Survey of Identifying Student and Industrial User Needs for a Newly Established Austrian University-Operated Makerspace 6th International Symposium on Academic Makerspaces

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Introduction

This paper reports from one of several surveys accompanying the founding phase of a makerspace at University of Applied Sciences Wiener Neustadt. Wiener Neustadt is a town of nearly 50,000 located approximately 30 miles south of Vienna in the province of Lower Austria. The University of Applied Sciences Wiener Neustadt offers undergraduate and graduate programs in business, engineering, health, sports, and security. Four thousand students are enrolled in these programs. Its makerspace named Innovation Lab was inaugurated in September 2021.

A. The Innovation Lab

With more than 1,000 square meters the Innovation Lab (Fig. 1) provides access to a variety of machines and tools. The Innovation Lab is designed as a makerspace but also offers fab lab facilities that shall be accessible to everyone. Managed by the Department of Industrial Management its goal is to appeal to a variety of diverse user groups. Hence, it is open to private individuals, students, companies, start-ups, researchers, and staff of University of Applied Sciences Wiener Neustadt.

Makerspaces and fab labs are characterized as collaborative spaces that aim to provide non-specialists with access to sophisticated technologies such as 3D printers, CNC machines, laser cutters and non-digital tools. Besides the aim of offering direct access to technologies and tools to support activities such as prototyping, tinkering, and solution development, Makerspaces and fab labs enable their users to meet and work with other like-minded individuals and to carry out projects [1, 2, 3]. In this sense the Innovation Lab at University of Applied Sciences Wiener Neustadt is a makerspace which also includes facilities of a fab lab.

The goal of the Innovation Lab is to promote open innovation. Open Innovation is an approach to accelerate the speed as well as the efficiency of the innovation process [4]. Open innovation is based on collaboration of different stakeholders. It is promoted by policy makers as well as scientists [5]. However, companies are less likely to take advantage of open innovation than they potentially could [4, 5, 6].

Fig.1 Innovation Lab at the University of Applied Sciences Wiener Neustadt

Offering nine sub-labs, a wide range of tools and machines is at the users' disposal. In addition to 3D printers, laser cutters, circuit board printers and robot arms, a textile lab, a wood and a metal workshop, the Innovation Lab is equipped with state-of-the-art and conventional tools and machines.

Users specifically addressed by the Innovation Lab are:

- private individuals (subscription fee based)
- employees of cooperating companies.
- students (in the course of classes no regular workshop fees have to be paid)

B. Project "Co-Inno-Lab"

The founding period and the early years of the Innovation Lab are accompanied by the research project CO-INNO-LAB funded by the province of Lower Austria and the European Regional Development Fund (ERDF). The project CO-INNO-LAB is led by the Department of Industrial Management and carried out in cooperation with the Institute of Entrepreneurship and Innovation, both University of Applied Sciences Wiener Neustadt.

The research project CO-INNO-LAB aims to study regional success factors and models for co-innovation in university-run innovation labs. The objective is to conduct studies with regional companies, in particular small and medium-sized industrial companies, using methods of classic social research and innovative methods of intervention and action research. The role of infrastructure (academic innovation labs) will also be examined. Not only for this purpose an innovation lab was set up. Another objective is to research the possibilities of digitizing the co-innovation process via combined real-virtual (cyber-physical) innovation spaces. The knowledge gained will be made available as recommendations for action, best practices and, in the case of technical developments, as conceptual prototypes.

The project consists of two main work packages:

(1) Investigating regional success factors and models of co-innovation in conjunction with an academic makerspace
(2) Investigating opportunities for digitization of an innovation process across real/virtual innovation spaces

The first work package included two qualitative surveys (expert interviews with makerspaces managers and focus groups with various makerspace users) and a quantitative survey of potential makerspace user requirements. The latter is presented in this paper.

C. Objectives

The overall objective was to identify success factors for makerspaces. Particularly, requirements of potential users regarding a makerspace were to be determined providing the Innovation Lab as an example for survey respondents. Thus, specific user groups ought to be distinguished and characterized.

Methodology

The present survey holds characteristics of both exploratory research and conclusive research. The objective of the first is to provide insights and understanding, the objective of the latter is to examine relationships and test specific hypotheses [7].

A. Sampling

The present sample is a judgement sample, which is often called a purposive sample, because sample elements are purposively selected. The targeted population is expected to serve the research purpose [8]. In October 2021, first a banner to click for participating in the survey was placed on the landing page of the Innovation Lab to recruit respondents for this online survey. Secondly, an introduction of the Innovation Lab was contributed to the newsletter of the chamber of commerce of Lower Austria twice, including a direct web-link to the online survey or a web-link leading to the landing-page of the Innovation Lab. Furthermore, the questionnaire web-link was placed in the online invitation for the Start-up Day organized by the Start-up Center of University of Applied Sciences Wiener Neustadt. The Innovation Lab was the location of the Start-up Day.

With support of Corporate Communications & Marketing of the University of Applied Sciences Wiener Neustadt Facebook and Linked-in postings were placed, targeting persons for whom the Innovation Lab ought to be of interest, seeking participation in the survey. In addition, an e-mail asking for participation was sent to Alumni. In February 2022 an invitation mail for the survey was sent to students and employees of University of Applied Sciences Wiener Neustadt. Before that, a handful of respondents were consulted personally. All that resulted in a sample of 147 respondents.

B. Questionnaire setup

To identify success factors for makerspaces in different target populations, a structured-undisguised questionnaire was used, as this design is most commonly applied in market research [8]. The questionnaire primarily consisted of multiple-response questions [9] and multi-items scales similarly to Likert-type scales [7]. Questions targeted makerspaces in general, but the Innovation Lab was provided as an example for better understanding.

The questionnaire setup was based on the results of three different sources:

(1) An extensive literature analysis of scientific publications focusing on success factors of regional and/or academic makerspaces which brought forward a list of relevant factors.
(2) A qualitative survey in the course of which expert interviews with makerspaces managers were conducted. The interview partners described performance criteria which from their experience are key to the acceptance of a makerspace by different target audiences
(3) A publication on needs and requirements of SME in relation to makerspaces [10]: some of the questions of the questionnaire were partly used in the survey that is presented in this paper in a modified or adapted format.

Literature analysis and the qualitative survey were performed by the project team that is also responsible for the quantitative survey presented in this paper. Questions targeted makerspaces in general, but the Innovation Lab was introduced at the beginning of the questionnaire as an example for a makerspace. It should help persons who are not familiar with the concept of makerspaces to gain clear understanding of what a makerspace is. Questions regarding sociodemographic characteristics of respondents such as gender or age were positioned at the end of the questionnaire [9]. The questionnaire was implemented in Qualtrics.

C. Statistical procedures

For comparing nominal/categorical variables crosstabs were utilized including Chi^2-tests for detecting statistically significant differences [9]. The Chi^2-test requirement that most expected values must be at least five [11] often was not fulfilled. Thus, exact test of Fisher was calculated and standardized residuals were calculated to reveal which groups differ from each other [12].

Since statistical tests cannot be performed for multiple response questions, respective analyses are limited to depicting frequencies and crosstabs [9]. Because data derived from questionnaire surveys rarely is normally distributed (either right or left skewed) [13], non-parametric statistical tests were performed as alternatives for parametric statistical tests.

Mann-Whitney U tests were performed as an alternative for the two independent samples T-Test when the dependent variable was not normally distributed and measured on an ordinal scale [7]. Kruskal-Wallis tests were performed as an alternative for ANOVA when comparing more than two independent samples and when the dependent variable was not normally distributed and measured on an ordinal scale [7]. That was followed by pairwise comparisons to find out which of the samples/groups differed from one another significantly [12]. Spearman's rho was calculated when the two variables compared were measured at the ordinal level, had outliers, were not normally distributed and the sample was small [12].

Results

Preliminary results cover the samples sociodemographic characteristics, frequency analyses and statistical tests.

A. Sociodemographic Characteristics

More than half of respondents of this survey indicates to be employed, followed by students as second largest group, with a percentage of 27 %. The remaining categories such as founders, high school students, entrepreneurs, self-employed people, and civil servants account for less than one third of the total sample (Fig. 2). The categories of high school students and founders have not been further considered in statistical analyses, as both categories were selected just once.

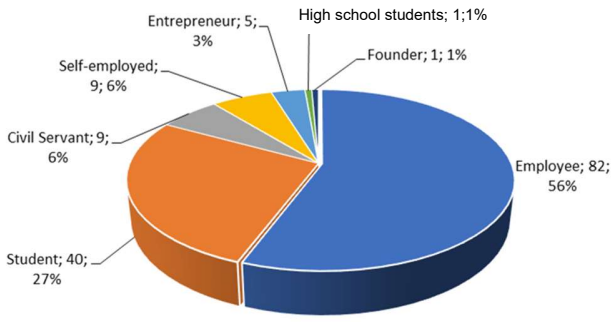

Fig.2 Survey respondent categories *(n=147)*

The high share of employees and students is reflected in the age groups, with more than 80 % of the overall respondents at an age between 21 and 50 years (Fig. 3). Male respondents outbalance their female counterparts. While 74 respondents indicate to be male, 53 state to be female, whilst the rest did not want to specify.

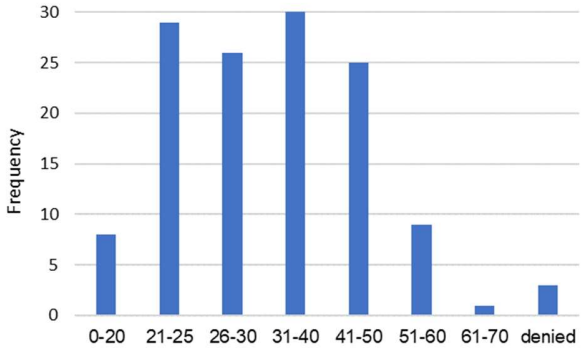

Fig.3 Distribution of age *(n=131)*

B. Frequency Analysis

Frequency analyses were performed for multi-response questions/variables, arithmetic means were calculated where interval scales were present. Preliminary results deemed most relevant, are presented here.

Regarding the question of how innovations are enabled in the respondents' companies, respondents indicate innovation is most often made possible by providing further training and technical resources for employees, but also by having a dedicated R&D department (Fig. 4). Less frequently, respondents stated that employees are provided with space or extra time for innovation, although these presumably contribute most to creativity.

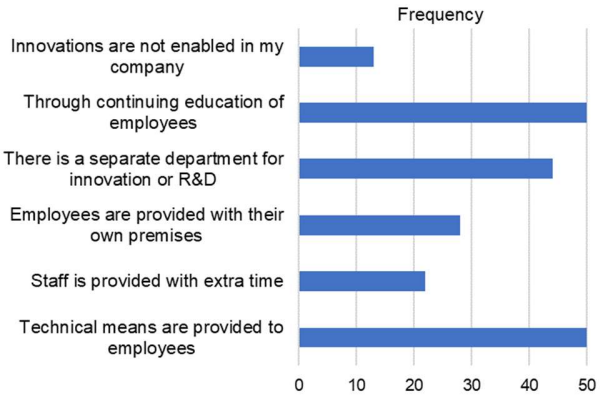

Fig.4 Respondents' Perceptions of how are innovations made possible in their companies? *(multiple responses)*

Moreover, it was in the authors' interest to find out why respondents would use a makerspace. Results show that especially self-interest such as implementing own projects, machine use, and developing new skills and abilities dominate responses.

When asked about the reasons why respondents would not use a makerspace (Fig. 5), it appears that lack of technical knowledge is a matter for not using a makerspace (there is also a gender-specific difference here, which will be dealt with in the statistical analysis section).

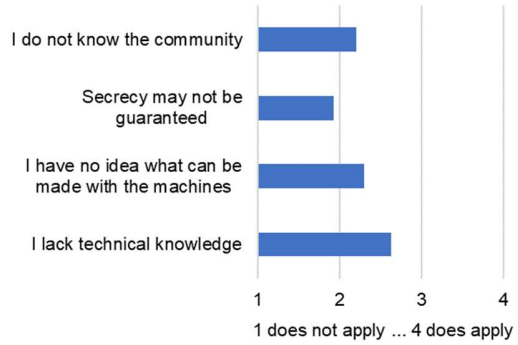

Fig.5 Respondents' ratings of reasons why they would personally not use a Makerspace *(n=144)*

Additionally, respondents were questioned which services they would use in a makerspace. Findings suggest that participation in further education events or in expert lectures, and the exchange of knowledge are of particular interest to respondents (Fig. 6). The development of prototypes occurs to be more favored by non-employed respondents.

According to respondents, their company/employer would nearly equally use the makerspace ranging from obtaining new know-how, advancing digitization, and supporting research and development to making use of it for team building and further training of employees (Fig. 7).

Fig.7 Respondents' ratings of reasons why a makerspace would be interesting for their company / employer? *(n=93)*

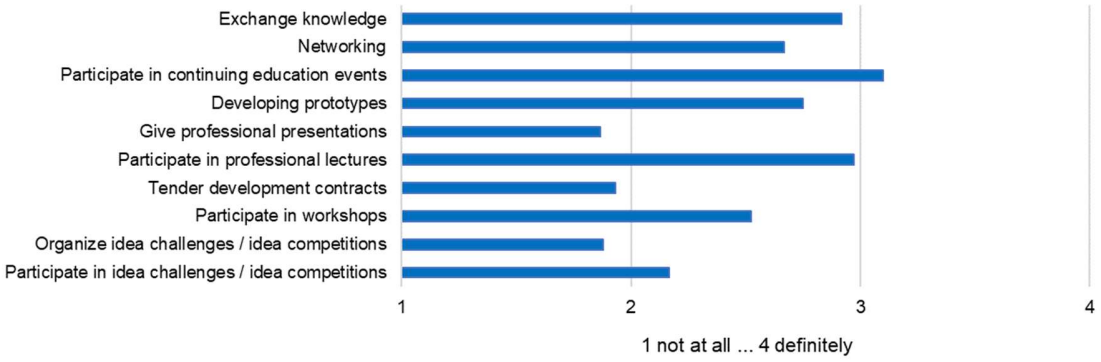

Fig.6 Respondents'ratings of offers they would use in a makerspace *(n=145)*

A possible lack of secrecy is rated close to similarly to other circumstances, why a company or employer would not use a makerspace (Fig. 8). This result comes surprisingly since the authors' interviews with managers of international makerspaces indicated the opposite.

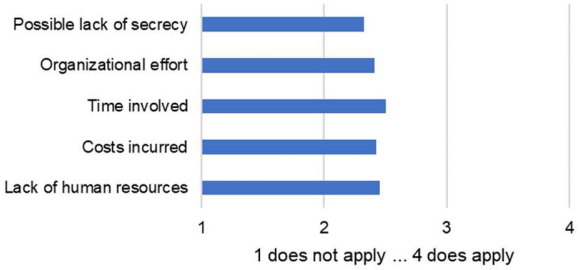

***Fig.8 Respondents' ratings of reasons why their company/employer would not use a makerspace** (n=89)*

With regard to the question, which equipment respondents would use in a makerspace, results indicate an across-category demand for wood workshops, 3D printers, and laser cutters. While the metal workshop with CNC milling machines also represents a more popular type of equipment in a makerspace, textile and plastics processing as well as the electrical and robotics workshop are rated less popular among respondents. Respondents' preferred usage time of a makerspace is on weekends as well as in the afternoons and evenings during the week.

C. Statistical analysis

Application of certain statistical tests for dependencies of independent and dependent variables or interdependencies of variables depend on the variables' type of measurement, either non-metric (nominal or ordinal) or metric (interval or ratio) [13]. (See chapter C *statistical procedures* in the Methodology section in this present paper*)*. In either case, statistical significance level alpha of 0,05 was applied.

First, non-significant differences considered to be of interest are introduced here, primarily sociodemographic characteristics constituting the independent variables.

The answers to the question "have you ever heard of a makerspace" neither depends on the respondent category (employed, students, founders, entrepreneurs, self-employed, and civil servants; standardized residual values <1.96 and >-1.96) nor on age (Kruskal-Wallis test, H=3.387, n=131, df=2, p=0.184), nor on gender (Fisher's exact test, value=5.140, n=131, p=0.262). This awareness of makerspaces is also independent of the respondents' industry affiliation (Fisher's exact test, value=9.470, n=61, p=0.066) and of the number of employees of respondents' employers, as a measure of company size (Kruskal-Wallis test, H=2.199, n=88, df=2, p=0.333). The willingness to use a makerspace does not depend on industry affiliation (Kruskal-Wallis test, H=5.017, n=61, df=3, p=0.171) and hardly on age of respondents (Spearman's ρ=-0.195, n=131, p=0.026) as the authors would expect.

Due to the fact that sample elements were chosen purposively a positive bias towards interest in makerspaces must be taken into account.

The situation is similar concerning the reasons why respondents would personally use a makerspace: following reasons were provided: (1) to find project partners, (2) acquiring skills and abilities, (3) to share knowledge, (4) to utilize certain equipment and machinery, and (5) to implement own ideas/projects. All these potential reasons for making use of a makerspace do not depend on industry affiliation (Kruskal-Wallis tests, n~60, df=3) nor on the category of respondents (Kruskal-Wallis tests, n~145, df=6).

Neither category of respondent (Kruskal-Wallis test, H=9.160, n=128, df=6, p=0.165), nor age (Spearman's ρ=-0.019, n=127, p=0.831), nor industry affiliation (Kruskal-Wallis test, H=3.838, n=61, df=3, p=0.280), nor gender (Mann-Whitney-U test, U=1716.000, n=123, p=0.478), have an influence on willingness to share own knowledge with others in a makerspace, as one might expect. Even willingness to share corporate knowledge for open collaboration in a makerspace is independent of respondents' category (Kruskal-Wallis test, H=3.188, n=14, df=3, p=0.364) and industrial affiliation (Kruskal-Wallis test, H=2.889, n=14, df=3, p=0.409).

More insights are provided by analyses providing statistically significant differences, again primarily based on sociodemographic characteristics serving as independent variables.

Two reasons for personally using a makerspace, (1) to implement own ideas/projects (Mann-Whitney-U test, U=1564.500, n=126, p=0.050) and (2) to utilize certain equipment and machinery (Mann-Whitney-U test, U=1399.000, n=124, p=0.009) were significantly rated higher by male respondents, indicating a gender gap in utilizing makerspaces [14, 15]. One reason, namely, to implement own ideas/projects was slightly rated higher by younger respondents (Spearman's ρ=-0.303, n=130, p=0.000).

Male respondents would significantly more likely use a makerspace than female (Mann-Whitney-U test, U=1582.500, n=127, p=0,045) as well as students and entrepreneurs more likely than respondents of other categories (Fisher's exact test, value=45.701, n=147, p=0,000, standardized residual values >1.96)). Once again, the gender gap becomes obvious: female respondents would significantly less likely use a makerspace because of their perception of lacking technical knowledge (Mann-Whitney-U test, U=1173.500, n=126, p=0.000) and because they state missing imagination of what can be achieved with machinery provided in a makerspace (Mann-Whitney-U test, U=937.500, n=126, p=0.000).

Imagining the point of view of their companies/employers, respondents differ significantly by certain categories: respondents from industry are significantly more concerned about secrecy issues than respondents of the category information & consulting. Respondents of the category education are least concerned that secrecy might not be ensured (Kruskal-Wallis test, H=18.373, n=53, df=3, p=0.021, pairwise comparisons included).

Furthermore, specifically entrepreneurs and self-employed respondents would significantly less likely use a makerspace because of secrecy issues (Kruskal-Wallis test, H=10.978, n=143, df=4, p=0.027). Respondents of smaller companies (less employees) are slightly more likely to share own knowledge with others in a makerspace (Spearman's rank, ρ=-0.270, n=86, p=0.012).

Respondents of the education category think that their company/employer will use a makerspace for following reasons significantly more likely than respondents of the information & consulting category and the latter more likely than respondents from industry (Kruskal-Wallis tests): (1) for continuing education of employees (H=8.975, n=56, df=3, p=0.030), (2) to support R&D (H=17.600, n=57, df=3, p=0.001), (3) to promote digitization (H=10.799, n=56, df=3, p=0.013), (4) for developing prototypes (H=9.457, n=59, df=3, p=0.024), (5) for networking (H=14.836, n=58, df=3, p=0.002), (6) for developing ideas H=15.483, n=57, df=3, p=0.001), (7) for exchanging knowledge (H=15.598, n=60, df=3, p=0.001).

Conclusions

Considering how innovations are made possible in respondents' companies, companies still provide measures, that promote creativity, least. Thus, there is still a lack of providing space and time for creativity, a prerequisite for innovation. A makerspace would provide such space.

Concerning reasons for using a makerspace, reasons of self-interest dominate among respondents. This contradicts one of the missions of a makerspace: fostering collaboration and exchange of knowledge. Thus, further measures of promoting cooperation are in demand. Addressing self-interest motivation can provide a well-suited first step therefor. It is proposed that self-interest is an important human motive (16) and a powerful determinant of behavior [17].

Appealing to self-interest is a good means to motivate people to utilize a makerspace. Once they use the makerspace, collaboration and exchange of knowledge can be stimulated for (new) makerspace users in the second step.

Most preferred equipment quoted by respondents were in descending order 3D-printer, laser cutter, wood workshop and metal workshop. Preferred opening hours are afternoons and evenings on weekdays and the whole day on weekends except nights.

Employed and non-employed respondents hardly differ in which offering of a makerspace they would use, except in that, non-employed respondents would more likely utilize a makerspace for prototyping. The main reason stated by respondents not to use a makerspace is the lack of technical knowledge. This points out the importance of respective instructions and training.

Taking the point of view of their companies/employers, respondents stated that their companies and employers would nearly equally utilize a makerspace for various reasons. No specific reason stands out as a reason for utilizing a makerspace. The same counts for reasons for their companies/ employers not utilizing a makerspace: No specific reason stands out. That somewhat contradicts results mentioned before and statements of the expert interview series with makerspace managers stressing the importance of secrecy issues for corporate makerspace users.

Altogether far less group differences and statistical dependencies than expected were detected based on data analyses performed so far, specifically sociodemographic characteristics. Thus, requirements of distinct user groups could not yet be clearly identified.

One issue was clearly detected and confirmed by several statistical tests in this survey based on sociodemographic characteristic: gender. Female respondents show significantly less confidence in utilizing a makerspace, hence confirming prior research e.g. [14, 15]. Inspiring females of all age to use makerspaces remains a challenge.

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