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ORIGINAL ARTICLE

Envisioning future innovative experimental ecosystems through the foresight approach. Case: Design Factory

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Abstract
Change makers are visionaries who wish to bring change to their respective fields. As technological change is accelerating, it is relevant to consider, how the way and what we teach can evolve with the future to remain meaningful and pioneering. Design Factory at Aalto University, as an innovative experimental ecosystem with interdisciplinary principles and new teaching methodologies has been successful in and at the forefront in educating the students to be change-makers. The paper presents a case study of holistically anticipating plausible futures for innovative experimental ecosystems utilizing a foresight approach. We analyze how the ways of working, spaces, and teaching methods of one such ecosystem, Design Factory at Aalto University in Finland, could support students learning in the year 20×6 $\{x = 2, 3\}$. We present the process of drawing virtual lines that connect trends, future drivers, visions, and scenarios using a contemporary approach that fuses qualitative and quantitative methods. The results from the study are six future scenarios for the Design Factory, that have implications for innovation ecosystems in general. These results are expected to further foster or trigger new research and development experiments, directions for building radical environments, new teaching methods and ways of working.

Keywords Foresight · Future ways of working · Future problem solving · Scenarios · Future education

Introduction

Twenty years from now, we will be leading a lifestyle that would currently be considered atypical, but change is inevitable. Trends such as personal robots, artificial intelligence (AI), synthetic biology, drones, self-driving cars and globalization will influence this change [1]. The changes also pose a challenge to innovation ecosystems to remain relevant and to continue to support the needs of the change makers of the future. To keep up with and, furthermore, to continue to drive change in a relevant direction, it is necessary for innovation ecosystems to focus on future needs and requirements. This need also applies to those ecosystems in the university context, such as Aalto University's Design Factory (Design Factory), which aims to educate students in new radical ways through continuous development and experimentation with pedagogy. In this research, Design Factory is considered as a case study to anticipate the future of innovative experimental ecosystems with a focus on educating and supporting university students.

The foresight approach is defined as a process by which an organization can satisfactorily identify and understand the drivers that impact their long-term futures and that must be considered when making decisions and planning strategies. These drivers can be directly related in analysis to organizing activities. The foresight approach consists of qualitative and quantitative ways for scouting for upcoming trends, drivers, opportunities, and developments [2].

With the foresight approach, organizations can plan for undesirable but plausible scenarios and can strategize to address the transformational opportunities of desired futures [3]. Foresight in future studies is sometimes also referred to as strategic foresight. The use of foresight or the strategic foresight approach has been increasing in large companies to increase the innovation competence of organizations [4, 5] and to support strategic management [6].

In nature, an ecosystem is an atmosphere involving all of the living things and non-living components, such as sunlight, soil, water, and air, with which the living things interact. Today, an innovation ecosystem in terms of economic value contains economic decision makers, such as government, businesses

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(producers) and consumers, as well as non-economic factors, such as culture, knowledge, organizations, and social interactions. These non-economic factors play important roles in aiding and fostering idea creation and in the initiating and distributing of innovation among all of the actors. An active and advanced innovation ecosystem facilitates members in cooperating beyond traditional limitations, and it enables knowledge for innovation [7]. For example, active members in most of the ecosystems today are venture capitalists, scientists, engineers, technology integrators, visionaries, entrepreneurs, etc. These members are spread around research institutions with their skills and activities, and ethical series of capital formation and redistribution aid in their symbiotic existence and development.

Innovations continue to be achieved through the convergence of different realms and technologies [8]. In these increasingly digital and connected environments, firms face opportunities that they cannot seize alone [9]. There is inherent risk in these innovations because business models are uncertain, costs are high, and new potential competitors emerge in a very fluid business environment [8]. However, the risks can be mitigated in innovation ecosystems through the diversity that increases understanding of new market opportunities and user needs [10]. It has indeed been argued that, despite even the risks involved in managing innovation ecosystems themselves, ecosystems will lead to more effective implementation and more profitable innovation and that innovation ecosystems allow firms to create value that no single firm could have created alone [11].

Singapore has long been used as an example of an innovation ecosystem, where the government has made a commitment to invest in scientific research. Coupled with an inviting regulatory environment, world-class universities, and heavy investments in infrastructure to support the ecosystem, Singapore has enabled the development of networks that host not only scientists and universities but also large international companies, such as GlaxoSmithKline, that hope to capitalize on the location with more open practices than typical for their industry [12]. It is significant that Singapore continues to invest in the development of its innovation ecosystems [13].

These innovation ecosystems are not new; learning from history, Renaissance Florence was a comparative model for innovation, and it is a good example from which to take inspiration to build next-generation innovation hubs [14]. The Renaissance as a cultural movement was considered the link between the medieval and modern periods. It influenced European intellectual life to frame and modernize its understanding of humanity, art, science, music, religion, and self-awareness [15]. The origins of the Renaissance go back to thirteenth century Florence and then spread to Italy and later to the rest of Europe. However, what triggered this movement?

The function of shared spaces goes back to the 500-year-old idea of the Renaissance "bottega" or workshop in Florence, where the master (capobottega) was the underwriter of the client and accepted the responsibilities for the quality and consistency of the work. New artists, talents, techniques, and artistic styles have begun while working together and by challenging themselves. The Renaissance communities were defined and shaped in these workshops because the workshops were the meeting and working spaces for all of the contributors or stakeholders, such as painters, sculptors, other artists; architects, mathematicians, engineers, anatomists, scientists, and wealthy merchants (sponsors). The outcomes resulted in creating entirely new ways of working, designing, and developing new products and services and a new breed of entrepreneurship, which was instrumental in shaping the Renaissance and creating knowledge-centered value creation [16].

One of the thought-provoking aspects of a foresight study is the decision about the timeframe. For this study, the scope is defined as 20×6 $\{x = 2, 3\}$; i.e., the study explores the plausible futures between the years 2026 and 2036. Anticipating futures 10 years from now provides a sense of urgency and a direct linkage to the changes occurring today, while 20 years from now provides the freedom to explore new and diverse topics in the research.

The outcomes of this study are future scenarios for Aalto Design Factory, and these scenarios are expected to further foster or trigger new research and development experiments, directions for building radical environments, new teaching methods and ways of working.

Research setting: Case Design Factory

The innovation system of Finland was developed largely in response to the economic collapse of the Soviet Union in the early 1990s and the subsequent recession in Finland. The country decided to focus on education, science, and technology and to improve its innovation capability, and decades later, Finnish innovation systems enjoy strong governmental stewardship. The forming of Aalto University, which officially opened in 2010, merged three established universities: Helsinki's School of Economics, University of Art and Design, and University of Technology. Aalto University has been seen as one of the best examples of Finland's large-scale, holistic approaches to innovation [12].

In a report predating the merger detailing the needs for the "Innovation University", Martti Mäenpää wrote that global operational environments, focusing on core competencies and the replacement of linear value chains with value networks, are the cornerstones of business, and Finland, as a nation, should be able to capitalize on these chains. He also proposed that the planned development of the innovation university is an answer to this opportunity and allows for interdisciplinary interactions and a focus on the necessary efforts [17]. The goal of the merger of three universities into Aalto University was to create an internationally competitive, business-focused institution that takes inter-disciplinary work to an extreme to develop a unique, integrated seedbed for innovation [18].

The first interdisciplinary platform and the first physical manifestation of Aalto University was Aalto Design Factory, which opened its doors in 2008. The spearhead project set a mission to become a passion-based co-creation platform and to experiment with and test what synergies the interdisciplinary collaboration within the forthcoming university could yield. The story of Aalto Design Factory dates back to 1997, when an interdisciplinary course called the Product Development Project was first offered to students by the Laboratory of Machine Design at the Helsinki University of Technology (HUT). To further build on these experiences and to prototype the vision of future interdisciplinary cooperation and education, a research project called the Future Lab of Product Design (FLPD) was launched in 2006. FLPD was a physical platform for interdisciplinary co-operation to "educate the world's best product designers". By 2008, it was scaled up and named Design Factory.

As of 2017, Design Factory has grown to be an influential ecosystem in Aalto University and the wider society around it. Through its passion and problem-based learning approach, it is flourishing as a safe place not only to experiment and develop ideas and to bring people together but also to unite people internationally through the development of an international network [19]. The Design Factory Global Network in 2017 had 21 Design Factories in 19 countries acting as innovation hubs at universities and research organizations around the globe.

In 2015–2016, Aalto Design Factory supported 42+ courses, 1500+ students and 35+ teachers [20]. In addition to students and academic staff, the ecosystem supports various stakeholders, such as industry partners, research communities, startup enthusiasts, the City of Espoo, and many more. The aim of Design Factory is to act as an experimentation platform for all stakeholders in the community. The main community members in Aalto Design Factory are Aalto University teachers, students, and researchers and external company/organization representatives who work together with the students and researchers.

Design Factory as facility inspires and encourages teachers to teach students with more hands-on problem-based approaches, teamwork and interactive-based teaching methods while solving real life problems. Students join the Aalto Design Factory while taking interdisciplinary courses that are organized and offered at Design Factory. Students enjoy the relaxed working culture, which gives them the freedom to explore while learning to solve problems on a team. In-house researchers use the dynamic community and activities to perform applied research and to form possible collaborations. The company/organization representatives consider Design Factory to be a place of inspiration, and they are also source of the projects and real-life problem briefs for student projects and assignments. The 10 observations about Aalto Design Factory's ways of working with respect to the Design Factory community, which are also considered basic principles or building blocks when designing any new Design Factories, are [19]:

- Be inspired by examples
- Attract people with helpful and proactive attitudes
- Ensure open knowledge sharing and keeping the community tight
- Low hierarchies and bureaucracy and keeping things informal
- Providing encouragement and practical support for development
- Rapidly turning ideas into actions
- Being proactive and taking initiatives
- Freedom in work
- Providing a physical home base
- Encouraging showcases and avoiding showrooms

Methodology

Futures studies involve interdisciplinary approaches to vision and narration of alternative futures. Around the world in business and academia, this field of work is cited as futures studies, strategic foresight, futuristics, futures thinking, futuring and futurology [21]. Most of the theories used in futures studies assume that the future is plural and not singular because it is difficult to say which entity will yield to prediction. The existing methods are based on collecting quantitative and qualitative data about the trends, areas of change, uncertainties, and wildcards. These insights are used to build a holistic view of possible futures. Maicho Kaku suggested that, based on experiences with futures studies, there must be more scientific means to support methods and theories of futures studies [22]. There exist various futures studies methods, but the most prominent methods are the Delphi method, causal layered analysis, environmental scanning, morphological analysis, scenario planning, future history, content analysis, back-view mirror analysis, cross-impact analysis, future workshops, and the future wheel.

Using Delphi and scenario planning, the qualitative and quantitative methods are complimentary to each other and will bring more value to study outcomes [23–26]. For this study, a combined approach to data collection and evaluating methods inspired by the Delphi method, as well as visualizing and testing the results using scenarios, was deployed. In addition, due to the nature of the topic, this process facilitates a comprehensive approach while actively involving the participants in the process.

Insights and drivers

For this study, insights and drivers were gathered from primary and secondary resources, the primary sources being interviews with the various direct and active members associated with the Design Factory ecosystem and the secondary sources being annual trend reports, publications and research reports related to the future of education, future of jobs, future of work and ways of working published by various think tanks, consultancies, government organizations, research institutes, etc.

The insights collected here can be primarily summarized in terms of trends and mega-trends, mega-trends being events that have persisted for a long time and that are expected to continue for many more years with impacts on humans worldwide and trends being events that occur for shorter periods and that have impacts on humans more locally [27]. Elina Hiltunen argued that it is critical to cover a wide range of topics in the scanning or data-collection process, as it is easy to omit other trends or events if the scanning is focused on a narrow area, and the areas for the scanning in this study were deliberately kept very broad.[1] The scope for scanning in this study examined the next 10 to 20 years.

Evaluating drivers

The gathered drivers were evaluated in two phases. In the first phase, the Design Factory core team primarily evaluated and shortlisted the drivers. In the second phase, a larger group consisting of various stakeholders of Design Factory and external experts in the field evaluated the shortlisted drivers through an online survey.

The initial plan for the online survey was to conduct a Delphi study with multiple online surveys until the results were saturated, and the participants reached a scope on the drivers. One of the main issues in using Delphi is that it is challenging for participants to reach a scope in a short time period [28]. Because this study was part of a master's thesis, the time restriction has limited the planned Delphi study to an online survey. Considering the advantages of the Delphi method guidelines in defining the format and structure of the survey to efficiently evaluate the drivers, the online survey takes much inspiration from the Delphi method.

Ideation: Primary scenarios

There are many tools for building scenarios. In this study, primary scenarios were built by starting with a sensible combination of two drivers. The two drivers were mapped on the two axes of a graph. The four quadrants that were formed represented four different cases for this combination. Please see Fig. 5, which provides an example for building primary scenarios using drivers.

[1] Personal communication with Elina Hiltunen on 23 November 2016 about topics scope for research on Future trends and Megatrends.

Testing scenarios

To relate the scenarios specific to the case study and to test their addressability in future innovation ecosystems with respect to students' education, a workshop was organized with various stakeholders and members of Design Factory. The feedback and observations from the workshop were analyzed to determine the factors affecting the scenarios and to sort and update the scenarios. A brief visualization of the methods and process flow can be seen in Fig. 1.

However, the proposed methodology makes the study outcome to be depended on the insights gained from the data-gathering methods, that is, research on trends and mega-trends and the participants in the study. To add value to the depth of the study, the following are the backgrounds of the participants that participated in the study.

- Professor 1, Design Factory
- Professor 2, Design Factory
- Researcher, Design Factory
- Staff, Design Factory
- Pedagogical expert, Design Factory
- Workspace expert, Design Factory
- Alumni, Aalto Design Factory
- Representatives, Design Factory Global Network.
- Representatives, other research organizations from Aalto University
- Representative, Aalto University management
- External researchers, Active Design Factory collaborators
- Active member, Aalto University startup scene
- Professor (philosophy), Aalto University
- Principal, high school
- R&D director, industry
- Head of business development, industry
- Expert, futures studies
- Representative, City of Espoo.
- Student, upper secondary school
- Master's degree students, Aalto University

Finding future drivers

The drivers are the trends that will affect the s occurrence of an event. They are identified from insights that are gathered from primary research, from interview insights and from secondary research on trends and megatrends.

Pilot interviews

To gather insights from the Design Factory ecosystem, 10 people representing all of the different stakeholder groups of

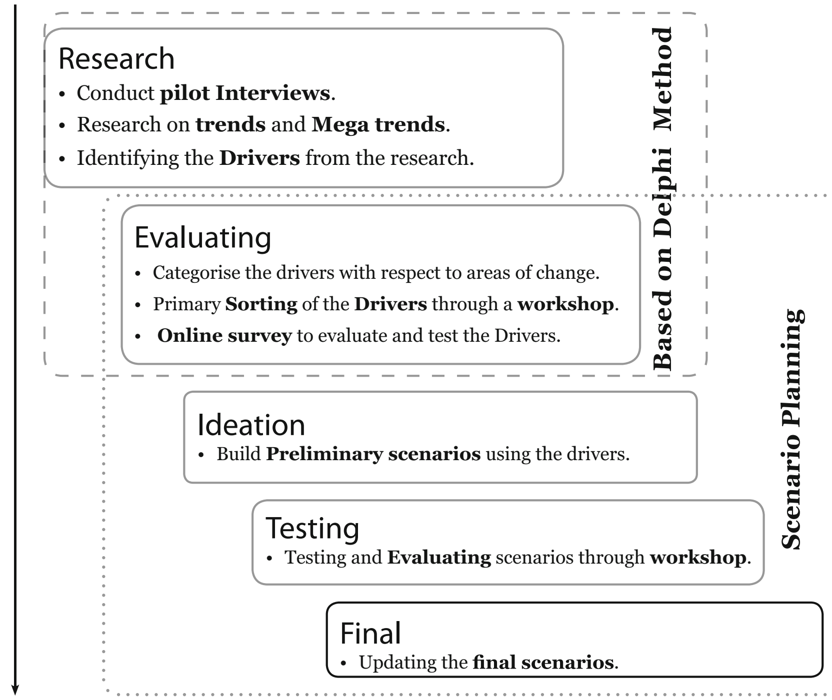

Fig. 1 Description of the study methodology

Design Factory were interviewed. The interviews were semi-structured with open-ended questions; occasionally, questions were reframed during the interview if the participant found it difficult to relate the question to the topic. Because the questions were deliberately left broad, it was difficult for a few of the participants to answer them. Because it was insisted by many experts that care must be taken while selecting the expert panel, the usual time and resources played significant roles in the selection process. The responses from the participants have been documented, and the *insights* were summarized into three categories: facts, challenges, and assumptions.

Trends and megatrends

The information about future events, trends, mega trends, issues and insights was gathered from various secondary sources, such as similar studies, articles, Web sites, reports, and talks. This process of gathering information on political, economic, societal, technological, events and trends that influence the business is also defined as environmental scanning [29]. The scanning is summarized regarding the following mega-trends and trends:

- *Mega-trends*: Globalization 2.0, Climate change, Demographic change-Urbanization, Immigration, Family structure, Technological convergence, Digital world-Hyper-connected planet
- *Trends*: Future job/Title, Future skills, Future workspace, Future food, Science, Artificial intelligence, Education and learning, Future generation/User, Future creative ways of working

Future drivers

A total of 36 drivers were identified from primary and secondary research insights and were categorized as areas of change. The most common origin of drivers pointed to the general areas of change, which are political, economic, social, technological, and legal (PESTEL) [30]. For the purposes of this study, to align the insights within the context of Design Factory, the following areas of change are used. See Fig. 2 for all of the drivers.

- *New methodologies* - This area is about supporting the learning of the student; technology or requirements can drive these methods.
- *New connected world* - This area is about the new participants in the network, new collaborations, and new emerging disciplines.
- *New operating model* - This area is about drivers that facilitate new business strategies while including new and old partners.
- *Society and demography* - This area is about societal drivers that can affect the activities of Design Factory.
- *Organizational* - This area is about Design Factory management, Aalto University management, active members

Fig. 2 Drivers picked chosen from the research insights

Area I- New methodologies

- Virtual World
- New methods in teaching vs old method
- Interdisciplinary and T shaped people
- Teacher role
- AI assisted services
- New Job Titles Future Job Skills
- Future user needs
- Design Approach
- Student centric education
- Online education (MOOC)
- AI and human interaction
- Collaboration with Robots

Area II - New Connected world

- Connected people
- Modular and Integrated labs
- Big data and data gathering
- Physical spaces
- New disciplines
- Co - working spaces
- Connected Devices
- Mobility

Area III - New operating model

- New education models
- Degree structure
- Industry university Interdependency
- New breed of entrepreneurship, startups

Area IV - Societal and Demography

- Elderly population
- City & Neighbourhood collaboration
- Personalized and mass customized services
- Finding Good students
- 3D printed world
- Health/ well-being services
- Automated world
- Sustainable use of resources
- Community based living
- Social media

Area V - Organizational

- Moving to new Place
- Change in Management

in the community and the Design Factory Global Network.

Testing and evaluating the drivers

The testing and evaluating of the drivers are performed in two parts: first through a primary workshop with a core Design Factory team to sort and prioritize the drivers; and then through an online survey with 25+ participants.

Primary testing – Workshop I

The first part of identifying critical drivers and shortlisting the drivers is addressed using the primary model, which is a graph with impact and certainty on the axes [31: 7–58, 66–67]. A workshop was organized with four participants representing Design Factory research, teaching, management, and strategy. The members discussed each of the drivers and placed them on the graph while categorizing the driver with respect to its impact on Design Factory and the possibility of it occurring in the next 20 years (see Fig. 3). The drivers, which are in the top right corner (highlighted in the ellipse, Fig. 3) were selected for further evaluation, along with a few drivers from outside the cluster.

The challenge in using this method for shortlisting the drivers was that it allows only choosing the drivers from the top right cluster, and there is a potential risk of ignoring a few potential drivers. To overcome this challenge, few of the drivers (highlighted in the box; see Fig. 3) are outside the top right cluster, but they are expected to have potential impacts on the case and are included among the shortlisted drivers. This suggestion of divergence from the outside cluster is based on research analysis performed during the scouting phase. In total, 19 drivers were identified as critical drivers and were shortlisted through this exercise.

Secondary testing - online survey

The second part of evaluating the drivers is addressed with an online survey with a selected expert panel. Typically, when following the Delphi method, the survey has multiple rounds, giving the participants an opportunity to iterate their options. However, due to time restrictions, the scope of the study and the primary analysis of the results after the first round already provided the necessary information that allowed us to continue with the next phase of the study, and only one round of the online survey was conducted.

The three elements of the survey, which are questions, data collection and selecting an expert panel, were based on Delphi guidelines. Each driver is framed as a question, except for two drivers that were found more useful when combined to form one question. The survey questionnaire contained 19 questions. A panel of experts was asked to evaluate the questions with respect to three scales, which were: 1) Desirability to Design Factory, 2) Feasibility to occur within the next 20 years; and 3) The respondent's experience with the drivers.

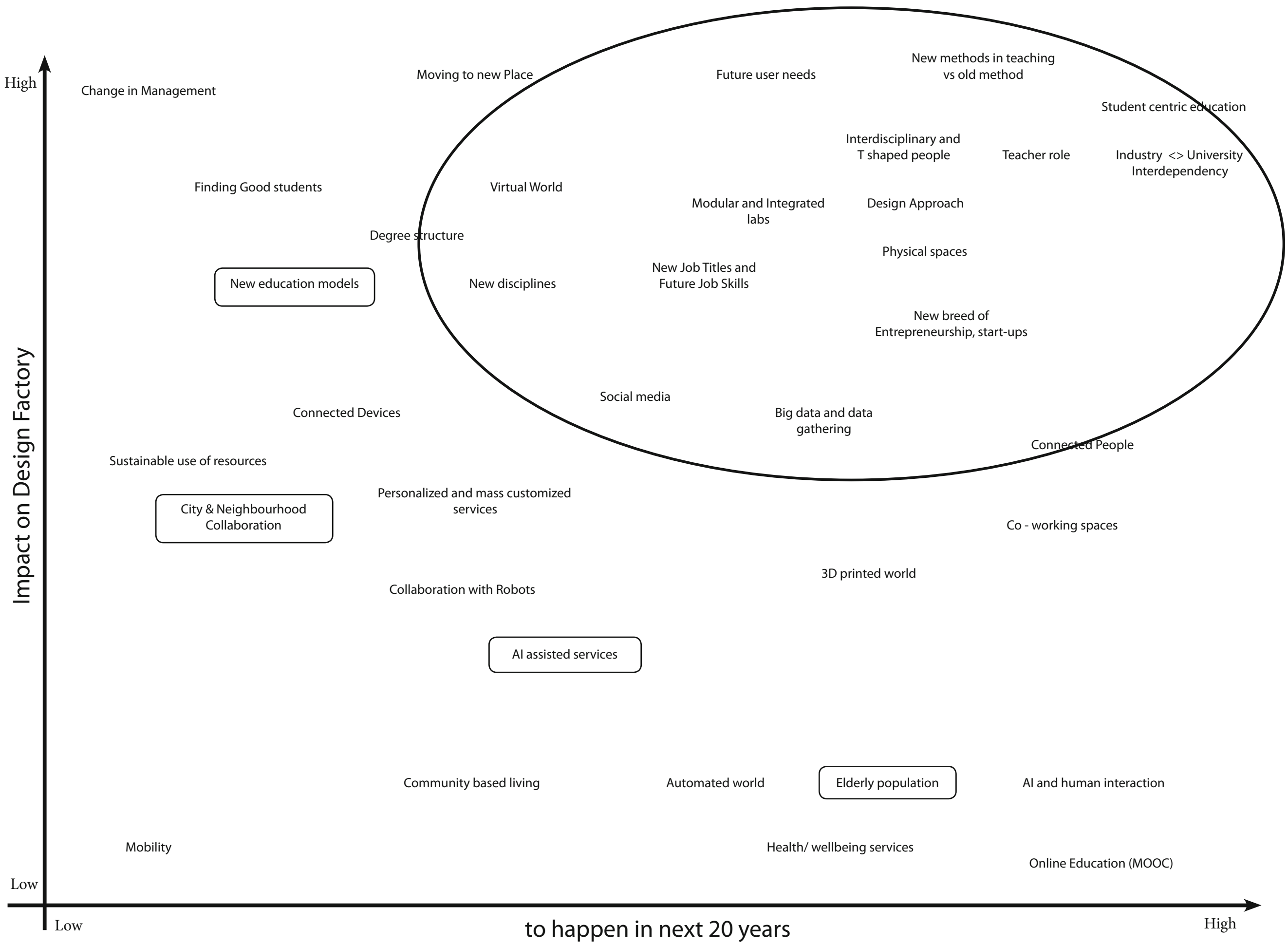

Fig. 3 Graph-based sorting of drivers

There was also a provision to provide open comments. The expert's opinions were recorded by providing four options per scale. For example, for the scale of Desirability, the expert could choose the opinion of very undesirable, which has score of 1, undesirable, which has score of 2, desirable, which has score of 3, and very desirable, which has score of 4, so that quantitative data can be captured. [31: 7–58, 66–67, 32]. For usability purposes, a visual aid (smiley faces) was embedded in the scale option [33]. See Fig. 7 in the Appendix for the format of the question and scale.

The questionnaire was tested with three people who have similar backgrounds to the members of the expert panel, and it was iterated with the feedback. The final questionnaire was sent to the participants with a deadline of two weeks to complete the questionnaire.

Primary scenarios

Based on the scores given by the participants in the survey, the means are calculated for Feasibility and Desirability. Based on the score that each driver received, a graph is plotted (Fig. 4) to summarize all of the drivers together. From the graph in Fig. 4, the drivers can be grouped into two major clusters. These clusters are based on the driver's position with respect to their scales of feasibility and desirability [34].

The cluster of drivers with low feasibility and low desirability is called *Potential Jolts,* and the cluster of drivers with high feasibility and high desirability is called *Significant Impactors*.

To build scenarios, one driver from each cluster is used to maintain dynamics in the scenarios. A trial and error method is used to determine the combination of two drivers that makes a sensible case, and later, more drivers are added beyond the two primary drivers [32: 7–58, 66–67]. For example, on primary scenario building (see Fig. 5), in this example, the drivers used are artificial intelligence assistance vs new methods that are student-centric. The artificial intelligence assistance is mapped on the vertical axis, while new teaching methods together with student-centric education is mapped on the horizontal axis. The quadrants represent different possibilities of the driver relations.

The scenarios are built from the drivers collected in a Design Factory-specific study, in which they remained generic and approached issues beyond the context of Design Factory

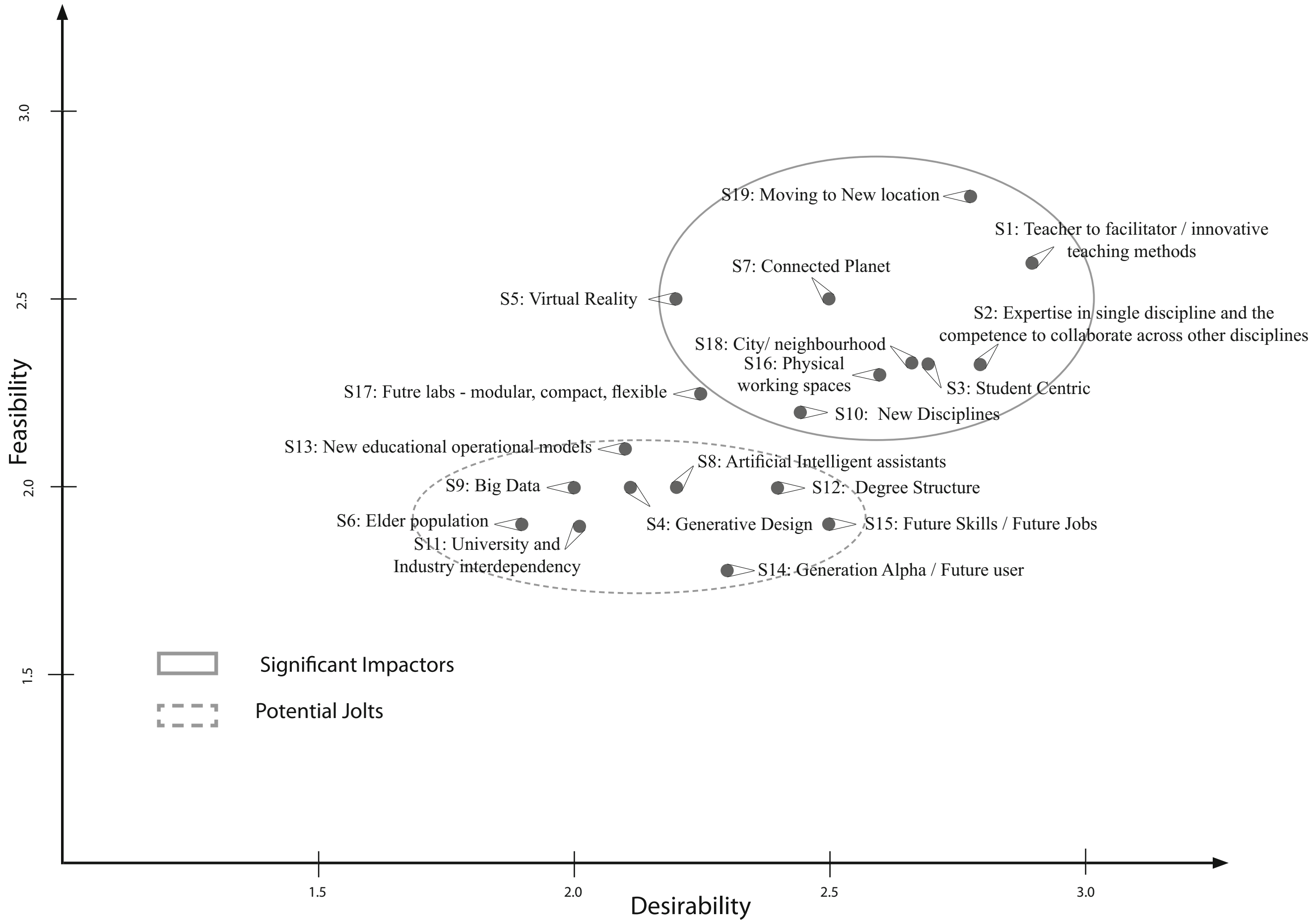

Fig. 4 Graph with survey results and identified clusters of drivers

in the fields of future education and ways of working and learning, to avoid limiting the creativity of the scenario testing and evaluation workshop participants. For brief descriptions of the drivers used to build scenarios and primary scenarios, see the Appendix.

Testing and evaluating scenarios

A workshop to test and evaluate these scenarios was organized with the various stakeholders and members of Design Factory. The aim of the workshop was to test the eight scenarios with participants by providing a framework with which teams could discuss and test the assumptions made in the scenarios. Because the given scenarios did not contain Design Factory-specific information, the participants were instructed to ideate with the following perspectives:

> "*What could be the elements in Design Factory that will support and enhance student education?*
> *What could be the elements in Design Factory that will attract, engage, and motivate students/people?*"

The process of the workshop was that the participants were divided into four groups; for two different ideation sprints in each of the two ideating session, they were asked to work on the given scenario and create a story that could be presented to the other participants, so the participants could vote for the top three scenarios. The participants in the workshop included various stakeholders of the Design Factory, master's level students, Design Factory Global Network representatives, and a high school student.

The teams were formed based on two factors: first, expertise with knowledge of the topic of the scenario; and second, representation of all of the stakeholders of Design Factory. Additionally, a few participants from outside Design Factory were invited to obtain an outsider perspective, and a high school student was also invited to bring the perspective of future Design Factory users.

A mock workshop with two people was conducted to test and streamline the workshop process. Because it was challenging for the participants to contemplate the future and keep their focus on futures thinking, there were a few activities, such as a warm-up exercise and providing some inspiration between the ideation sessions. From the observation of being a

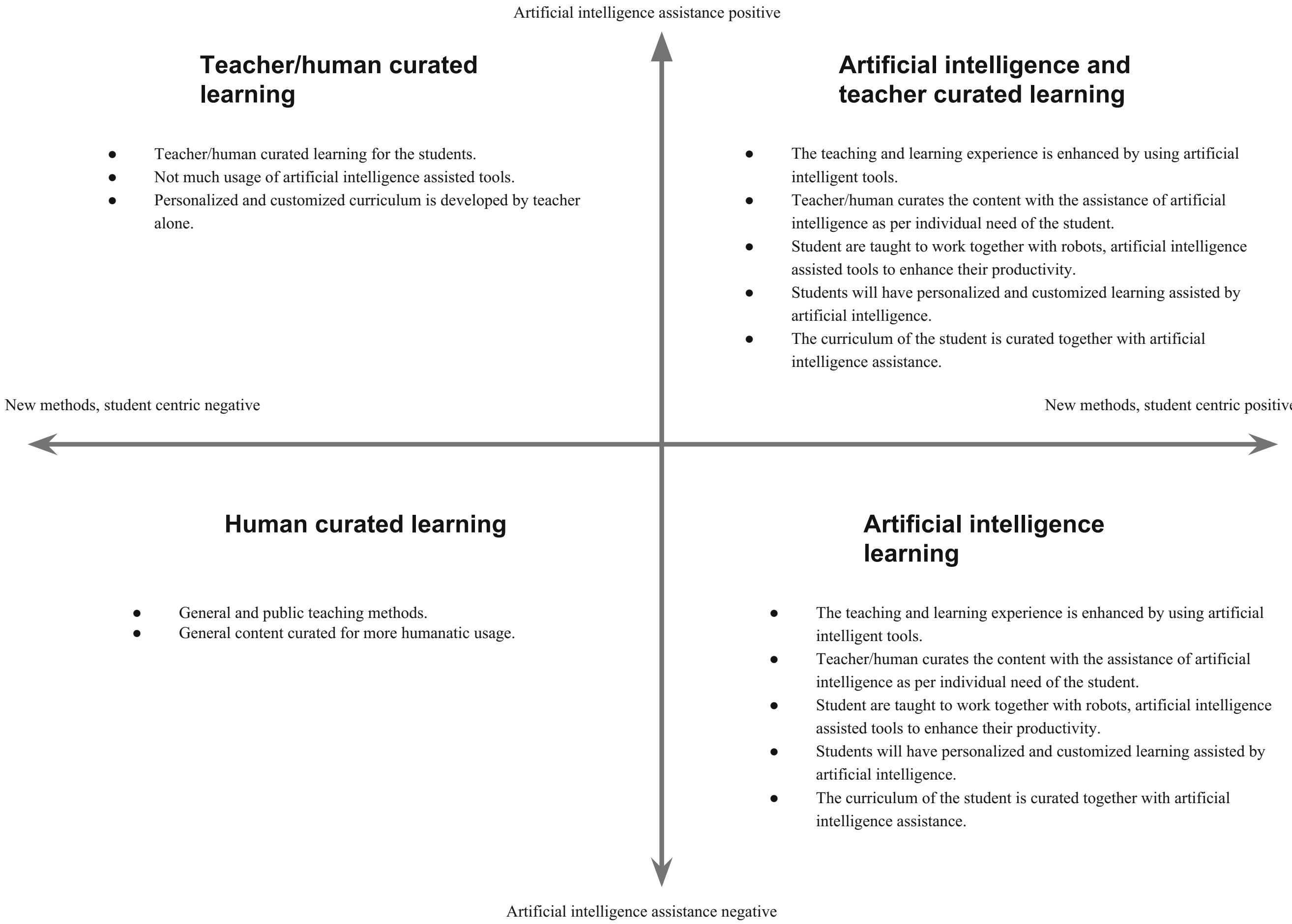

Fig. 5 Example for building primary scenarios using drivers

facilitator, these activities were helpful in challenging the mood and energy of the participants into thinking about future possibilities.

The scenarios were chosen based on two criteria:

- Based on participant voting, the scenarios were prioritized based on the votes received from participants. The scenarios with the scores (number mentioned next to scenario) received are Symbiotic world (7), Hyper-connected humans and devices (6), Co-creating education (4), We also love you (6), Intuitive world (0), Data-driven experience (8), Unreal world (2), and Synergy (1)
- Going through the workshop materials that the participants produced assessed the participants' understanding and interpretation of the scenario about the Design Factory.

The final chosen scenarios were *Data-driven experience*, *Symbiotic world*, *Hyper connected humans and devices*, *Co-creating education*, and *We also love you*.

Factors effecting the scenarios

By analyzing the boundaries that were defined for the driver and the content produced from the scenario testing workshop and comments from online survey participants, the agility of the scenarios could be measured through two factors: technology enabled/driven; and community enabled/driven (see Fig. 6).

- Technology enabled/driven addresses with usage of new and emerging technology enabling and driving the scenarios.
- Community enabled/drive addresses the initiative that the community will take that will drive and enable the scenarios.

The observations from the graph show that all of the scenarios have their agility in the positive extreme to explore the other extreme; that is, the factors *technology enabled* and *community enabled* are consider in their negative extremes,

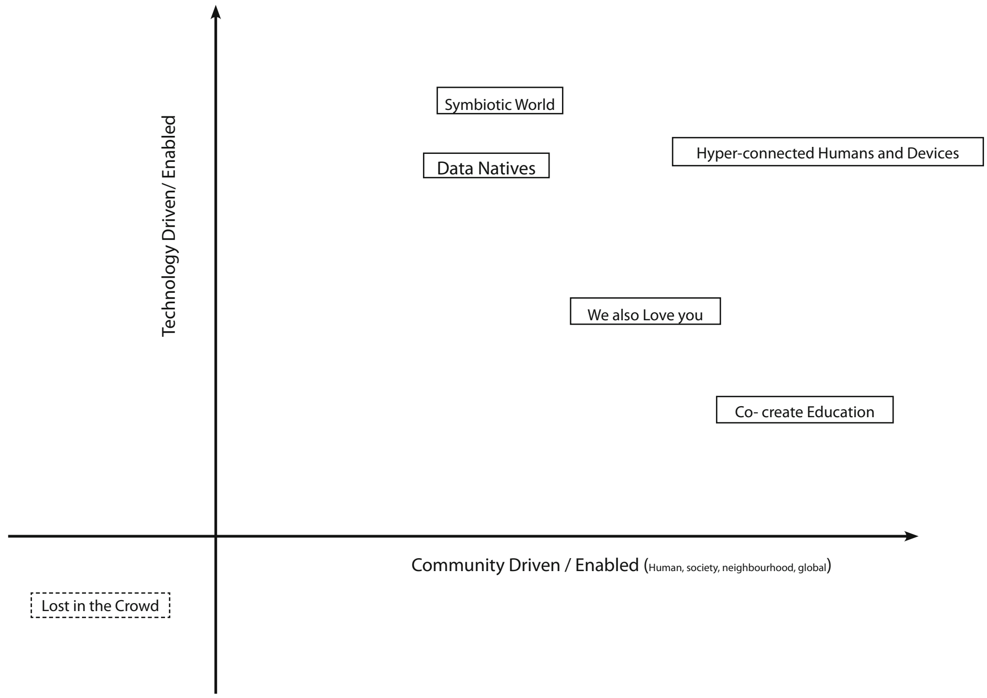

Fig. 6 Factors affecting the scenarios

and the new scenario "lost in the crowd" is proposed. The final scenarios are updated with the content produced in the workshop. These scenarios now are explicit and refer to the futures of Design Factory. In addition, a few facilitators that are driving the scenarios are mentioned for each scenario.

Final scenarios

Scenario 1: We also love you

This scenario is based on the current core principle of Design Factory, which is to bring disciplines together and teach problem- and passion-based learning. In this scenario, the Design Factory will be a place bringing together students from new and emerging disciplines, such as organic electronics, nanotechnology, cognitive economics, computational science, synthetic biology, wearables, exo-meteorology, quantum mechanics, genetics, artificial intelligence, and more, to teach students problem-based learning. The focused approach is on design thinking and human-centered, real-life problem solving.

These students can come from various disciplines and schools. A physical or virtual working medium is provided to support the interactions and teamwork. For example, Design Factory on Mars brings together students from new disciplines, such as new emerging space tech, and they join the day-to-day work actively through virtual media.

Design Factory acts as home-like, safe environment to all students from other disciplines to experiment and participate in problem-solving processes. The new teaching methods also consider the importance of finding a common language for student group work because it is challenging for students from different disciplines to understand each other's insights. With these new collaborations, new job titles are shaped, new breeds of skills are fostered, and new ways of developing products are taught to students. The master's program at Aalto University supports discipline fluidity, i.e., one may not have a major study but one may specialize in a field.

The teachers are supported with new methods for working with new disciplines. There is active collaboration with stakeholders to resolve other disciplines' problems. There will be new compact and modular labs and facilities integrated with Design Factory to support these projects.

Facilitators

- The strong foundation that Aalto University has laid to encourage interdisciplinary activities; the new wave of energy and interest that is visible on the University campus for interdisciplinary-related activities
- The awareness of the people of the importance of involving various disciplines in solving problems; the growing dependency of one discipline on another

Scenario 2: Temple of co-creation

This scenario regards how new actors can play important roles in providing new education models, education as service, school as service in the sharing economy or life as service, unlike currently, when the government plays the main role in

Finland. These new actors can spread around the globe, and students can pursue their educations while utilizing Design Factories globally. New actors, such as cities, NGOs, startups or industry, will play vital roles by supporting programs and courses in the university, where students can major or minor in their degree studies.

Instead of a pre-planned study path, it will be phenomenon-based learning, in which students will have options to choose from and freedom to explore.

Design Factory acts as a platform that collaborators/stakeholders can approach for projects and challenges that are more agile, and ad hoc, this platform helps to find the right match for collaborators. This platform acts more like a consultant to industry/society challenges, bringing outsider perspectives and using the latest technologies, such as virtual collaboration, to form new collaborations and to solve global problems by reaching remote locations.

Because students are qualified through co-creation to solve their domain-specific problems, the actor will directly support students. Support can be based on sponsorship or ownership. For example, a student wants to solve NGO problems, the student conducts his or her study together with an NGO, and the NGO adopts the student. Therefore, the student earns his or her degree with NGO problem-solving abilities. The education does not end after graduation; it continues in work life, so the person continues to learn the new skills required to for the job.

Facilitators

- The disruptions that are now seen in terms of new service and business models, such as Uber and Airbnb, are also becoming popular in other industries. In addition, Design Factory can undertake active initiatives in this regard because it closely collaborates with the actors within the Design Factory global network.

Scenario 3: Symbiotic world - AI enabling the new renaissance

This scenario is based on using artificial intelligence (AI)-assisted virtual assistants and robots in day-to-day, labor-intensive activities, such as managing teaching-related activities and data-assisted services to personalize education to the student. The human can devote more time for human-to-human interactions and creative work. The humans learn from robots, and robots learn from the humans. Since there are active robots, i.e., artificial intelligence-assisted virtual assistants in Design Factory, and students are taught to work together with robots and virtual assistants to enhance their productivity and creativity.

Teachers can monitor the interactions of students and robots, and the robots help the teachers to gather data related to student interests and preferences, which can be used to refine the course content in real time. In addition, students' curricula are refined based on skillset needs, which are required for future jobs. Therefore, the teacher/human curates the content with the assistance of artificial intelligence per the individual need of the student.

Robots will be a part of artificial intelligence and virtual-assisted Design Factory community, and they will help in building trust among the community by gathering common insights, understanding, and intelligence. In addition, they will help in forming student groups, organizing group activities, encounters and collaboration with other groups with similar interests and needs, which will\facilitate serendipity among the students, teachers, and community.

The experimental and agile nature of the Design Factory platform to innovate new methods in teaching and learning is strongly supported using artificial intelligence, virtual assistance and robots for day-to-day activities. The teaching and learning experience is enhanced using artificially intelligent tools.

Because it is challenging for teachers/humans to interact with students 24/7, this model is supplemented using virtual assistants and robots for study-related issues. It also provides access to relevant content beyond space and time. Students will have personalized and customized learning assisted by artificial intelligence.

Facilitators:

- Already, people today are spending more time interacting with virtual chat bots than in human-to-human interaction, and this trend will continue to increase in the future. Embedding a virtual assistant, which can help in having conversations about study-related issues will help in bringing back the focus to education in this virtually rich interaction and environment.
- Artificial intelligence-assisted tools are already used in many applications, such as health care, media, and automotive, and in the future, there will be more trust in using these tools for more dynamic applications.

Scenario 4: Hyper-connected humans and devices

Humans and devices are connected from very remote parts of the world. New digitally connected and collaborative teaching is offered to students across all of the Design Factories. This scenario is based on enhancing learning by utilizing connected humans, the Design Factory community and devices by an active platform. The hyper-connected humans in this scenario have two perspectives:

- With standardization of 5G, the information can be shared easily, virtual collaboration can be achieved with remote locations, and human-Device (internet of things) interactions will enhance team working.
- The growing Design Factory Global Network, in which Design Factories in other universities around the world with common visions are in a tightly connected community by engaging in various collaborations and projects.

Teaching and learning methods are curated while working in the hyper-connected philosophy and community. The information enhances the teaching and learning experiences available from the connected resources and devices. Connected thinking is used to experiment and develop new ways of working, learning, and teaching and to curate curricula.

There will be approximately 100 Design Factories around the world in next 20 years. There is the availability of consistent knowledge and people in the community. This knowledge can be shared with in the community actively. A student will have the option to choose elements from Design Factories and earn a degree. The working and interaction medium will evolve to digital and virtual formats. The new teaching methods support this new way of working, which are based on connected and virtual collaborations.

For example, a student can join the Design Factory Global Network and choose to study and gain knowledge from any Design Factory with a subscription model for a lifelong learning experience or even to earn a master's degree. Moreover, for other stakeholders, such as industry, there is another subscription model and an option in which billing is performed for an idea or knowledge.

Facilitators:

- The possibility to work and share information in real time with remote locations.
- The ability to integrate humans and machines more organically.

Scenario 5: Data natives

This scenario is about supporting student learning using data collected from students in addition to human support. The data are used to personalize study plans, and degree structures enhance the learning experience. Design Factory as a data-collecting environment provides an agile platform through which data are collected in real time from the student about behaviors, interests, gaps, and preferences to build and refine course content in real time. The new teaching and working methods in this agile environment provide freedom for teachers to teach and share their knowledge.

The data from the students are collected from the day they were born to enhance lifelong learning. Because the future student is now in his or her early childhood, in principle, the data about the person's preferences and interests can be collected from now. Based on the personal data, there is an option that the student is invited to the university based on his or her career preference. The education is designed based on the trends and new requirements that future jobs require. When student takes a break from education to work in industry or goes abroad as an exchange student, once he or she returns to his or her education, the study plan and degree structure are refined based on the student's new learning and experience gained at work.

The data from the community are used to find a demand-driven approach, which is important for building student teams and stronger community aspects. It is possible for students from various locations and disciplines to converge over common interests and relevant knowledge.

Working spaces are agile and intuitive to use based on user data. The data used to plan coincide virtually and physically to encourage encounters and open innovation. The physical environment/lecture rooms are modified based on real-time data collected from the users so that they act as a safe environment and inspiration to innovate and work. Generational and knowledge gaps between teachers and students are minimized using in-house data resources, which help the teachers and students to find synergies.

Facilitators:

- Currently, personal data facilitate mass customization; similar, data about student preferences, learning, and skills can facilitate personalized and tailor-made education for each student.
- Collecting meaningful data and making sense out of the data using sophisticated machine learning tools are reaching new applications.
- The culture of providing personal data for customizing and personalize services is gaining popularity.
- There is always a demand for personalized and tailor-made services. Because these services demand so many resources to be consumed and it is impractical to provide personalized education, it has not reached a mass scale. The use of data and machine learning tools can now facilitate the providing of mass customization and tailor-made education with respect to the needs of individual students.

Scenario 6: Lost in the crowd

This scenario is about when technology-enabled and community-driven factors are at the negative extremes; that is, technology and community do not drive the Design

Factory's experiential nature. Design Factory dissipates other actors inside Aalto University because other actors provide similar philosophies, facilities, and environments to Design Factory.

In this era, when digital and virtual environments drive interactions and collaborations, Design Factory has its own physical environment, which is solely driven by face-to-face and human-to-human interactions. The experimental nature of Design Factory is highly conservative. The teaching methods, communication, collaboration and co creation with other stakeholders are based on traditional methods.

Design Factory teaches students using the same methods used on campus. It is difficult for the students, researchers, teachers, and other stakeholders to find the differences between the Design Factory and other actors on the Aalto campus. The stakeholders lose sight of the community aspect and are scattered around the campus without a shared vision.

The collaborations with other disciplines will be limited. The current major disciplines with which Design Factory works are engineering, design and business, the collaboration between these disciplines will be constrained and restricted. Few emerging disciplines are brought together. The aim of education and degree program is focused on field specific research rather than problem solving.

The curriculum and study plan of the student's degree program are not flexible and are based on traditional structures. The student does not have the freedom to create his or her study plan or to choose courses to his or her interest.

Discussion

The systematic method that is proposed and used in this study aims to apply foresight approach or futures studies in envisioning the plausible futures for innovation ecosystems that are spread around university and focus on student's education. This study method can act as an inspiration to similar foresight studies that aim to involve all the stakeholders, external experts and future drivers to anticipate futures visions that assist their organisation in decision-making and future preparedness.

The study's findings and outcomes such as future drivers and scenarios can act as research resources when working on similar cases such as future of education, future of university, future university industry and society interactions. However, the limitations of the study, which are today's futures drivers, participants view on futures and the Aalto Design Factory centric study environment, have a significant impact on study outcomes. This could be also an interesting challenge for future prospects in terms to address the issue both in content wise and method wise.

Conclusions and observations

Based on the final scenarios and insights gathered in this study, the radical nature of education and experimental ecosystems over next 20 years could be impacted by, and therefore, we must prepare for, the following:

- Personalization of learning experience or giving choices to the student regarding ways of learning and working, which will add value to the student's education. It is important to have a balance between the personal and community aspects while defining the study plan or the teaching methods.
- Educating students with respect to the confluence of various distant disciplines is vital in problem-based learning. Already today, few of the basic disciplines are brought together, but emerging disciplines, such as nanotechnology, artificial intelligence and, biotechnology, will play important roles in the confluence in the future.
- Flexibility in the education system – and taking inspiration from new business/service models, which are redefining the current operating systems and the educational system. For example, with new actors, education can be offered as a service rather than a product.
- Changing means of interaction and communication – The communication and interactions will go beyond human-to-human and voice to voice. Virtual and brain-to-computer communications will bring new challenges and opportunities while defining and planning the interactions and encounters in the community and outside. For example, current innovation spaces, which have the purpose of encouraging collaboration and encounters, might not serve the same purpose in the future.
- A "Design"-based approach will reach a wider audience and industry; the key factors for creative processes will regard how to use design principles, along with generative tools to solve problems.
- In the gig economy, people will have multiple careers, and skills play a more critical role than a degree. There will be a need to offer a flexible degree structure that supports the development of a wide skillset.

Further, based on the research, the following observations are identified:

- Four out of eight primary scenarios that were chosen are technology related, showing that technology will drive societal change and will greatly influence the next generation of experimental education.
- From the online survey results, it is observed that all of the participants are aware of the proposed drivers and have some experience with them.

- Because this study aimed to trigger new research directions, there are many ideas that arose during the study that can be further explored in detail and in experiments to determine the limits. Some of these ideas can also be implemented today, and a few would require some maturity in terms of technological advancements and societal changes.

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Appendix

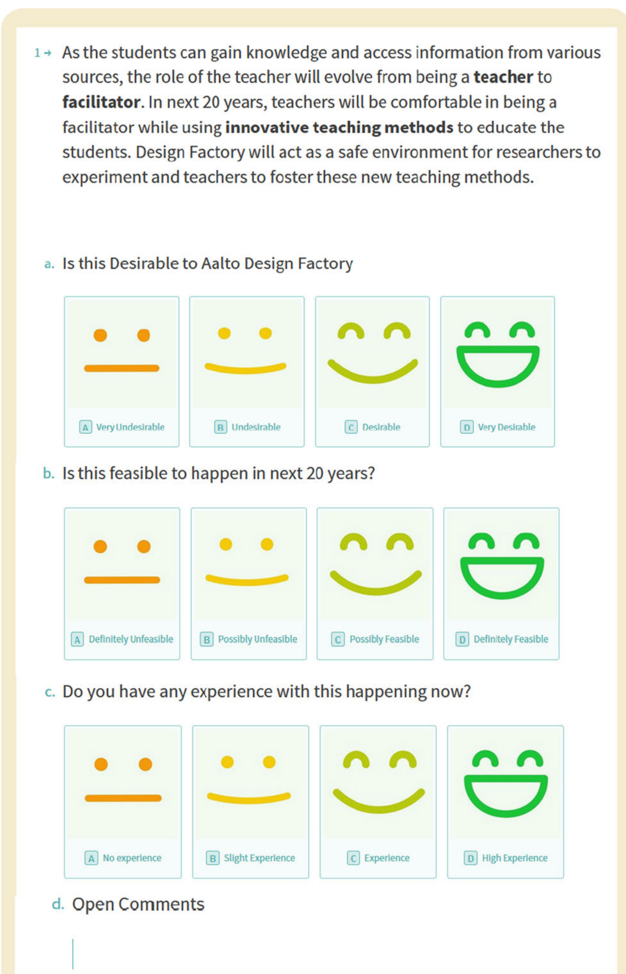

Fig. 7 Online survey question and scale reference

The following Table 1 explains the primary scenarios with the drivers on which they are built.

Scenarios	Descriptions	Drivers
Symbiotic World	• The teaching and learning experience is enhanced using artificial intelligent tools. • Students are taught to work together with robots and artificial intelligence-assisted tools to enhance their productivity. • Students will have personalized and customized learning assisted by artificial intelligence. The curriculum of the student is curated together with artificial intelligence assistance.	• Artificial Intelligence • New Teaching methods • Robot, Human teacher • Student-centric education
Hyper-connected Humans and Devices	• People and devices are connected from very remote parts of the world. There are 100 connected design factories on Earth and one on Mars. • Teaching and learning methods are curated to work in the hyper-connected philosophy and community. • Teaching and learning experiences are enhanced by information available from the connected resources and devices.	• Connected World • Internet of Things • New Teaching methods • Degree structure
unREAL World	• The virtual environment is seamlessly blended into the real environment. • Virtual media enhance day-to-day collaboration, group work, communication, interaction, teaching and ways of working. • Teaching methods are experimented with and developed to support these virtual interactions.	• Virtual medium • Mixed Reality • New Teaching methods • Virtual Collaboration
Synergy	• New teaching methods are developed and experimented on with respect to close collaboration with industry and universities. • Teaching methods are based on real-time and very dynamic collaboration and interaction with industry and universities. • In the quest for innovation, industry strategically collaborates closely with universities.	• Industry and university collaboration • New Teaching methods • Degree structure
Co-creating Education		• New Actors

(continued)

Scenarios	Descriptions	Drivers
	• New actors, such as cities, NGOs, start-ups or industry, will play vital roles by supporting programs and courses at the university, where students can major or minor in their degree studies. • The curriculum of the program will be developed with the actor, university, and student's interests. In addition, the student will have options to choose. • Because the student is already trained through co-creation to resolve domain-specific problems, the actor will directly support students. Support can be through sponsorship or ownership.	• New Business model • New Teaching methods, • Degree structure Student-centric
We **Also** Love You	• People/students from emerging disciplines will be brought together and will be part of co-creation to solve the problem. • Actors from these disciplines can be from inside Aalto or outside Aalto. • The actors are bought together to cater to the students and faculty's new methods, which they would not have encountered otherwise. • With these new collaborations, new job titles are created, new breeds of skills are fostered, and new ways of developing products are taught to the students.	• New Disciplines • New Teaching methods • Degree structure • Student-centric
Intuitive World	• The creative approach/process will be based on generative and intuitive design tools with respect to students' needs. • For example, a chisel will carve where we want to, or software does what we want. By 2036, tools with machine learning and artificial intelligence will enhance our creative process toward generative and intuitive design. • To enhance creativity and productivity, new teaching methods that are experimented on, developed and taught will be closely based on generative and intuitive design tools.	• Generative Creative tools, • New Teaching methods • Student-centric

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