https://doi.org/10.36315/2023v2end097
Education and New Developments 2023

A FICTITIOUS VEHICLE MANUFACTURING COMPANY AT A UNIVERSITY AS INTERDISCIPLINARY FRAMEWORK TO COMBINE STUDY PROGRAMS

Tobias Peuschke-Bischof, & Stefan Kubica
Digitalisation and Quality Management, Technical University of Applied Sciences Wildau (Germany)

Abstract

Interdisciplinary thinking is becoming an increasingly important competence for meeting the challenges of our time, for example in the areas of sustainability or even digitalization. Successful value creation can only be achieved if all subject disciplines work together. Universities, too, must adapt to these needs and anchor the teaching of these competencies in their courses of study. In this context, interdisciplinary cooperation cannot be limited to the curricula, but must also bring together the teachers and the learners in a common context. Traditionally, universities have found it difficult to develop interdisciplinary scenarios. The teaching scenarios themselves must already provide interdisciplinary content and learning objectives. The challenge here is multi-level. First, it is a great challenge to connect the modules of a course of study in a thematically meaningful way. Second, it is the linking with other study programs that brings about the most sustainable interdisciplinary effects. One possible solution, which has been tested for several years, is to set up a fictitious company as a digital learning factory, which serves as a basis and reference for the interlinking of individual modules of the various courses of study. The scenarios that can be depicted here are extremely application-oriented, which means that not only can internal university modules be very easily aligned with them, but external partners, can also get a simple participation. Furthermore, the participating courses of study can continue to maintain their original core competencies while participating in the interdisciplinary scenarios via the modules that are aligned accordingly with the learning factory. A company from the vehicle construction sector was selected as the business model in order to be able to map another focus at the same time, autonomous driving. The individual departments of the company are linked professionally with the contents of the individual courses of study. Study programs, such as industrial engineering, form the design department, whereas technology-oriented study programs, such as business computing, represent technical development, in particular the area of driver assistance system development. In addition, the relevant departments also include economics and so on. The special feature, however, is the fact that real products in the form of vehicles on a scale of 1:14 are also created and continuously developed, which is an important success factor of the learning factory. The following article transfers the experiences made into a scheme of different levels of interdisciplinary forms of teaching within the framework of the learning factory and classifies and explains the existing scenarios accordingly. Furthermore, the teaching formats used, which have proven to be effective in imparting competences, are described.

Keywords: *Higher education, science and technology education, educational environment, technology in teaching and learning, new learning and teaching models*.

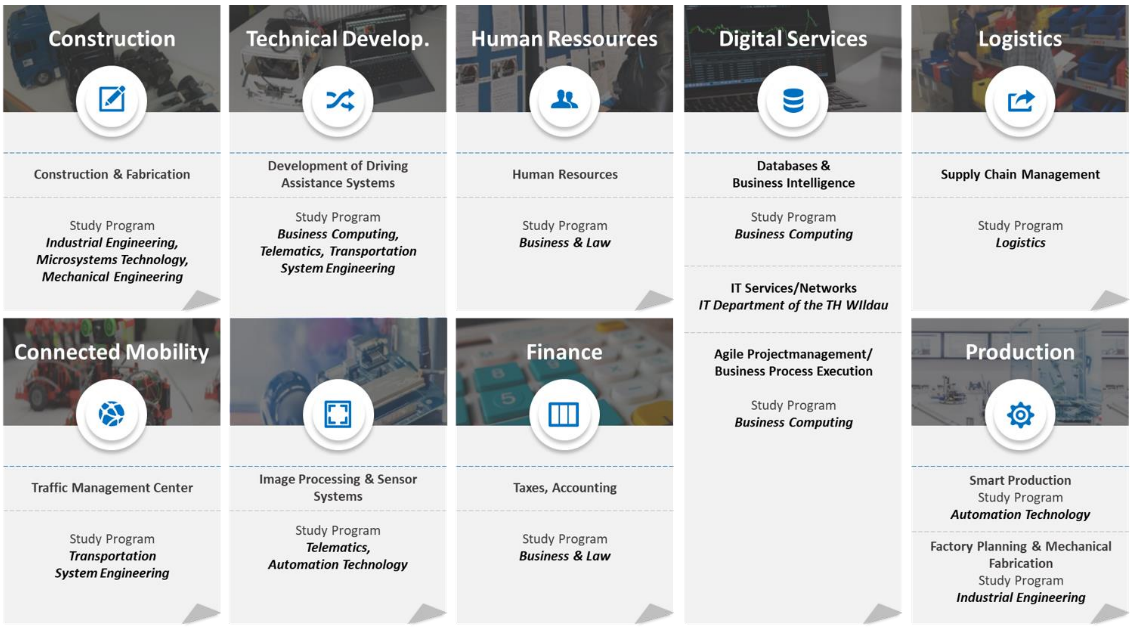
1. Introduction

Even though universities are an established and traditional institution for training professionals, they are not immune to disruptive change and the constant need to reinvent themselves. Several aspects come together here and justify the increased need for new teaching formats. As described in Morris-Lange (2019), demographic change, in this case related to Germany, is leading to declining capacity utilisation and more competition for new students. Furthermore, as described in Putrienė (2015), the demands of the labour market for interdisciplinary and application-related competences of graduates are increasing in order to meet the needs of the fast-moving world of work. Acquired competences count more than the name of the degree program. As explained in Ehlers and Kellermann (2020), the so-called future skills are the focus of these developments. Braßler (2020) sees interdisciplinarity as one of the possible options for solving this problem. Interdisciplinarity in teaching should, as described in Frehe, Klare, and Terizakis (2015), represent an interplay of subject content, didactic form and its organisational embedding. The approach of a university-wide learning factory described below, as it has been tested in practice at this university since 2017 and is constantly being expanded both horizontally and vertically, represents an application-related solution to the challenges listed above.

2. Overview of the pilot learning factory

As already mentioned, this learning factory was launched in 2017 as a university-wide format. This was preceded by in-depth considerations of how future teaching formats at a university of applied sciences can meet the increasing need for practical orientation and interdisciplinarity in the future. As described in Abele et al. (2017), the concept of learning factories is not new and at the same time in many different uses. In this work, the learning factory teaching format is used as an open format, constrained both internally and externally and thematically only by the lived business model. Thus, the present learning factory "Wildauer Maschinen Werke - WMW" is not limited to the field of production engineering or finance, but includes all relevant courses of study that can be aligned with the business model of an automotive manufacturer. Figure 1 shows the assignment of courses of study at the university with the classic departments of an automotive manufacturer. In the assignment, care was taken to highlight as many core competencies of the degree programs as possible and to dock them onto the WMW as classic job profiles. Students of industrial engineering, for example, function as classic design engineers (Construction) in the context of WMW-related lectures, whereas students of business computing function as development engineers (Technical Development) in the area of driver assistance system development. According to this system, courses in economics up to logistics or automation technology are also involved in the respective departments.

Figure 1. Assignment of departments of the learning factory to study programmes.



A significant feature of WMW is the fact that it is not only a fictitious business model, but that real products are also designed, manufactured and further developed. Figure 2 shows a vehicle from the WMW fleet. The fleet itself is implemented on a scale of 1:14, although there are also extensions in the context of industry cooperation with vehicles on a larger scale. The fleet vehicles are completely self-designed (computer-aided design) within the framework of lectures, projects and theses and are predominantly manufactured at the university (3D printing, computerized numerical control milling, etc.). In addition to in-house design, the development of autonomous driving functions and the corresponding equipment of the vehicles represents a further focus of the learning factory, via which a large number of study programs can be integrated. The vehicles are equipped with the corresponding state-of-the-art electronics for sensors (lidar, ultrasound, cameras, GPS, WLAN), actuators (servo motors) and computing technology (AI-capable developer kit). The components are networked via the Robotic Operating System (ROS), which enables lightweight processing and use of the vehicle data. Students can develop driving functions using various programming languages (Python, C/C++) or model-based development frameworks (MathWorks MATLAB/SIMULINK) and test them on the vehicles. Thus, an environment is provided that enables the further development of all relevant areas of the learning factory within the university itself, but in such a consistent, application-oriented and practical way that students, prospective students as well as internal and external partners can participate very easily.

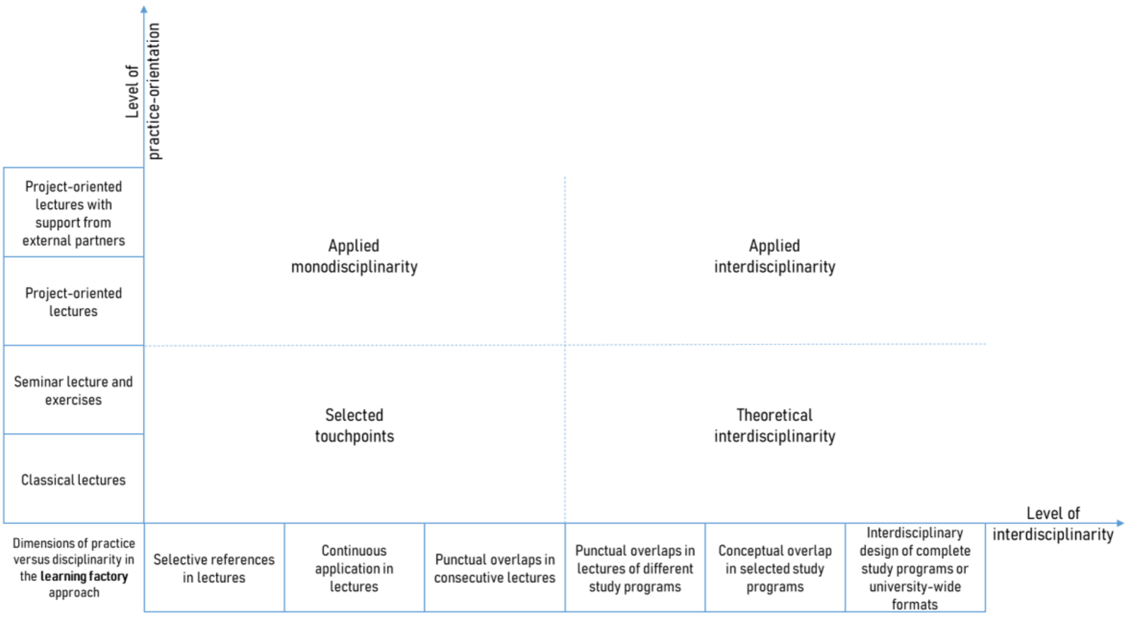
Figure 2. Example of a self-designed vehicle of the WMW fleet.

3. Scheme for classifying the scenarios according to the levels of interdisciplinarity

In the following, the teaching formats tested so far, which could be implemented in the learning factory, will be explained in more detail with regard to their interdisciplinarity and practical relevance by means of examples. Figure 3 shows a proposal for a scheme, which helps to classify the level of the characteristics accordingly by a corresponding classification.

In the interdisciplinarity dimension, connection and reference points in courses with an increasing level of interdisciplinary networking within and beyond the boundaries of the study program are plotted. In the practice orientation dimension, abstract teaching formats are plotted in ascending order with respect to practice orientation. Four quadrants can be derived from these dimensions, which can be used to cluster the following application examples of the learning factory and facilitate understanding. Further formats are conceivable, but only the examples tested so far will be discussed.

Figure 3. Dimensions of interdisciplinarity and practise-orientation in learning factories.



3.1. Selected touchpoints

This quadrant represents a mixture of classic teaching formats and initial content linkages from the content of the learning factory. Selected references in a classic format is, for example, the lecture Investment and Financing in the Business Administration study program, which refers to the WMW production facilities on campus. In selected exercises, students apply their acquired knowledge to calculate depreciation and procurement of these production facilities. In addition, students visit the production facilities on campus to gain real-world exposure to items in their calculations that would otherwise be covered only in theory.

An example from the continuous adaptation of a lecture with the contents of the learning factory is the database course in the study program business computing. Here relational database models are used and built up in lectures and exercises using the example of WMW, i.e. the requirements of a manufacturing company. Aspects such as employee and customer administration, production locations and also the vehicles themselves are modeled in a normalized data structure.

Based on this lecture, the following lecture Business Intelligence in a later semester was adapted accordingly. This module deals with the visualization and analysis of data. In the context of the learning factory, the already known data sets are now used for learning visualization and analysis techniques. For the students, this can provide a faster and deeper learning effect, since the WMW data structures are already known and they can fully concentrate on the new technical content, instead of having to understand new accompanying case studies with each new lecture, as was previously the case. This increases the understanding of the big picture from a data perspective.

3.2. Theoretical interdisciplinarity

In this quadrant, touchpoints in lectures of different courses of study are addressed with reference to the learning factory, which at the same time remain predominantly in the classic lecture format and few references to external topics. This type of overlap is still relatively rare and will be expanded more in the future. One example of selective overlaps of two study programs is the lecture risk management in the European management study program with the seminar-oriented lecture function development in the study program business computing. In this case, the students of both lectures come together for several joint dates in the current semester. The business computing students present their respective group work in the area of WMW function development. The European management students then begin to apply the theoretical knowledge they have previously acquired about risk analysis and avoidance to the WMW topics. In further follow-up sessions, the risk analyses are further refined together and the final reports are then distributed to the entire group. The students of both groups experience very practically and from both sides what is important in such audits as well as the developments.

3.3. Applied monodisciplinarity

The lectures in this quadrant are characterized by a high level of practical orientation, partly also with strong references to topics of external partners in the context of the learning factory, although at the same time only one study program is involved. One focus here is on lectures dealing with the mapping of WMW's driver assistance systems department. The development of autonomous driving functions is an important innovation topic for mobility companies and offers a large number of study programs potential for linking up. In particular, the project-oriented lectures of the Business Computing program are worth mentioning. In this setting, students in the Bachelor's and Master's programs work in an agile context over several semesters on the implementation of various user stories in the area of driver assistance. This includes, for example, the modeling of assistance functions for WMW fleet vehicles or the development of simulation environments. At the same time, various cooperations with external partners, for example an automobile manufacturer, a supplier and a research company, could be achieved in this format, which contribute their own user stories in the context of WMW to the project events. The WMW scenarios are thus supplemented with real content from the business world. Students get to know representatives from practice and these in turn gain access to future specialists.

3.4. Applied interdisciplinarity

Lectures in this quadrant represent the highest level of interdisciplinarity and practical orientation. The activities surrounding the ongoing design and production of the WMW vehicles themselves represent a link between several study programs that has been practised from the very beginning. Analogous to real companies, the product is constantly evolving due to internal and external requirements. In the case of the WMW learning factory, for example, the car body must be constantly adapted to the requirements resulting from the driver assistance electronics, for example, in the design of modified car body parts for the integration of sensors. Here, the students involved in the development of autonomous driving functions for the WMW, which include the study programs automation technology, telematics, traffic systems engineering, logistics and business computing, coordinate with the students from the design department, whereby here the study programs in industrial engineering and mechanical engineering with their computer-aided design lectures and agree on corresponding task packages. The interdisciplinary experience gained here is not only of a technical nature. Nontechnical topics, such as conflict management in the event of non-compliance with agreed deadlines or insufficient implementation because requirements were not specified in sufficient detail, are also included and result in invaluable experience, especially for later professional life.

An example of the simple integration of external topics in this context is the cooperation with a regional vehicle construction company, which is developing a new chain-driven, floatable vehicle for use in disaster scenarios. For later equipping with assistance systems, for example autonomous fire-fighting water procurement, the vehicle was also implemented on a scale of 1:14 by the WMW design students. Subsequently, the corresponding WMW electronics were integrated into the vehicle by the students of the driver assistance system department and the first assistance systems were developed and demonstrated.

4. Conclusion and outlook

In summary, it can be said that the interdisciplinary and practice-oriented characteristics of courses in the context of the learning factory are very diverse. The learning factory was established bottom up through the involvement of committed colleagues. There are many more examples of links between different courses of study in the WMW, for example in the areas of logistics, human resources management or IT administration. In the next step, the learning factory should also serve the aspect of internationality more strongly, which is why, similar to real companies, other universities are being sought to expand the location. The goal is to have students from all participating universities work together or in competition on learning factory scenarios and thus train the corresponding competences already during their studies. In the meantime, the learning factory is also being developed top-down as a strategic instrument of the university, for example by founding further learning factories with other business models, as not all course competences can be combined in the business model of a vehicle manufacturing company. For this reason, the "Wildau Software Factory - WSF" was founded, which deals with student software development and consulting projects in teaching. This learning factory also works together with the WMW on an interdisciplinary basis, for example when an accompanying software solution is needed for the WMW and this is implemented by WSF students on behalf of the WMW. Another learning factory that is currently being founded is the "Wildauer Bike Factory - WBF", which deals with solutions for cycling. In this case, a joint venture was agreed between the driver assistance system department of the WMW and the WBF, since the study programs subsumed there do not teach electronics skills and such cooperation constructs also make sense in the real economy.

Last but not least, another university-wide instrument has been derived from the approach of the learning factories in order to sustainably anchor the interdisciplinary and project-oriented approaches in all study programs. The so-called "Interdisciplinary Module" will be a fixed module with constantly changing internal and external topics in several study programs from the summer semester of 2023. The respective topics are worked on jointly by students from different study programs at the same time, allowing completely new teaching and learning formats to be combined with interdisciplinary experiences.

References

Abele, E., Chryssolouris, G., Sihn, W., Metternich, J., ElMaraghy, H., Seliger, G., Sivard, G., ElMaraghy, W., Hummel V., Tisch M., & Seifermann, S. (2017). Learning factories for future oriented research and education in manufacturing. *CIRP annals*, 66(2), 803-826.

Braßler, M. (2020). Interdisziplinäres Lernen als Antwort auf den Bildungsauftrag: die hochschullehre. *die hochschullehre, 6 (1)*, 576-586.

Ehlers, U. D., & Kellermann, S. A. (2020). *Future skills: The future of learning and higher education*. Karlsruhe: Books on Demand.

Frehe, H., Klare, L., & Terizakis, G. (2015). *Interdisziplinäre Vernetzung in der Lehre: Vielfalt, Kompetenzen, Organisationsentwicklung.* Tübingen: Narr Francke Attempto Verlag.

Morris-Lange, S. (2019). *Dem demografischen Wandel entgegen: Wie schrumpfende Hochschulstandorte internationale Studierende gewinnen und halten.* (2019-1). Berlin: Forschungsbereich beim Sachverständigenrat deutscher Stiftungen für Integration und Migration (SVR) GmbH.

Putrienė, N. (2015). The Links between competences acquired through interdisciplinary studies and the needs of the labour market. *Socialiniai mokslai, 2 (88)*, 54-65.