflicted by the common group work malady of piling all the work on just 1-2 people (this group had to be given extra tasks individually), the rest used the role distribution as designed and finished with good results. The only dropouts from the course were the 10 people (out of 120 participants) who registered but did not start. We used the 'traffic lights' system to monitor the progress - only 2 teams (out of 20 ever dropped into the 'red' zone, requiring direct help from lecturers. There were some more 'yellow' (needing advice) moments, e.g. one team had to change the topic during the project.



**Figure 2: The Roles and Responsibilities in a Team (How to Form a Team)**

Students reported that it was a challenge to develop a solution and write an academic paper about it in parallel within a limited timeframe (notably, they had trouble with proper academic writing - seems that their previous training in this section had been inadequate). The students enjoyed teamwork, pointing especially to the role of “team coherence builder” (essentially a community manager) whose responsibility was to see that everyone was contributing to time, and no one was left alone. This also helped to free the team leaders for other responsibilities (to represent the team and make final decisions). The students also pointed out that while the “writing wizard” and “presentation star” were the most competent for their respective jobs, they were used in trainer/coordinator roles instead (teaching others to do the work properly and ‘package’ the results at the end).

### 3.4 Presentations and Feedback to Them

We asked students for two presentations: a) explaining the idea at the beginning, and b) explaining the results at the end. Assessment was based on several criteria: clarity and sufficiency of the project title and team information, comprehension and course relevance of the project's main idea, the feasibility and clarity of the solution steps, the realism of the project timeline, and the definition and justification of the projected outcomes and finally piloting the results and outcomes. Additional evaluation provided feedback about the clarity of slides, effective use of the allotted time, the overall delivery and logic of the presentation, and the appropriateness of responses to any follow-up questions. Peer reviews focused on the understandability of the project idea, the added value compared to existing solutions, and the clarity of the project’s alignment with course objectives, also offering recommendations for improvement and noting any deficiencies in presentation length or content.

At the initial evaluation, 90% of the ideas were considered clearly understandable; 86% were deemed to add value and improve the situation; 80% of the ideas were considered realistic, and the final summary quality estimate was 95%. The main recommendations given by the peers were: a) to define the focus group (customer) well and understand the problem/needs thoroughly, b) information gathering must be selective and follow regulations, c) consider the size and limits of the task chosen (whether it is doable within the timeframe).

On a positive note, we recognized the common trend among the students - instead of competing with other teams, they helped and advised others as well. Still, when asked to provide constructive feedback, the quality of it was low - one of the reasons being the lack of previous knowledge about giving polite and useful feedback instead of mere criticism.

### 3.5 Exam: Stirring the Waters with Generative AI

For the exam we developed new exercises using generative AI (Chat GPT 4.0, paid version). The main prompt was “Develop a multiple-choice question about [topic] for the Bachelor-level course [course name] for the exam. Example of the question is [example]. Explain correct and incorrect answers.”. Some examples are provided in Table 2.

**Table 2: Examples of the original multiple-choice questions and the AI-added narrative versions**

	Original question	AI modification
1	<p>In his 1968 demo (probably the first of its kind), Douglas Engelbart did NOT demonstrate.</p> <p>a) computer mouse</p> <p>b) graphical user interface</p> <p>c) packet communication *</p> <p>d) text editing by several users at the same time</p> <p>e) a screen presentation (like today's MS PowerPoint)</p>	<p>In 1968, Douglas Engelbart conducted a historic demonstration, often referred to as the "mother of all demos", which was notable for several technological innovations. During this demo, he introduced several innovative concepts and devices that are standard in computing today. Despite demonstrating several revolutionary technologies, there was one particular technology that he did not introduce at the time, even though it is an important part of digital communication and data transfer today. Which of the following was not part of Douglas Engelbart's 1968 demonstration?</p> <p>a) Computer mouse b) Graphical user interface c) Packet communication * d) Text editing by multiple users at the same time e) Screen presentation (like MS PowerPoint today)</p>
2	<p>Protocols that enable web content aggregation (pooling</p>	<p>The website owner wants to provide his readers with a convenient way to keep track of fresh articles and posts. He decides to integrate technology into his</p>

	Original question	AI modification
	sources into one application for easier reading) are a) MariaDB b) Atom * c) RSS * d) NFT e) NTP	website that allows users to subscribe to news feeds and automatically receive notifications when new content appears. To do this, it uses two popular web standards that are specifically designed to aggregate web content and allow users to read news and blog posts from different sources in one place using the appropriate application or service. What are these two protocols? a) MariaDB b) Atom * c) RSS * d) NFT e) NTP
3	Terms that characterize the Anglo-American legal system are (a) common law * (b) civil law (c) property law (d) Roman law (e) case law *	The Tallinn law firm "LexGlobal" specializes in international law, offering consulting services to companies operating in various legal systems around the world. The firm conducts training for young lawyers who have recently joined the team to introduce them to different legal systems. One of the main topics of the training is the Anglo-American legal system, which is significantly different from many other legal systems.  What terms best describe (as a whole) the Anglo-American legal system covered in the "LexGlobal" training? Choose two correct answers. a) Common law. * b) Civil law. c) Property law. d) Roman law. e) Case law. *

We used the test questions in a mixed way, each test featuring both human-made and AI-made questions. The exam was technically yet another similar test (the exam was open book, but web search and AI tools were prohibited). As a twist, at the exam we introduced a) questions presented as graphics, making copying difficult and forcing the students to read and understand the question, and b) negative points for wrong answers, which made blindly clicking through the test a bad strategy.

The students considered the test rather interesting, in fact grasping the idea behind both ‘twists’ quite well. They admitted that they had to read and understand both the questions and answers, and while negative points caused some grumbling, they understood the reasons behind them.

### 3.6 Student Feedback to the Course

The feedback of the students was collected via comments and Likert scale questionnaires, they had to comment on both the course and their team (see Table 3). The teams were almost universally well-appreciated, also emphasizing the role distribution. They also outlined the improvement of their academic proficiency - notably the ability to provide constructive criticism - and leadership skills that were boosted by teamwork. The overall positive, inclusive and cooperative atmosphere was also praised.

**Table 3: The percentages of positive reaction to various aspects at the course**

Feedback to the course itself	Yes, rather yes
Were you able to contribute to the group work as you wished?	98%
Did you manage to use your Belbin-based skills in group work?	68%
Did everyone in the group contribute equally (giving their best according to their skills)?	84%
Did learning through the problem-solving methodology suit you?	96%
Was 3 months enough time for a PBL project to achieve the goal?	92%
Did you manage to participate in all the practicals?	92%
Would you recommend this course to other programs?	90%

Did your group work well together?	76%
Are you happy with the results of the outcome in the given time?	84%

Concerning the course, a valuable experience (besides many of the ones already covered above) mentioned by the students was the need for time management and meeting deadlines. We note that a lot of the course feedback from students suggests reaching the Flow discussed above - the course managed to balance the challenge and existing knowledge/skill rather well, provided a well-crafted set of tasks, and immediate and detailed feedback. The appreciation of teammates in student feedback also hints of reaching the autotelic experience where the activity itself becomes a reward.

#### **4. Discussion**

The findings of this study demonstrate the actual impact of the shift from traditional teaching methodologies to Challenge-Based Learning (CBL) in the "Ethical Social and Professional Aspects of IT" course at Tallinn University of Technology. A crucial element of this shift was the appreciative feedback from participants regarding their peers, reflecting a broad acknowledgment of the benefits derived from effective team collaboration and the tailored application of individual skills within these teams.

The participants notably appreciated their teammates for facilitating a supportive and dynamic learning environment. This was not only beneficial for personal growth but also instrumental in enhancing academic performance, particularly in writing, project, and time management. The transition to CBL highlighted several key areas:

- The students liked the structured approach to forming teams based on diverse skills and personality traits, which led to well-optimized team performance - this will also be needed in the future to manage complex projects. The results suggest the course being a success in preparing students for real-world challenges by simulating professional team settings.
- The development of leadership skills was frequently highlighted. The participants were grateful for the opportunity to lead and manage teams, which not only improved their leadership capabilities but also their ability to work effectively in teams under pressure. The roles such as 'team coherence builder' were particularly valued for maintaining team unity and ensuring that all members contributed equally effectively.
- The course improved the participants' abilities in academic writing and project management significantly, aligning with university standards and expectations. Students were thankful for the practical application of these skills, which are critical for their future academic and professional life.
- The emphasis on constructive feedback was another aspect that participants found extremely valuable. This process not only enhanced their learning experience but also fostered an environment of mutual respect and continuous improvement. The ability to give and receive feedback effectively is a crucial skill in both academic and professional contexts, and students acknowledged the benefits of this practice extensively throughout the course.
- The role of effective time management was another critical learning outcome from the course. The participants appreciated how the course structure and team dynamics encouraged better planning and adherence to deadlines, which are essential skills in any professional setting.

We propose that the transition to CBL has not only enriched the learning experience by connecting academic theory with practical application but has also cultivated a nurturing and productive educational environment that encourages personal and professional growth. These outcomes support broader adoption of CBL in educational settings, especially in disciplines that benefit from hands-on, collaborative learning approaches.

#### **5. Conclusion**

The shift from traditional teaching methods to Challenge-Based Learning (CBL) within the "Ethical Social and Professional Aspects of IT" course at Tallinn University of Technology has demonstrated significant positive outcomes in both academic and interpersonal domains. This study evaluated the impact of CBL on first-year IT administration and development students, revealing that the methodological shift not only enhanced student engagement and learning outcomes but also fostered a more dynamic and responsive educational environment.

Key findings from the study include the effective use of CBL to bridge the gap between academic knowledge and practical application, particularly in addressing real-world IT ethical, social, and professional challenges. Students appreciated the structured, yet flexible team dynamics encouraged by CBL, which allowed for the optimal use of diverse skills and personalities within teams. Leadership skills, responsibility, and the ability to work under pressure did improve significantly, preparing students for the future work life.

Moreover, the emphasis on cultivating the Flow (balance of skill and challenge, well-defined tasks, constructive feedback) as well as promoting proper academic writing and project management practices resulted in a rounded educational experience, equipping students with essential skills for their future careers. The appreciation for these elements among participants underscores the value of CBL in creating an engaging, supportive, and productive learning environment.

Considering these findings, the study supports the continued integration of CBL into educational curricula, particularly in fields that benefit from hands-on learning and real-world application. The success of the CBL approach in this course at Tallinn University of Technology suggests that such pedagogical strategies can significantly enhance educational outcomes, providing students with the tools they need to succeed in both academic and professional settings. Further research is recommended to explore the long-term impacts of CBL and its potential for broader application across different disciplines and educational contexts.

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