Scientia Moralitas International Journal of Multidisciplinary Research
ISSN 2472-5331 (Print) | ISSN 2472-5358 (Online) | Vol. 9, No. 1, 2024
DOI: 10.5281/zenodo.12801131

Towards Education 4.0: How Flexibility, Design, Interactivity, and Wellbeing Improve Learning Outcomes. A Real-Life Experiment in an Innovation Laboratory

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ABSTRACT: This study aims to analyze whether providing design, flexibility, interactivity, and well-being can benefit learners. The deductive research approach is based on a qualitative exploratory design, including a real-life experiment and a survey with 94 participants. The participants completed a new one-week, full-time course in marketing and sales management in a newly created Innovation Laboratory. This study found that providing a flexible environment with design elements such as writable and magnetic walls, mobile sofas and seating sets, chairs, tables and lecterns support interactivity and collaboration. The coordinated use of color concepts and plants can enhance learners' sense of well-being and their ability to learn efficiently, while also promoting future-oriented skills such as creativity, analytical thinking and problem-solving. All this at low cost.

KEYWORDS: Education 4.0, innovation laboratory, educational infrastructure, design, wellbeing, real-life experiment

Introduction

Innovation research now encompasses not only technological innovations but also economic, social, organizational, and educational innovations: "Innovation can be directed toward progress in one, several, or all aspects of the educational system: theory and practice, curriculum, teaching and learning, policy, technology, institutions and administration, institutional culture, and teacher education. It can be applied in any aspect of education that can make a positive impact on learning and learners" (Serdyukov 2017, 8). The development from Education 1.0 to 4.0 is fluid but can be measured in levels of maturity (Berghaus and Back 2016). "Hence in Higher Education 1.0 students were largely consumers of information resources that were delivered to them for absorption" (Salmon 2019, 97). Education 2.0: communication, collaboration, connecting, invasion of technology and social networking. Education 3.0: from hybrid teaching settings to blended learning (Sanchez, Paukovics, and Cheniti-Belcadhi 2022, 4510). Methods: Small learning

units, online forums, shared learning, webinars, digital scripts, quizzes, free access to online libraries, OER and face-to-face events (Salmon 2019, 108ff.; Kauffeld and Othmer 2019, 100). Education 4.0: The goal is to learn collaboratively and interactively in a kind of flipped classroom, online and face to face - using agile methods and collaboration software (R. Sauter, W. Sauter, and Wolfig 2018, 76; Cheng, Ritzhaupt, and Antonenko 2018). Places can be separate, flexible, virtual, or co-working spaces. New forms of learning such as meetups, BarCamps or hackathons can take place (R. Sauter, W. Sauter, and Wolfig 2018, 77-82). This so-called social blended learning is recommended for agile competence development because digital transformation is a megatrend that will accompany us (R. Sauter, W. Sauter, and Wolfig 2018, 82). With practice-oriented and interactive teaching, this can be promising (R. Franken and S. Franken 2020, 184). Learning whenever, wherever, and however you want. To achieve and develop new competences to raise the skills for the future it is important to try new approaches (see figure 1).

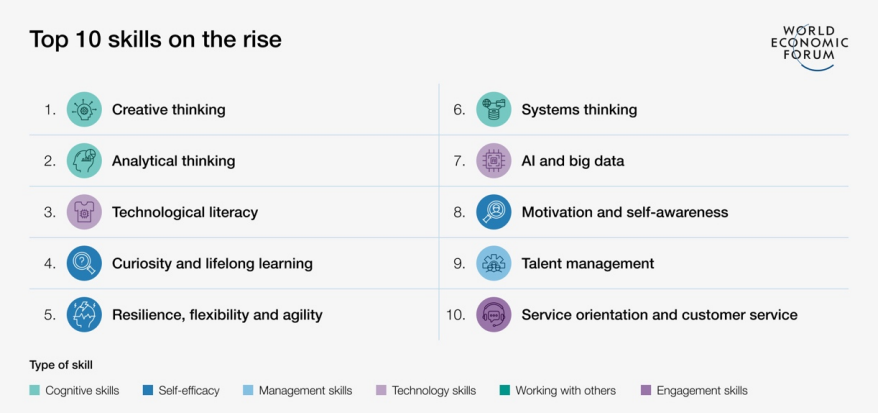

Figure 1. Top 10 skills on the rise
Source: World Economic Forum (WEF 2023)

The author of this article set up an Innovation Education Laboratory to test some of these methods and techniques and to convince shareholders and stakeholders to change the infrastructure and teaching methods towards Education 4.0. He conducted a real-life experiment in face-to-face teaching. Educational innovations should improve learning quality (Serdyukov 2017, 8). Five components are relevant: the novelty, the object, the change, the finalized action, and the process (Sanchez, Paukovics, and Cheniti-Belcadhi 2022, 4503f.). An innovation laboratory (short: Innolab) is a place dedicated to work (*laborare* in Latin) and to manufacture something. It is supposed to be a space dedicated to scientific experimentation (Sanchez, Paukovics, and Cheniti-Belcadhi 2021, 4504). Definitions: "(…) a physical, digital and human space for observation, experimentation and evaluation, to rethink and enrich learning and teaching attitudes and practices" (Sanchez, Paukovics, and Cheniti-Belcadhi 2021, 4511). „A space that aims to support the transformation of education through experimentation with emerging technologies, the promotion of creativity and the implementation of new teaching methodologies" (Almarez-Menéndez, Martín-García, and López-Esteban 2021, 5).

There remains a scientific gap in understanding how the design and functioning of an Innolab affect its performance. (Osorio et al. 2019, 1). Positive design can be viewed as a framework that encompasses designing for pleasure, function, personal significance, and virtue (Cooper and Kohlert 2017, 25). The users need to be in a space that reduces hierarchy and supports participation, dynamism, playfulness, and communication. It should encourage creative behaviors and support innovative projects with all needed resources, visualization-tools, and the ability to prototype (Lewis and Moultrie 2005, 4). It should stimulate the creativity (Moultrie et al. 2007). Studies have identified the success factors of collaborative learning (Delgado et al. 2020, 131). Lateral thinking should be promoted (Ștefănescu 2022, 115). The design, equipment and furnishings of the rooms can set the direction for the desired emotional behavior. A culture of joy should be conveyed. A culture of fear arises when signs show prohibitions, rules of conduct or the consequences of violations (Barsade and O`Neill 2013, 24). It is recommended of putting people at the center and planning for them (Gerstbach 2022, 46f.). These spaces disrupt structures to create networks of knowledge and change people's consciousness to develop and disseminate ideas more productively. They support conscious and chance encounters for sharing and collaboration. New connections are intended to promote communication and an active exchange (Gernstbach 2022, 117). Six dimensions are provided, that aim to boost positive wellbeing in the work environment by offering people choice and control over where they work and how they work: Optimism, Mindfulness, Authenticity, Belonging, Meaning, Vitality (Cooper and Kohlert 2017, 62). The design should support independent and individual learning processes. Alternation between learning input, practice, support, and reflection including presentation of performance - depending on the level of development and the emotional situation of the learner (R. Franken and S. Franken 2020, 178). Learning together supports the individual understanding. It promotes communication and problem-solving skills, it increases performance, self-confidence, belonging, ability to work in a team, conflict resolution, enjoyment of the work performed together and motivation (Töpfer 2010, 45). In an interactive group learning develops. It's easier to learn together, because the desire to belong to the group motivates people (Lienhart 2017, 45). A playful look of the rooms helps to approach project issues in a more joyful, experimental, and open-ended way (Brandes et al. 2014, 65). "Flexible spatial concepts are necessary for creative processes, e.g., movable furniture, standing tables, cushion landscapes, places of retreat, flexible partitions, whiteboards, presentation areas (…) are required" (R. Sauter, W. Sauter, and Wolfig 2018, 47). This stimulates creative thinking and strengthens well-being (Dopfer 2019, 121). Aesthetic buildings and design, colors, plants, daylight, wide spaces can have a positive influence on motivation and mood. These extraordinary places can create a "wow effect", which would increase the intrinsic motivation to also create something

extraordinary (Poguntke 2019, 84). Such places strengthen dialogue, an essence of Education 3.0 and 4.0 (Weis 2015, 226).

Methodology

The author conducted a qualitative experiment to uncover causal relationships. "The qualitative experiment is the intervention in a (social) object carried out according to scientific rules to research its structure. It is the exploratory, heuristic form of the experiment" (Kleining 1986, 724). "The aim of qualitative research is to depict reality based on the subjective view of the research subjects and thus to understand possible causes for their behavior and to understand their behavior" (Berger-Grabner 2016, 117f.). This real-life experiment took place in a newly created Innovation Lab in an Education Center at the public chamber of crafts in Nuremberg, Germany. The experiment involves two parts: first, changing the educational infrastructure, which includes the conception, planning, design, equipment, transformation, and operation of the Education Innovation Lab, and second, changing the way of teaching and learning. The design of the experiment is based on the above scientific findings and aims to demonstrate practical benefits.

Duration in months (planning until the final seminar in October 2023)	10
Seminar weeks - full-time (8 hours per day):	12
Number of participants:	124
Number of participants who completed the questionnaire:	94
Age of the participants in years:	18-36

This article focuses on the first part of the experiment – changing the educational infrastructure: the transformed classroom, its new design, and its changed equipment. The goal of these changes: Collaborative, flexible, and interactive learning with a feeling of well-being should be promoted and tested. The focus is on uncovering structures within the Education Innovation Lab. The object, a 25-year-old classroom (84 sqm) for 16 participants, is changed into an Innolab, i.e., the area of investigation is intervened. The object or area of investigation is then checked to see what happens at what effects. Manipulation is not carried out at will; the changing interventions should be carried out as controlled as possible and appropriate to the object under conditions that are as natural as possible (Mayring 2016, 58f.). When it comes to testing causal correlations, the experiment is considered the ideal way of research. The theory and the postulated cause-effect relationships are actively highlighted (Döring and Bortz 2016, 194). The process is not a deductive-hypothesis-testing, but inductive-discovering. The structures of the object should be made visible (Hussy, Schreier, and Echterhoff 2013, 213). The process consists of four steps: Description of the subject, experimental intervention, description of the changed object and conclusions on its structure (Mayring 2016,

59f.; Hussy, Schreier, and Echterhoff 2013, 213f.). In this article, the conclusions are drawn and analyzed in the chapter "Results and Discussions".

(1) Description of the subject matter

So far, lessons in this room have mostly consisted of frontal teaching. This is the classic lecture that aims to impart theoretical specialist knowledge and has been criticized by scientists for years. The lecturers stand or sit in front of the class and provide information from the front. Discussions or group work are rarely carried out. Some lecturers place teaching material under the documentation camera and have the participants copy it. Due to this system, participants are encouraged to concentrate only on the exam content (Kauffeld and Othmer 2019, 128f.). All walls are painted white. PVC floor is gray and old. Cupboards are gray and are rarely used. There are no colors other than gray and white. Tables are one behind the other and should not be moved or regrouped. Tables and chairs are neither mobile nor ergonomic. Visualization consists of a screen, a projector, and a document camera.

(2) Experimental intervention and (3) description of the changed object

Note: the interventions (conversion work and equipment) should be carried out as cost-effectively as possible. The experiment is intended to show that change can work with limited financial resources (De Massis et al. 2017). Common techniques of qualitative experimentation: Structure (separation, segmentation, or combination), Limitation (reduction or attenuation), Expansion (adjection or intensification), Conversion (substitution or transformation) (Kleining 1985, 737). Five of them were used: combination, reduction, intensification, substitution, and transformation.

Design - Walls and Colors: The intervention consists of several combinations: All walls were repaired and initially painted white. The pillars of the walls were painted in gradating shades of blue. The front wall was filled, and a level surface was created. A blue color frame was applied to it. This frame is like the screen frame in movie theaters in 16:9 format. Training masters in the painting trade carried out this and paid attention to the proportions to maintain a pleasant visual experience. An approximately 4 x 1.5-meter rectangle was cut out in the middle of the wall. Like the magnetic pins on the refrigerator, this rectangle was partially magnetized with plaster to hold sheets or foils for collaborative work. The entire rectangle was painted with innovative white paint, which replaces the projector screen and serves as a writable whiteboard. This innovative color was discovered, tested, and applied by the training masters. The advantages: the separate screen and whiteboards (and paper) are unnecessary. The wall has been transformed and combines four functions: projector screen, magnetic wall, writable whiteboard and, thanks to the color and shape design, an aesthetic well-being with a pleasant feeling of space. A 4 meter piece of the cupboard wall was removed (reduction). The remaining 3 meter

long cupboard wall was painted and varnished in 8 graduated colors: from yellow, orange to pink and red, to simulate a sunset and ensure well-being (intensification of the color design). Effort: Removing the cabinets took two days. The painting work took four people around six days.

Floor: The old gray PVC floor was removed, the concrete floor was sanded, and two coats of transparent protective varnish were applied: the floor and painting trainers call this style "used" or "industrial look". The floor is writable for fun (reduction and transformation). Effort: It took six people around five days to do the groundwork.

Lounge Furniture: In the niche created by the removed cupboards, wooden pallets painted dark gray were converted. Large dark blue seat cushions on them invite you to linger (substitution). The goal was to provide opportunities for breaks, but also for group work or discussion. Effort: It took two people two days to work on the lounge furniture.

Chalkboard and Document Camera: Hauschildt and Salomo (2011, 114) warn of resistance from those affected when changes occur. "Anyone who wants to innovate successfully should be clear about what they expect of those affected." Teachers are different in their teaching and have decades of habits. Therefore, the chalkboard and document camera were left in the room.

Tables and Chairs: Used curved tables and semi-ergonomic chairs were removed from disused offices and placed in the center of the room. The old tables and chairs were replaced (substitution). Effort: two people needed two days. At the beginning of every experimental seminar week, the learners are asked to arrange tables and chairs as they see fit to create a relaxed and personal atmosphere. It considers that all experiences and emotions of those affected can have a direct impact on the course of the change process. Because the consequences could be resistance (Klinkhammer 2015, 21). Those affected (participants in the lesson) are thus made participants (in the design of the setting). The tables are distributed in the room at different angles and at different distances (combination and transformation) in different situations. Green plants and colorful flowers were placed on the windowsills (transformation). Indirect lamps were distributed (transformation). A mobile light green presentation desk was manufactured by a master carpenter (transformation).

Hybrid Setting: A hybrid setting was established to enable hybrid teaching. (Education 3.0): a laptop with a camera, microphone, light, a second projector. The online participants are projected onto the second screen so that the lecturers can see them and the participants in person at the same time (combination and intensification). "Qualitative experiments are interventions in a social object; like all experimental techniques, they change it. But their exploratory aim should prevent them from destroying it in the process" (Kleining 1986, 744). The room was slightly changed, not destroyed. Around € 6,000 was spent on these changes.

Results and Discussions

This chapter summarizes structural conclusions (Mayring 2016, 59f., Hussy, Schreier, and Echterhoff 2013, 213f.). "The methodology includes its careful application: the adaptation of the procedures to the object, the testing of limits, the gradual maximization or minimization of aspects in the object of study, the constant question-answer game in the dialogue principle, if possible, with the direct participation of those affected" (Kleining 1986, 744f.). At the end of the seminars, the participants were invited to take part in a survey. The questionnaire, comprising 36 questions, was standardized in German using "Microsoft Office Forms" to ensure equal conditions for all participants: period and time, wording, rating scale and order of questions. This standardization ensured the comparability of statements. The survey was carried out using a numerical scale ranging from 1 to 5, where 1 is "very good", 2 is "good", 3 is "satisfactory", 4 is "sufficient" and 5 is "inadequate". The school grade scale was selected because the target audience is familiar with these ratings from their educational and vocational experiences. This scale can measure the opinions and behaviors of respondents (Berger-Grabner 2016, 118). The average response time was around 6 minutes. Out of 124 participants, 94 completed the questionnaire, resulting in a response rate: 75.8 %. Theoretical sampling is given (Berger-Grabner 2016, 117). The majority of participants rated the overall room design as good to very good as illustrated in figure 2 "How do you rate the room design?"

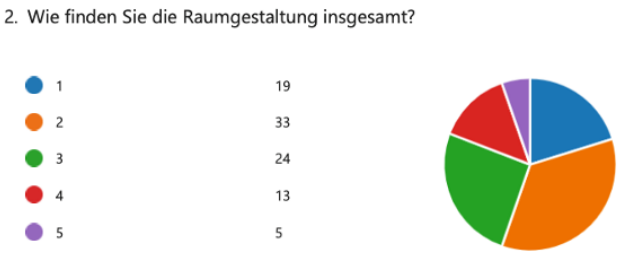

Figure 2. How do you rate the room design?

All responses (see Figures 2 through 15) show that most of the changes were rated very good to good (1 to 2) by the majority of respondents, over 50%. There is a causal relationship between the changes and the user acceptance. The following changes were best received: "How useful is the writable whiteboard wall?" (very good = 43; good = 22: see figure 9); "How well does this space support you in socializing?" (very good = 29; good = 38: see figure 3); „How important is the flexibility of the furniture to you?" (very good = 33; good = 32: see figure 12). The following ratings stand out: "How important are the additional seating options (upholstered furniture, sofas) to you?" and "How comfortable do you feel in this learning space (well-being)?" (see figures 13, 6): over 60% rated this as very good or good. This shows that the functional and emotional design changes are perceived as useful and

lead to better well-being (Cooper and Kohlert 2017, 25). The causal relationship between the changes and user acceptance is even more significant.

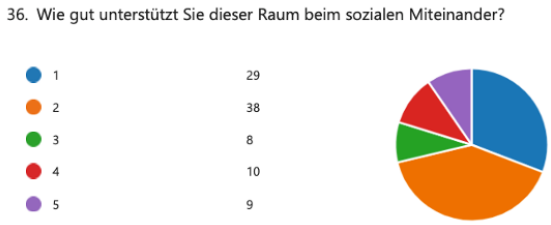

Figure 3. How well does this space support you in socializing?

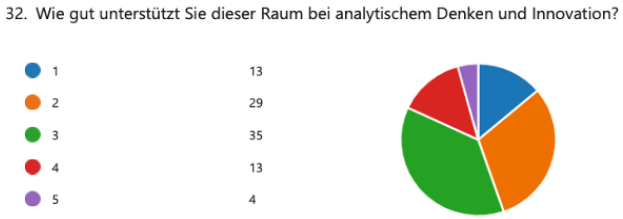

Figure 4. How well does this space support you in analytical thinking and innovation?

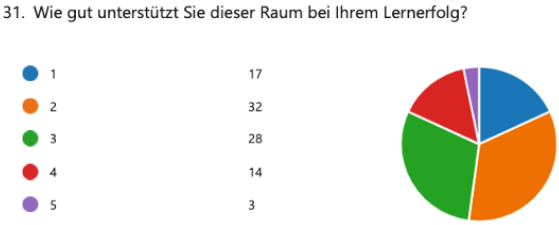

Figure 5. How well does this space support you in your learning success?

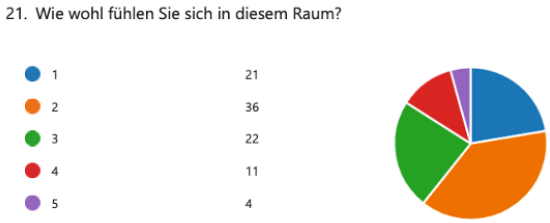

Figure 6. How comfortable do you feel in this learning space (well-being)?

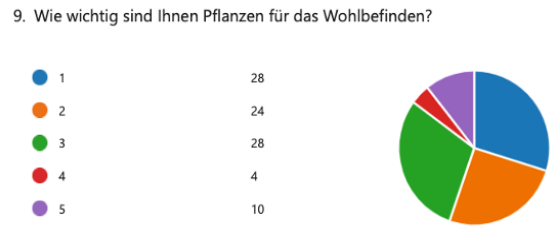

Figure 7. How important are plants to your well-being?

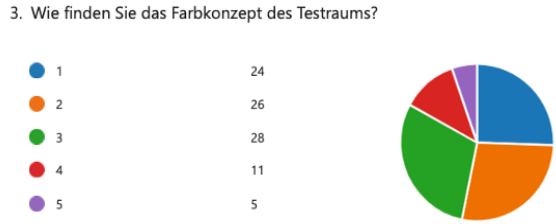

Figure 8. How do you rate the color concept of the test room?

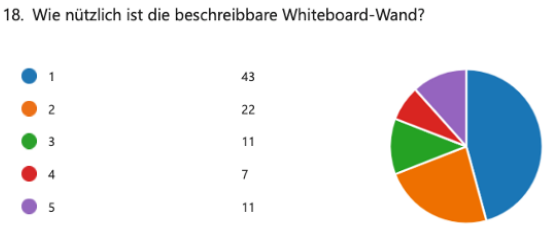

Figure 9. How useful is the writable whiteboard wall?

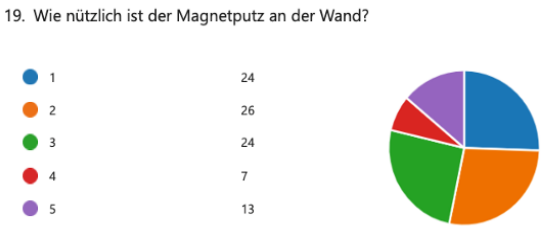

Figure 10. How useful is magnetic plaster on the wall?

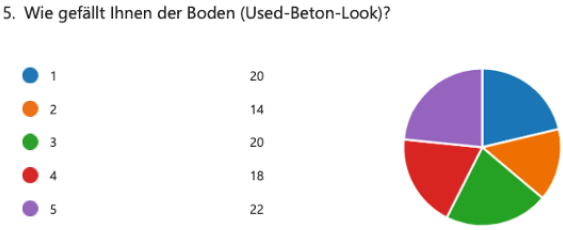

Figure 11. How do you like the floor (used look)?

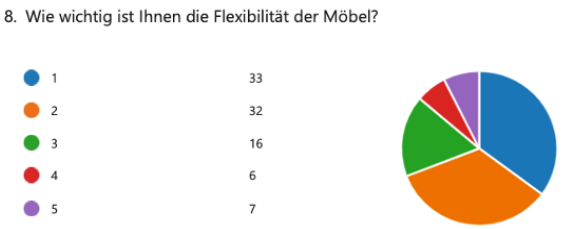

Figure 12. How important is the flexibility of the furniture to you?

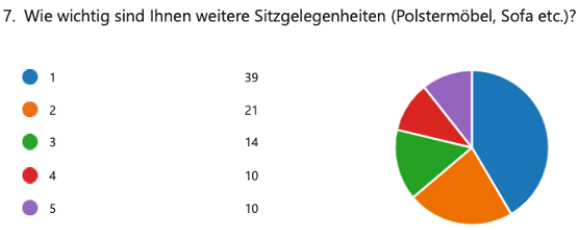

Figure 13. How important are the additional seating options (upholstered furniture, sofas) to you?

Figure 14. How do you rate the interactivity in this room?

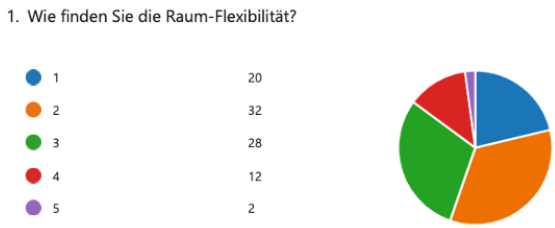

Figure 15. How do you rate the flexibility in this space?

If the grade "3 = satisfactory" is subsumed as acceptable or useful and included in the positive evaluation of the survey, the picture changes. Nearly all changes, except for the new floor and the additional seating (see figures 11 and 13), received positive feedback. Over 80% rated them as very good, good, or satisfactory.

The floor received the worst rating (see figure 11: 18 = sufficient; 22 = inadequate). Around 43% do not like the used look of the floor. On the other hand, the functional design is effective, and no additional expenses were incurred for carpeting or hardwood flooring. The magnetic wall received the second worst rating. Around 22% did not think it was useful (see figure 10: 7 = sufficient; 13 = inadequate). On the other hand, the majority consider it as useful. The survey included an open section for suggestions. Participants requested improvements such as better Wi-Fi, more ergonomic furniture, nicer floors, and air conditioning.

These answers demonstrate the existence of complementarity between innovative learning spaces and future-oriented learning (see figure 5 "How well does this space support you in your learning success?": very good = 17; good = 32). The study demonstrates that a flexible environment, including writable whiteboard walls and flexible, mobile furniture promotes interactivity and collaboration (see figure 14 "How do you rate the interactivity in this room?": very good = 20; good = 29). The use of a design concept that coordinates color and furniture designs, incorporates various plants, and utilizes indirect warm lighting supports learners' sense of aesthetic and emotional well-being, facilitating their learning process. This could support the development of future-oriented skills at a low cost. The research shows that an Innolab can provide useful test results. The outcomes of a qualitative experiment, through inductive discovery, help to understand possible causes for learners' behavior.

Conclusions

The tests in this Innolab are carried out carefully and step-by-step, with the involvement of the learners to provide scientific insights and practical effects. From an internal company perspective, this experiment and the study results mean that the author has received approval to make further investments and accelerate transformations towards Education 3.0 and 4.0. A concept for a fully digitalized learning space to test was already created. The upholstered furniture that was perceived as useful will be replaced by lounge sofas in a colorful American diner style

to facilitate group work and recreation. Another wall has already been painted with whiteboard paint. Rollable 5-corner tables in different colors for each learner have been purchased to improve flexibility and interactivity. The installation of a new floor, improved Wi-Fi, and air conditioning is currently being calculated.

After communicating the results of this study, the author of this article received approval from management to participate in a public tender to receive funding from the German Federal Ministry of Education and Research. This funding could be used to convert and equip three additional seminar rooms in different analog, hybrid, and digital maturity levels. The study results serve as the justification for the official funding application. A main part of the funding applied for, is the design transformation and the technical equipment towards a "flipped classroom" (Cheng, Ritzhaupt, and Antonenko 2018) - to gradually achieve Education 4.0. These technical developments will be utilized in the next stage of development for digital educational infrastructure based on maturity levels, which will require additional testing and research.

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