THEATRICAL TECHNOLOGY ASSESSMENT: A ROLE-PLAY SIMULATION FOR TRANSDISCIPLINARY ENGINEERING EDUCATION

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ABSTRACT

To be able to contribute to societal challenges, engineering students need to learn how to interact with societal stakeholders and incorporate their viewpoints in technology development. This proves to be difficult, especially when it concerns newly emerging technologies, which are characterized by uncertainty and ambiguity. This paper presents a novel educational method – Theatrical Technology Assessment – which combines insights from Constructive Technology Assessment and improvisational theater in a role-play simulation that enables engineering students to explore the socio-technical dynamics and alternative futures of emerging technologies. This method is tested with bachelor students at the University of Twente. Students were involved as players of the role-play simulation, but also as co-designers and role-instructors. The pilot study corroborates that a role-play simulation is a powerful means for students to learn about the complexity of societal interactions around emerging technologies. They learn about differences in stakeholder perspectives and ways to anticipate or transcend these, and about general patterns in socio-technical dynamics.

1 INTRODUCTION

To cope with societal challenges, such as the transition to cleaner energy production, engineers need to collaborate across disciplinary and societal boundaries. Yet, this transdisciplinary collaboration is challenging [1], due to the often mono-disciplinary education of engineers [2] and the differences in interests, values and practices between engineers and other societal actors [3]. Several engineering programmes have taken up this challenge [4] [5] and have enriched their curriculum with social sciences and humanities [6], or with transdisciplinary projects, in which engineering students engage with other disciplines and societal partners to address challenges [7]. Such courses and projects provide students with an understanding of the complex socio-technical nature of technology development and how they, from their discipline, can contribute effectively and responsibly.

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Understanding the complex relation between technology and society, and incorporating this in solutions that take both societal and technological opportunities and limitations seriously, is difficult. This becomes prominently visible in education on 'emerging technologies', i.e. technologies that bear a promise of contributing to the mitigation of grand challenges, but are still in an early phase of development, and inherently uncertain and ambiguous [8]. In projects on emerging technologies, students tend to deal with uncertainty by bracketing the societal complexity, acting as 'technocratic modernists' who push new technologies through society with technological roadmaps and 'tell & sell' implementation plans. They understand that there are technological uncertainties, public concerns, and competitive dynamics in play, but they often frame these as technical problems to be solved and as resistance to be overcome by better explaining the technology and its benefits to the people. The future then becomes a straight line of technological success and societal acceptance. For educators with ambitions to raise engineers who can effectively and responsibly cope with societal complexities, this simplified view is unsatisfactory [9].

In this paper, we present a novel educational method – a role-play simulation named Theatrical Technology Assessment – which aims to enable engineering students to explore and anticipate the complex socio-technical dynamics of emerging technologies. Conceptually, the role-play is rooted in Constructive Technology Assessment (CTA), a method that enables learning of real-world stakeholders from different disciplinary and societal perspectives around emerging technologies, and creates opportunities to steer and anticipate the development of new technologies and their embedding in society [10]. Using techniques from improvisational theater, Theatrical TA mimics and extends CTA in a role-play simulation. In this concept paper, first the outline of the role-play simulation will be presented. Subsequently a pilot study will be described, which was conducted with teachers and students of a bachelor's programme in Technology and Liberal Arts & Sciences, to explore what students can learn from this simulation. The paper will end with conclusions and directions for further research and development.

2 THEATRICAL TECHNOLOGY ASSESSMENT

2.1 CTA Background

Theatrical Technology Assessment has its conceptual roots in Constructive Technology Assessment. CTA was developed as a method for the prospective and reflexive steering of the development of emerging technologies [10] [11]. CTA aims to foster anticipatory learning among stakeholders in an early phase of the development, when options for steering are still open yet uncertainty and ambiguity prevails [12]. Stakeholder interaction in CTA takes place in workshops that are designed as 'micro-cosmoses', condensed representations of the stakeholder field. These workshops are 'bridging events' between 'enactors' and 'selectors' [13]. Enactors are promoters of a

new technology, such as engineers, scientists and entrepreneurs, who consider the development of the technology as progress and often identify with the technology [14]. Selectors, such as consumers, regulatory agencies and big companies, have a broader scope and evaluate various technological options in comparison. By staging constructive confrontation between enactors and selectors, CTA reduces the costs of 'trial & error' learning. It provides scientists, engineers and entrepreneurs with a basis to develop integrated plans for the societal embedding of their technologies, and gives stakeholders the opportunity to prepare for future developments and to steer technology in a desirable direction in an early stage.

2.2 Toward a role-play simulation

Role-play simulations are powerful means for students to learn about the complexity of technical and societal decision making [15] [16]. They enable students to experience stakeholder positions from the inside, learn to face conflicts with other stakeholders, and explore options for bridging the gaps between different positions and disciplines. A role-play can stage 'constructive controversies' [17] around alternative interests, problem diagnoses and solutions, and enable students to transcend these differences.

To make a role-play simulation into an authentic CTA-like learning experience, students need freedom to act in line with their stakeholder role, while a clear structure is needed to allow relevant and realistic stakeholder dynamics to arise [18]. It is important to include a variety of stakeholder positions, including enactors and selectors. Because students are not really stakeholders, the risk is that they only play on the basis of their assumptions about stakeholder behavior and opinions, which may result in interactions that have little resemblance with the world outside the classroom. As a role-play simulation needs a certain verisimilitude [18], role descriptions are required, based on research of the field, which stipulate what stakeholders want to accomplish and how they assess new technologies. Besides, knowledge of the state-of-affairs of the emerging technology and society should be enacted in the role-play to make it realistic.

To make the role-play simulation into an engaging learning experience, techniques from improvisational theater were used. Improvisation is characterized by 'yes-anding', which means that players accept each other's actions in the play as 'real' and build on that, resulting in quick interactions, path-dependency, and opportunities for path creation [19]. Adding improvisational theater to the role-play simulation can make students more confident in their roles and the interactions quicker. Improvisational theater allows for experimentation and adds to the dynamism and outcome variability of the simulation. Rather than trying to become 'almost real life' [15], the theatrical setting condenses and amplifies stakeholder interactions, which can make tensions more visible. Besides, it allows for jumps in time and stakeholder constellations.

2.3 Role-play simulation design

The purpose of the role-play simulation is to provide engineering students with insights on the complex societal dynamics around emerging technologies and on options to anticipate and steer this development. The simulation is designed specifically for a context in which students work on an emerging technology and its (future) development. The basic idea of this simulation is that the process and context are pre-structured by the teachers, but that the content is provided by a group of students studying an emerging technology. They decide which stakeholders will be in the role-play and which issues regarding the societal dynamics will be on the table. They make instructions for the players, articulate questions, and observe the role-play. We will call this group the 'instructor/observers'. The simulation will be played out by another group of students, the 'players'. There are two teachers involved. One is inside the role-play simulation as 'moderator', facilitating and steering the discussions, thus being the linking pin between the instructor/observers and the players. Another teacher supervises the overall process, starting and stopping the simulation, and leading the instructions before and the reflective sessions after the role-play.

The role-play simulation consists of two rounds of playing, one in which a CTA workshop is being mimicked and one which is a pressure-cooker later in time. Both playing rounds are preceded by a preparation phase and followed by a reflection and debriefing (cf. [20] [18]). A theatrical rehearsal phase is added to enhance the quality of the role-playing. Table 1 gives an overview of workshop protocol.

Table 1: Theatrical TA protocol

Preparation	15 min	• Players read role descriptions • Instructors/observers discuss questions with moderator
Role rehearsal	15 min	• Players rehearse persona with instructors
CTA workshop	20 min	• Moderator explains the aims and the set-up of the CTA workshop, acknowledges uncertainties related to the emerging technology, and stresses the need for reflection and steering in an early stage. • Participants discuss pros and cons, problems, opportunities, and preferences. • Participants question each other, explore options for aligning actions and finding consensus. • Moderator safeguards attention for the main questions of the instructing/observing group. • When saturation is reached, the discussion is closed.
Reflection	10 min	• What happened between stakeholders? What are learning points regarding technology and stakeholders?

		• Have questions of the observing group been answered? Which new questions pop up?
Coffee break & Preparation	15 min	• Players take a break. • Teachers and instructors/observers discuss questions, given their newly gained insights. • Setting is changed accordingly (e.g., time-lapse of 5 years, changed stakeholder constellation, adding facts).
Pressure cooker	15 min	• Moderator notifies players of changed circumstances, provides the task to make a concrete plan on a short notice (e.g., investment scheme, design). • Moderator leaves the table and joins the observers. • Players discuss and carry out their joint task. • Moderator returns and players present outcome.
Reflection	15 min	• Articulate learning points regarding socio-technical scenarios, stakeholder dynamics, plans of action, and the questions of the observing group. • Personal reflection of players on their role.

3 METHODOLOGY

3.1 Context

To develop and test this method, a pilot was carried out within the context of a semester project at the Technology and Liberal Arts & Sciences bachelor programme (ATLAS) of the University College Twente. This programme is an honours programme educating 'new engineers' [4], combining technology and social science to analyze complex societal problems and design solutions for a range of contexts [21]. The role-play was part of a semester project focusing on emerging energy technologies. Five project groups of about seven students were involved. They worked on molten salt reactors, piezo-electric roads, space solar power systems, AI grids, and solar updraft towers. They explored different disciplinary and societal perspectives related to their technology and were given the assignment to develop long-term socio-technical scenarios [22] and concrete short-term plans for advancing the new technology. The role-plays were positioned halfway this 9 EC project, when they had studied the technology, its context and potential developments, and were about to make choices regarding scenario and plans.

3.2 Design approach, data collection and analysis

For the design process we took a pragmatic approach [23], which involves going through multiple cycles of reflection-in-action on paper and in class [24] to create a working design. The process consisted of a series of small group discussions about the function of the workshops in the semester project and the opportunities for

mimicking CTA and using improvisational theater, followed by a co-creation session, in which a number of teachers, students, and improvisation consultant created the general set-up of the simulation. This format was finetuned and elaborated (including instructions for students) based on feedback of students and teachers.

After the role-plays, students wrote a concise report with their lessons learned, individually and as a project group. Besides, the project tutors and an improvisation expert observed the role-plays and evaluated it in a group discussion. The lesons learned of both students and teachers were coded using open coding [25], and categorized in different themes. The role-plays and teacher discussions were also audio-recorded, and these recordings were analyzed to corroborate and substantiate the themes, and to identify further points. The most prominent lessons are described in the results section.

4 RESULTS

4.1 Instructor/observers

What instructor/observers learned from the role-plays related to the specific questions and expectations about stakeholder dynamics they articulated beforehand. Students wanted to know, for instance, with which arguments an activist member of an NGO could be convinced, or whether stakeholders with opposite viewpoints could converge towards a large-scale or small-scale implementation of a certain energy source. The observers reported frequently that the role-play outcomes matched with their expectations, but each group also reported new findings, for instance related to the influence of a certain stakeholder, the seriousness of a specific tension, or novel solutions for social or technological problems. These new insights stemmed from the creative processes among the role-players. Particularly interesting in the light of the overall purpose of Theatrical TA were the insights related to the complexity and non-linear dynamics of the emerging technologies. This was the case, for instance, in the piezoelectric roads role-play, where stakeholder dynamics and the time-lapse showed the working of a ‘hype cycle’. Because of the high expectations raised by the promoters of this technology in the first round of the role-play, all parties joined a pilot enthusiastically, but when the results were less than expected in the second round, most stakeholders were severely disappointed and abandoned the technology instantly. The group incorporated this into their scenario and plans by taking more time for pilots and urging the enactors of this technology to be more modest in their communication strategies.

4.2 Players

The playing students generally found the roleplays an enjoyable experience revealing relevant insights. A student who was quite skeptical at the start, wrote ‘*At the beginning, I honestly thought that this workshop would be useless, but I changed my mind halfway through. We had to make decisions the project group could not make*

themselves. We were able to do that because we are more objective and less involved than the project group'. Several students mentioned that it was revealing to act from the perscpective of a specific societal stakeholder rather than taking a helicopter view or acting from the standpoint of the engineer, which they would normally do in a project. A student wrote it was an '*interesting learning experience for me as it allowed me to see from the perspective of a single stakeholder and, for lack of a better word, be selfish and argue for my own interest as opposed to keeping all the aspects and perspectives in mind when forming an opinion*'.

The role-playing experience also increased the players' understanding of the complexities around emerging technologies. Students experienced, for instance, the differences regarding return on investment criteria between public and private stakeholders, or the different functions of pilot studies (learning about the technology vs getting media attention). The above mentioned hype-cycle in the piezoelectric roads case '*was really interesting to experience*', one student wrote, as she recognized how her arguments and opinion changed radically during the workshop. Another student found it fascinating to experience how much influence he could exert and how much he was trusted in his role as 'professor', especially when the discussion centered around technological uncertainties. Also negative experiences proved insightful. A student playing a citizen felt frustrated that she was marginalized and had little influence on the decision making. And a student who played a minister really felt the dilemma when he was urged to make a decision in a situation where so much was still uncertain.

5 CONCLUSION

In this paper we presented a novel educational method, based on insights from constructive technology assessment, improvisational theater and role-play simulations, which we coined Theatrical Technology Assessment. This method aims to enable engineering students to explore the socio-technical dynamics around emerging technologies and to provide insights they can incorporate in scenarios and plans that transcend disciplinary and societal boundaries. The results of the pilot indicate that this method can indeed have the intended effects. Both participating in the role-play simulation as a player and using the simulation to observe the interactions around 'your' technology provides novel and meaningful insights related to differences in stakeholder perspectives, ways to anticipate or transcend these, and socio-technical dynamics in general. These insights are relevant for the specific projects students work on, but also more generally, for their development into engineers that are competent in dealing with complex, uncertain and ambiguous technological and societal challenges.

The pilot corroborates that role-play simulations can be powerful means for students to learn about the complexity of technical and societal decision making [15] [16] [26] [27]. Several principles underlying this role-play design have been described earlier in

literature [18] [20], but they have been adapted to the transdisciplinary engineering context and the purpose of the role-play. What is novel in this role-play simulation is how students are involved. They are not only players and observers, but have an active role in shaping the content of the simulation and the flow of action. The use of improvisational theater strengthens the active role of the players. Techniques from theater have been used before in role-plays [28], but especially the improvisational aspect enhances the players' agency and the variability of the outcomes, which are important for the purpose of this role-play.

To further develop Theatrical TA, additional experimentation and a more elaborate evaluation of the effects on student learning is needed. This can be done in the context of projects on emerging technologies, but also in other projects on scenario development and courses on technology and society. In some settings, there will not be enough time to involve students as co-designers and instructors of the roles, which requires the development of cases that can be used more 'stand-alone', with students as players and observers. The learning outcomes may then be different. The broader application requires the development of a library of educational materials, including introductions to the technologies, role descriptions, fact sheets, and guidelines for teachers. One should beware of workshops with unidimensional roles and strict scripts, in which the interactions can be fully predicted, as the creative aspect and outcome variability of improvisation is core to this method.

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