MINISTRY OF CULTURE, YOUTH AND SPORT

— Industry 4.0 in vocational education and training —

Mapping didactic approaches for learning factories in Baden-Württemberg

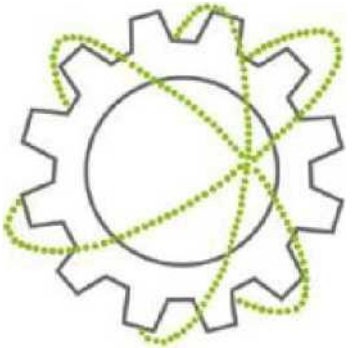
14.05.2024
Aalen
“LCAMP CONFERENCE 2024”

Dipl.-Gwl. Tobias Barthruff
Unit 42 Vocational Schools

smartBaWü

smart energy

LFT smartEnergy



INDUSTRY 4.0 BW
LEARNING
FACTORIES

LFT smartFactory

AI

LFT AI

BIM

BIM Project Group

Malte Knaack/Stuttgarter Zeitung

Consequences for vocational training

Thanks to Industry 4.0, production and communication processes as well as business processes are radically changing and they are merging together.

Consequences for vocational training

Demand for vocational training:

Learning arrangements to
- Internet-based
- complex production facilities

with
- mechanical,
- electrification and
- commercial

The processes.

digital@bw

Ministry of Economy, Labour and Housing

"We are launching a new start-up period and with the initiative "Economy 4.0 we create suitable framework conditions for the digitalisation of the economy"

Fields of action	Detail
Reasoning plant Baden-Württemberg	• Networking of founders with investors, research institutions and established companies as a one-stop-shop
Initiative Economy 4.0	• Roof for all activities of the state government on the digitalisation of the economy • Involvement of external actors from all relevant areas • Establishment of an Internet platform for the digitalisation of the economy as a service offering
Further development of Allianz Industrie 4.0	• Integration of other industrial sectors into Allianz Industrie 4.0 • Improving technology transfer in the area of Industry 4.0
Digitalisation in small and medium-sized businesses	• Support for small and medium-sized businesses in IT security, especially through the Cloud Mall BW and the IT security center • Support for "digital newcomers" in SMEs through the promotion of digital controllers • Supporting the digitalisation of small and medium-sized businesses, especially the craft sector, with the Smart Home & Living initiative
Work 4.0	• Qualification of junior staff within the scope of the Learning Factory 4.0 • Strengthening continuing vocational training in the field of digitalisation • Scientific study "Dialog Arbeitswelt 4.0" on the impact of digitalisation on the world of work

State Press Conference 13. December 2016

https://www.baden-wuerttemberg.de/fileadmin/redaktion/dateien/PDF/161213_Anlage_zu_PM_132_Digitalisierungsaktivit%C3%A4ten_der_Ressorts.pdf

Coalition Agreement “Now for Tomorrow”

- We want to consolidate the learning factories 4.0 in vocational schools, expand them flat-coveringly and position them even more strongly in continuing education.

- The change in operational reality is in full swing. “4.0” is a keyword for all industries – from craftsmanship to trade and industry to care. This is precisely why we will also make the digital transformation sustainable in vocational education and training by extending the principle of learning worlds and learning factories 4.0.

Vocational school as Learning Factory 4.0

- Learners are introduced in a structured manner to the changing changes in working conditions through Industry 4.0
- Around EUR 12 million in state funding (WM)
- 3 funding tranches (2015, 2018 and 2020)
  - **Tranche 1**: 15 school providers, 27 schools involved
    - Learning factories in operation since 2017
  - **Tranche 2**: 21 school providers, 37 schools involved
    - Learning factories in operation since 2021
  - **Tranche 3 (AI, AR, digital twin)**: 14 school providers, 25 schools involved
    - Commissioning since 2022

Subject-matter of the funding

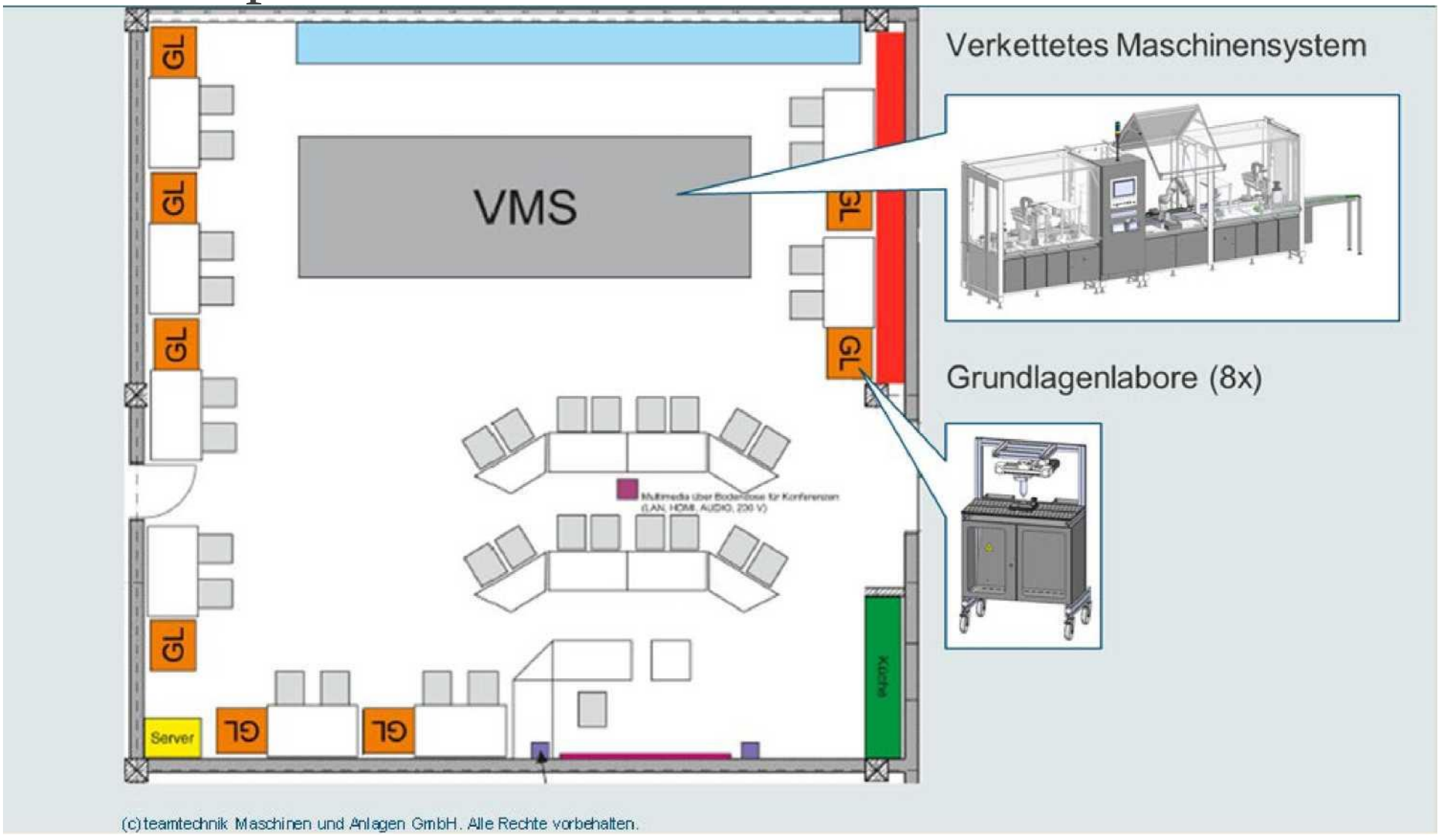
Picture: Commercial school

- **Basic laboratory** fordigitally controlled production modules for standard tasks of industrial production
- **chained machine system** with intelligent production processes based on real industry standards
- **pedagogical approach** to the use of Lernfabrik 4.0 in dual education and continuing education
- **Concept for the use of Lernfabrik 4.0 as a demonstration centre** for the medium-sized economy.

Grant amount

	Tranche I	**Tranche II**	**Tranche III (AI)**
School institution	50 %	50 %	50 %
Economy	10 %	10 %	
Land	40 %	40 %	50 %
Maximum funding of the country a) One school b) Several schools	EUR 500.000 of which EUR 100.000 Qualification	(a) EUR 250.000 b) EUR 350.000 of which EUR 50.000 Qualification	(a) EUR 40.000 b) EUR 60.000 of which EUR 10.000 Qualification

Example



SmartFactory today: ...

Use as Demonstration centre

Picture: Commercial school

- The “learning factories 4.0” are intended to define the character of a public perception within the respective region.
  Get showcases for Industry 4.0 technologies
- In particular, they should inform small and medium-sized enterprises.

Vocational school as Learning Factory 4.0

Currently 253 public vocational schools in BW,
of which 111 with M+E calls

Status of school year 2023/2024:

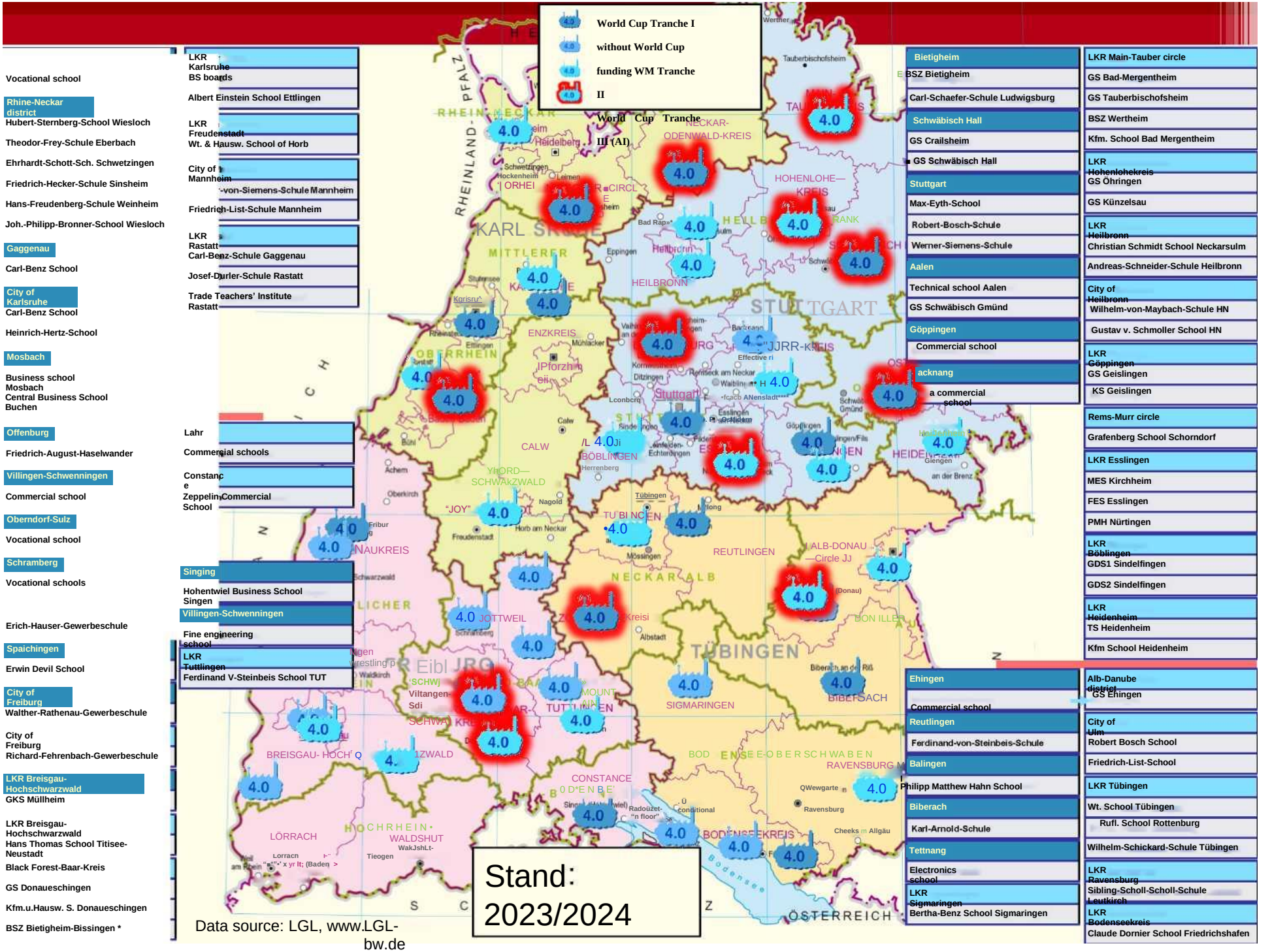
- 48 learning factories
- 79 schools involved
  - including non-subsidised
  - incl. 12 purely commercial schools
  - incl. 9 “mixed” schools

  ♈ Approx. 62 % of M+E vocational schools

36 of 44 city and county counties are “4.0”

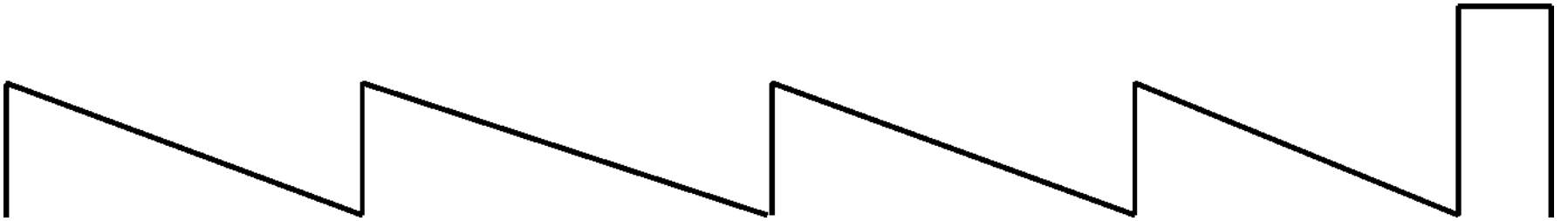
Vocational school as Learning Factory 4.0

♈ 82 %


World Cup Tranche I
without World Cup
funding WM Tranche
II
World Cup Tranche III (AI)
Vocational school
Rhine-Neckar district
Hubert-Sternberg-School Wiesloch
Theodor-Frey-Schule Eberbach
Ehrhardt-Schott-Sch. Schwetzingen
Friedrich-Hecker-Schule Sinsheim
Hans-Freudenberg-Schule Weinheim
Joh.-Philipp-Bronner-School Wiesloch
Gaggenau
Carl-Benz School
City of Karlsruhe
Carl-Benz School
Heinrich-Hertz-School
Mosbach
Business school Mosbach
Central Business School Buchen
Offenburg
Friedrich-August-Haselwander
Villingen-Schwenningen
Commercial school
Oberndorf-Sulz
Vocational school
Schramberg
Vocational schools
Erich-Hauser-Gewerbeschule
Spaichingen
Erwin Devil School
City of Freiburg
Walther-Rathenau-Gewerbeschule
City of Freiburg
Richard-Fehrenbach-Gewerbeschule
LKR Breisgau-Hochschwarzwald
GKS Müllheim
LKR Breisgau-Hochschwarzwald
Hans Thomas School Titisee-Neustadt
Black Forest-Baar-Kreis
GS Donaueschingen
Kfm.u.Hausw. S. Donaueschingen
BSZ Bietigheim-Bissingen *
LKR Karlsruhe
BS boards
Albert Einstein School Ettlingen
LKR Freudenstadt
Wt. & Hausw. School of Horb
City of Mannheim
-von-Siemens-Schule Mannheim
Friedrich-List-Schule Mannheim
LKR Rastatt
Carl-Benz-Schule Gaggenau
Josef-Durler-Schule Rastatt
Trade Teachers' Institute Rastatt
Lahr
Commercial schools
Constanc e Zeppelin Commercial School
Singing
Hohentwiel Business School Singen
Villingen-Schwenningen
Fine engineering school
LKR Tuttlingen
Ferdinand V-Steinbeis School TUT
Bietigheim
BSZ Bietigheim
Carl-Schaefer-Schule Ludwigsburg
Schwäbisch Hall
GS Crailsheim
GS Schwäbisch Hall
Stuttgart
Max-Eyth-School
Robert-Bosch-Schule
Werner-Siemens-Schule
Aalen
Technical school Aalen
GS Schwäbisch Gmünd
Göppingen
Commercial school
acknang
a commercial school
Ehingen
Commercial school
Reutlingen
Ferdinand-von-Steinbeis-Schule
Balingen
Philipp Matthew Hahn School
Biberach
Karl-Arnold-Schule
Tettnang
Electronics school
LKR Sigmaringen
Bertha-Benz School Sigmaringen
LKR Main-Tauber circle
GS Bad-Mergentheim
GS Tauberbischofsheim
BSZ Wertheim
Kfm. School Bad Mergentheim
LKR Hohenlohekreis
GS Öhringen
GS Künzelsau
LKR Heilbronn
Christian Schmidt School Neckarsulm
Andreas-Schneider-Schule Heilbronn
City of Heilbronn
Wilhelm-von-Maybach-Schule HN
Gustav v. Schmoller School HN
LKR Göppingen
GS Geislingen
KS Geislingen
Rems-Murr circle
Grafenberg School Schorndorf
LKR Esslingen
MES Kirchheim
FES Esslingen
PMH Nürtingen
LKR Böblingen
GDS1 Sindelfingen
GDS2 Sindelfingen
LKR Heidenheim
TS Heidenheim
Kfm School Heidenheim
Alb-Danube district
GS Ehingen
City of Ulm
Robert Bosch School
Friedrich-List-School
LKR Tübingen
Wt. School Tübingen
Rufl. School Rottenburg
Wilhelm-Schickard-Schule Tübingen
LKR Ravensburg
Sibling-Scholl-Scholl-Schule Leutkirch
LKR Bodenseekreis
Claude Dornier School Friedrichshafen
Stand: 2023/2024
Data source: LGL, www.LGL-bw.de

“Vocational School as Learning Factory 4.0”

- **“hardware” is available...**
- **overall pedagogical concept**



Overall pedagogical concept Lernfabrik 4.0

Handout

» Industry 4.0 — Implementatio

n in Teaching» Module retraining

Industry 4.0

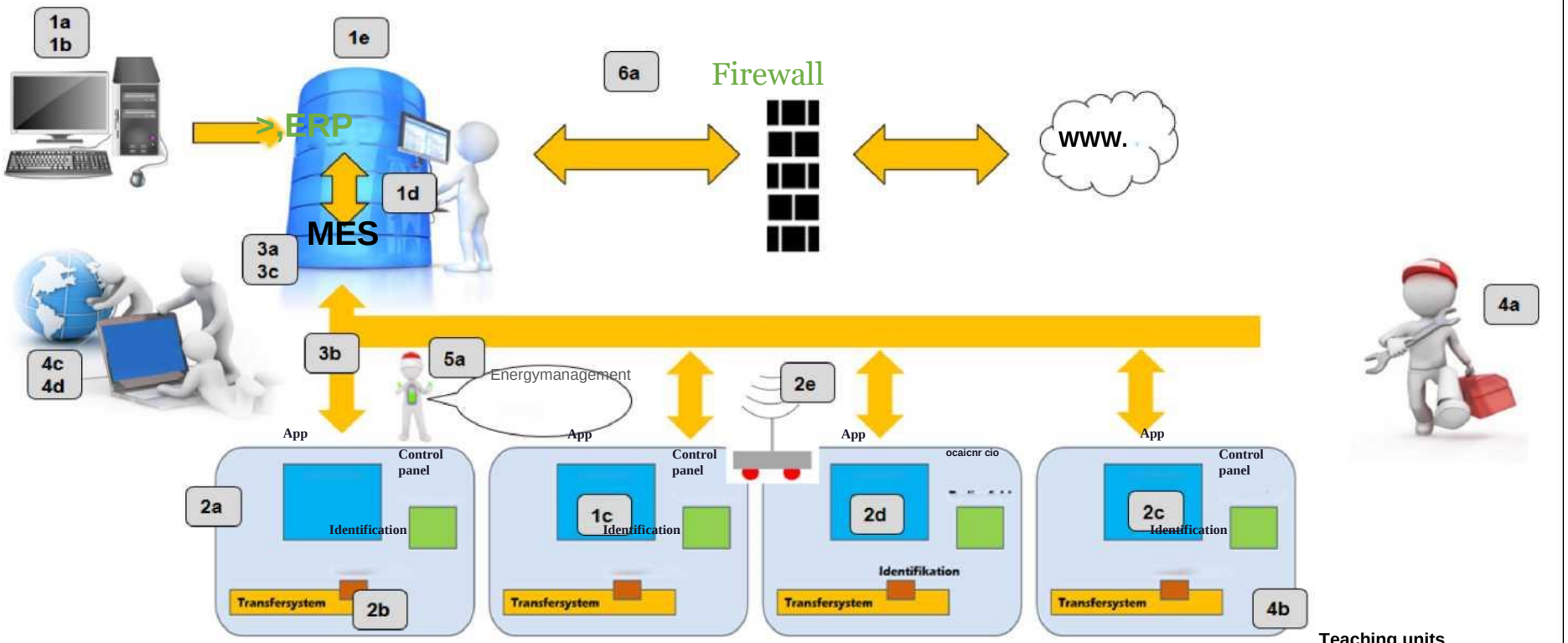
National group Learning factory 4.0

to

Coordination Provisioning from Teaching materials

Sample solution BW

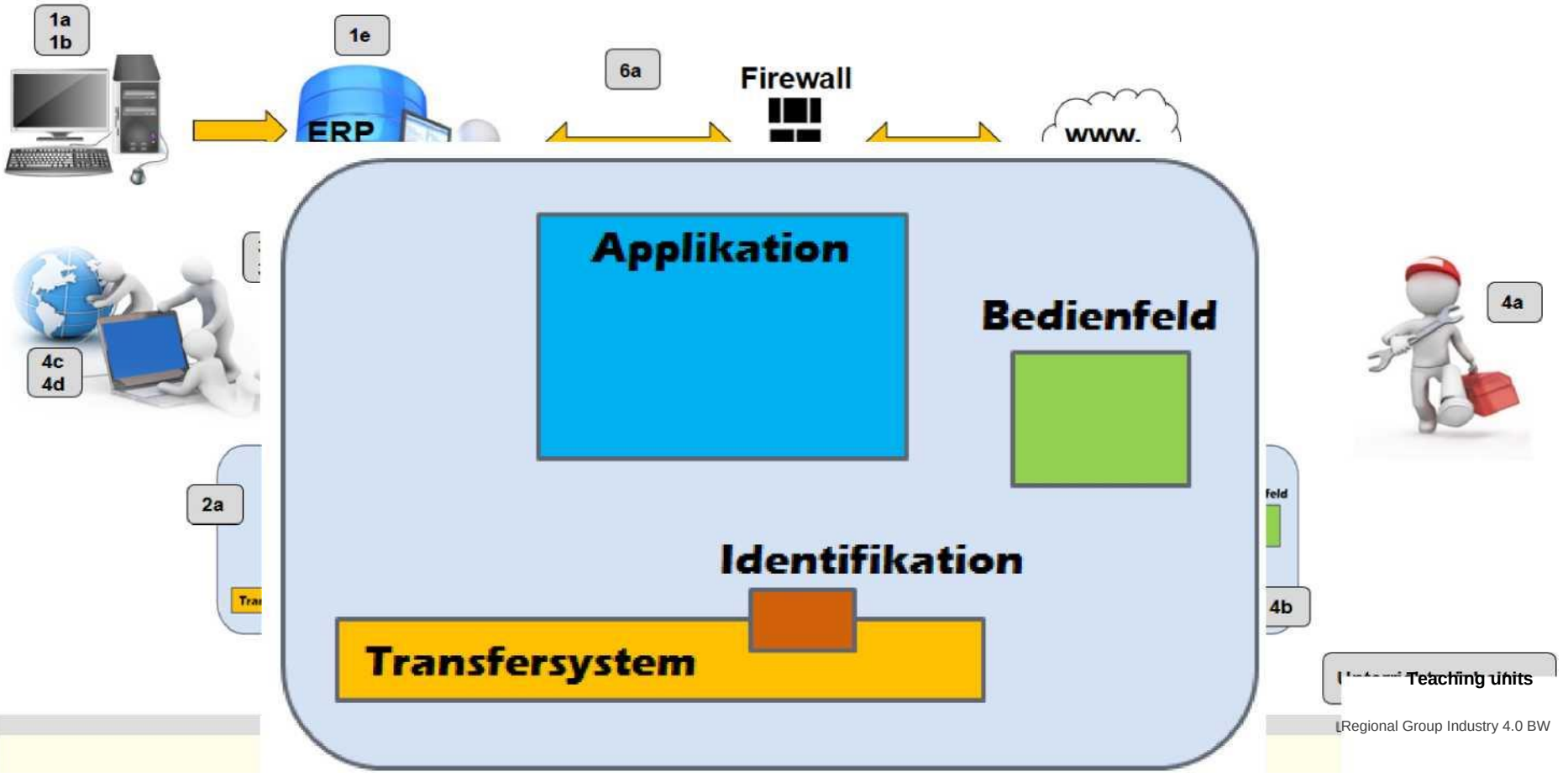
Sample solution BW “smart factory 4.0”

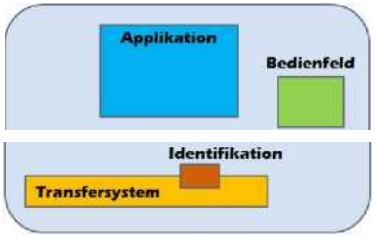


Teaching units

Regional Group Industry 4.0 BW

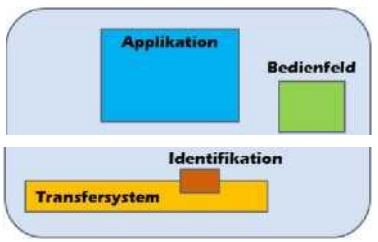
Musterlösung BW „smart factory 4.0“





Objectives of the sample solution:

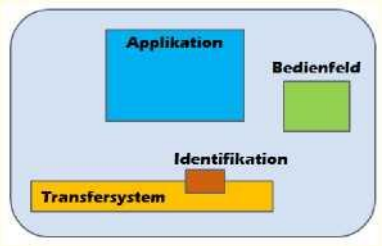
- **End-to-end concept** by implementing **all professional content on concrete practical examples**
- Basic laboratory model “Industry 4.0” as a basis, so that even schools without a learning factory can realise the concept
- Basis of the nationwide teacher training concept “Industry 4.0”



3-stage concept:

Stage 1: **Basic training**

- Classical content according to curriculum
- Adaptation of the teaching examples in the direction of smartFactory



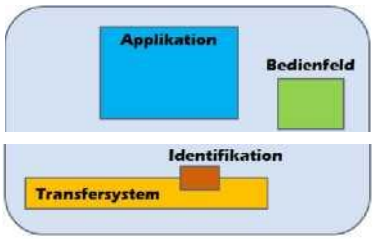
3-stage concept:

Stage 1: **Basic training**

- Classical content according to curriculum
- Adaptation of the teaching examples in the direction of smartFactory

Stage 2: **Basic laboratory Industry 4.0**

- Basics expanded with I4.0 content
  (agile product development, identification systems, MES,...)



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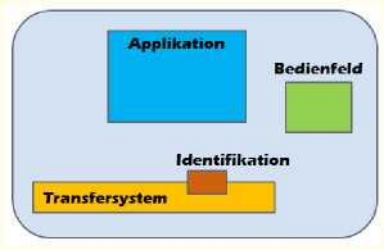
(agile product development, identification systems, MES,...)

Stage 3: **Complex machine system (Cyber-Physical-Factory)**

- Optional, as this does not provide any basic new learning content
- Practical use



3-stage concept:

All I4.0 content can be with the first two stages to be covered

Stage 1: **Basic training**

- Classical content according to curriculum
- Adaptation of the teaching examples in the direction of smartFactory

Fi

Stage 2: **Basic laboratory Industry 4.0**

- Basics expanded with I4.0 content
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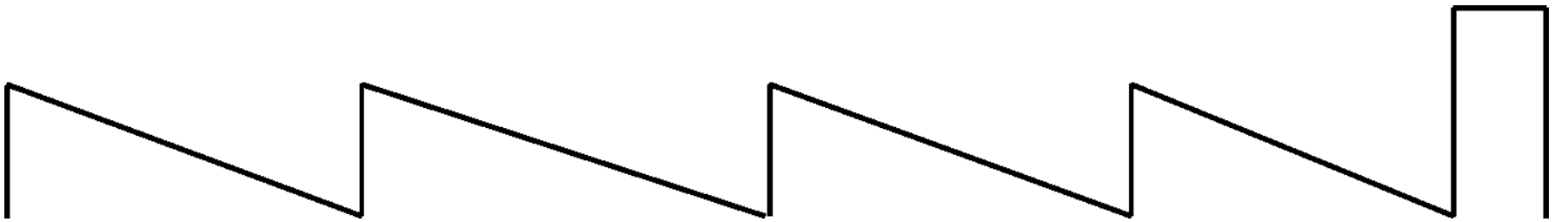


Overall pedagogical concept Lernfabrik 4.0

Handout

» Industry 4.0 — Implementatio

n in Teaching» Module retraining Industry 4.0

National group Learning factory 4.0 to

Coordination Provisioning from Teaching materials

National solution
BW

Centre for School Quality and Teacher Education
BA den-Württemberg

Handout “Industry 4.0 – Implementation in Education”

Industry 4.0
Smart factory

Implementation in vocational schools Vocational school/technical school

ZSL - 04.2023

https://www.schule-bw.de/faecher-und-schularten/berufliche-schularten/schulartuebergreifend/industrie_4.0

Industrial Metal and Electrical Professions 2018

Hotel manager/hotel manager	Download
Real estate clerk/real estate clerk	Download
Industrial electrician/industrial electrician	Download
Industrial clerk/industrial clerk	Download
Industrial mechanic/industrial mechanic, (expiring from SY 2018/19)	Download
Industrial mechanic/industrial mechanic	Download
(valid from SY 2018/19; with markings on Industry 4.0 and partial innovation 2018J	
Industrial Ceramics Plant Engineering/Industrial Ceramics Plant Engineering	Download
Industrial ceramics decoration technology/industrial ceramics Decoration technology	Download
Industrial ceramics Model technology/Industrial ceramic model technology	Download
Industrial Ceramic Process Engineering/Industrial Ceramics Process Engineering	Download
Computer Science clerk/Informatics clerk	Download
Information-electronics/information-electronics	Download
Information and Telecommunications System-Electronics/	

Learning field 5: Manufacture of individual parts with factory equipment machines — **2. Year of training Time limit: 80 hours**

Target formulation:

The pupils manufactureworkpieces from different materials on machine tools using **data**management systems, taking into account work and environmental protection

They refer to group drawings, partial drawings. Sketches and BOMs the necessary information. You also create and modify sketches and partial drawings with the help of applicationprograms

The pupils select suitable manufacturing companiesfrom the technological aspects. You decide whether or not it is necessary to carryout processes for changing fabrics before the machining process You specify the necessary technological data and select the necessary auxiliary materials for this purposethey also use digital information For the chosen manufacturing processthey create work plans, select clamping devices for workpieces and tools and set up the machine for production

The students and students develop test plans basedon the regulations on quality management They select test equipment, run and interpret test protocols you doku menateand present theresults of the work, evaluate them and developIn Alternativen. They also secure the test results using digital data processing systems

They examine the influences of the manufacturing process on dimensions, surface quality and shape. They determine the production costs and assess the cost-effectiveness of the selected fertilisation-processes.

Students justify their decisions and respond to criticism of their work.

MUÖUIIUUIig^juiii i, Ä, o unu %

With markings on Industry 4.0

With markings of the change by partial amendment 2018

Content:

technical sources of information cutting
production processes Machining
parameters
Cutting materials
Material standardisation
Annealing process
Main usage time
Cooling lubricants
Test instructions
Test equipment selection and
monitoring Attributive and variable test
features Form- and position-tolers
Digital measuring instruments

https://www.bildungsplaene-bw.de/,Lde/ausbildungsberufe

Overall pedagogical concept Lernfabrik 4.0

Handout

» Industry 4.0

Implementation in Teaching»

Module retraining

Industry 4.0

National group Learning factory 4.0

to

Coordination

Provisioning from Teaching materials

National solution BW

Module training

Industry 4.0

ZSL

Centre for School Quality and Teacher Education

BA d en -Wü rtte m berg

Module trainingx Industry 4.

School year 2023/2024

Dear colleagues,

With this flyer you getthe annual overview of the modut trainings»Industrie4-0.
For the explanation:

► Are online shares marked with the words ‹bVeb 1›; thus, these important components of the Modu training courses and thus also a prerequisite for the attendance day.

► The online portions ("web"') can be inheritedga nztags, afternoons (usually 14h3O - 17h00) or asynchronously for free time editing. The presentation is then carried out in the flyer by the information "Web (G)"for full day, "Web (N)"for afternoon or "Web (A)" for the asynchronous processing.

The time limit of the asynchronous online shares is about SO-90 minutes.

► An online portion can also take placeas anoffice hour after a face -to-face appointment.

► Participants will be informed about the exact times of the Onli ne events and the corresponding pl attforms and channels in good time by the course management.

Industry 4.0

* Industry 4.0 [140]
1401 | New developments, concept of modeling BW will not be offered 2023/2024

* Production planning/production development [141] *Details here ±*
14111 Virtual commissioning of a Bai^ruppe
15.05.2024 Presence R52Q5 | Cancelled due to low TN-Zah l
1412 | Prod uktron plan to implement prod. process from ERP Uber MES to smart factory
25.01.2024 Presence XRDL8 | Cancelled due to too low TN number

* Flexible manufacturing [142] *Details here 1*
1421 | PLC programming of sample solution BW (Level 1) on a CPM
23.11.2023 *Presence* 82MJD | Esslingen (ZSL)
1422 | Integration of Identifi cations systems in the sample system. BW (Level 2) at a CPM

* Manufacturing Execution System [143] *Details here:* 1
1431 | Tasks and functions of an MES and application of the MES4-lite
K.03.2024 Presence 72805 | Cancelled due to too low TN number

* Maintenance /maintenance [144] *Details here:* I
1441 | Service and Maintenance Strategies – Condition Monitoring and Predictive Maint.
21.03.2024 *Presence* LE2JZ | Karlsruhe
1442 | Condition Monitoring – Generate and manage process data
Cancelled because of gerin
1443 | Predictive Maintenance – Process data evaluate and represent ird 2023-2024 not offered

08 02.2024 *Presence* I Cancelled because of gerin
1423 | Connection of the MES4-Lite to the sample solution BW (Level 3)
18.0
1424 | Robotics – Communication and Integration into a CPF
19. C—
1425 | Parametric CNC program rung is not offered 2023/2024

* E n ergie m a nage ment [145] *Details here.* 4
1451 | Smart Grid – Energy Monitoring, Energy Efficiency and Intelligent Load Management *12.03.2024 Presence* XRDJ4 | Aalen

* Networking/data security [146] *Details here:* I
1461 | Basics of Networking a Cyber-Physical Factory
05.+ 06.02.2024 *Presence* ZEV69 | Cancelled due to too low TN number
1462 | Switching and VLANs in a Cyber Physical Factory
16.07.2024 *Presence* 82M5D | Cancelled due to low TN number

Previous knowledge:
Prior knowledge is required to participate in some modut trainings, e.g. by actively participating in upstream module training. Please check this by reading the corresponding module clarification.

Online registration:
Through the course numbers indicated here in the flyer, you can register via LFB-Onl'me to the module training you want from 11.9.2023.
This registration must be made by04.10.2023!

Clarification of the modules:
The modules are deliberately described only briefly in this flyer. Further Information can be found in the module details, which can*be found at* https://lehrerfortbikiuna-bw.de/s bs/professional / eiektrotechnik/. This can also be reached via the stored links in the module groups with the symbol 4.

Definition of module trainings:
Through the cooperation of the regional offices of the ZSL, after submission of the applications, it is possible to decide which Modullfortbilung is actually carried out at which location. A minimum number of participants is assumed to be 8. This circumstance therefore also makes it necessary that the registration numbers reliably hold us until 4.10.2023. When choosing the location, we assume the regional focus of the participants, provided that equipment specifications do not determine the location.

Online access:
Via the LFB online portal you have an early insight into which ModuAdvanced training you could be admitted to. Please note that you provided a valid, personal, official e-maal address when registering.
Ei ne non -personal e-mail address wi rd is not used, since no further lists with names or similar are attached due to data protection regulations of the e-mail and therefore this e-mail could not be assigned to you.

We wish you every success and a high return in participating in the Module extensions»Industrie 4.0

At the regional offices of the ZSL, the following contact persons are available for general questions about modut training:

- ** Regional offices Stuttgart and Schwäbisch Gmünd*
  RA phae horns O *raphael.hoerner@zst-rsgd.de*
- ** Regional offices Karlsruhe and Mannheim*
  Roland Hasenohr E3 *roland.basenohr@zsi-rska.de*
- ** Freiburg Regional Office:*
  Jürgen Schna iter 0 *juergen.schnaiter@zsi-rsfr.de*
- ** Regional office Tübingen:*
  Elmar Dehler 0 *elmar.dehler@zsl-rstue.de*

ZSL

• f * • * A Centre for School Quality
® . and teacher education
•,'*,■ Baden-Württemberg

Module training industry 4.0
School year 2023/2024

https://lehrerfortbildung-bw.de/s_bs/berufsbezogen/elektrotechnik/modulfortbildungen/modul_industrie40/index.html

Trainings on Learning Factory 4.0

- Continuing education concept since school year 2016/2017

- more than 20 different training modules

- Interdisciplinarity
  (Electrical/Informatics/Metal/Commercial)

- Opening up to in-company training staff in the case of free
  Capacities

Overall pedagogical concept Lernfabrik 4.0

Handout

» Industry 4.0

Implementation in teaching»

Modul-
fortbildung

Industrie 4.0

Landesgruppe
Lernfabrik 4.0

to
Coordination
solution

Provisioning
from
Teaching
materials

National group

Learning Factory 4.0

Coordinatio n

LFT smartFactory

Km – Country group group 14.0

R PS FB Metal FB Electric	RPK FB Metal FB Electric	RPT FB Metal FB Electric	RPF FB Metal FB Electric
RPS- Lemfabriken Schooltrete r	RPK learning factories Schulverkicks	RPT- Lemfabriken Schooltrete r	RPF learning factories Schulverkicks
RPS Group 14.0	RPK Group 14.0	RPT Group 14.0	RPF Group 14.0

Overall pedagogical concept Lernfabrik 4.0

Handout

» Industry 4.0

Implementation in teaching»

Modul-fortbildung

Industrie 4.0

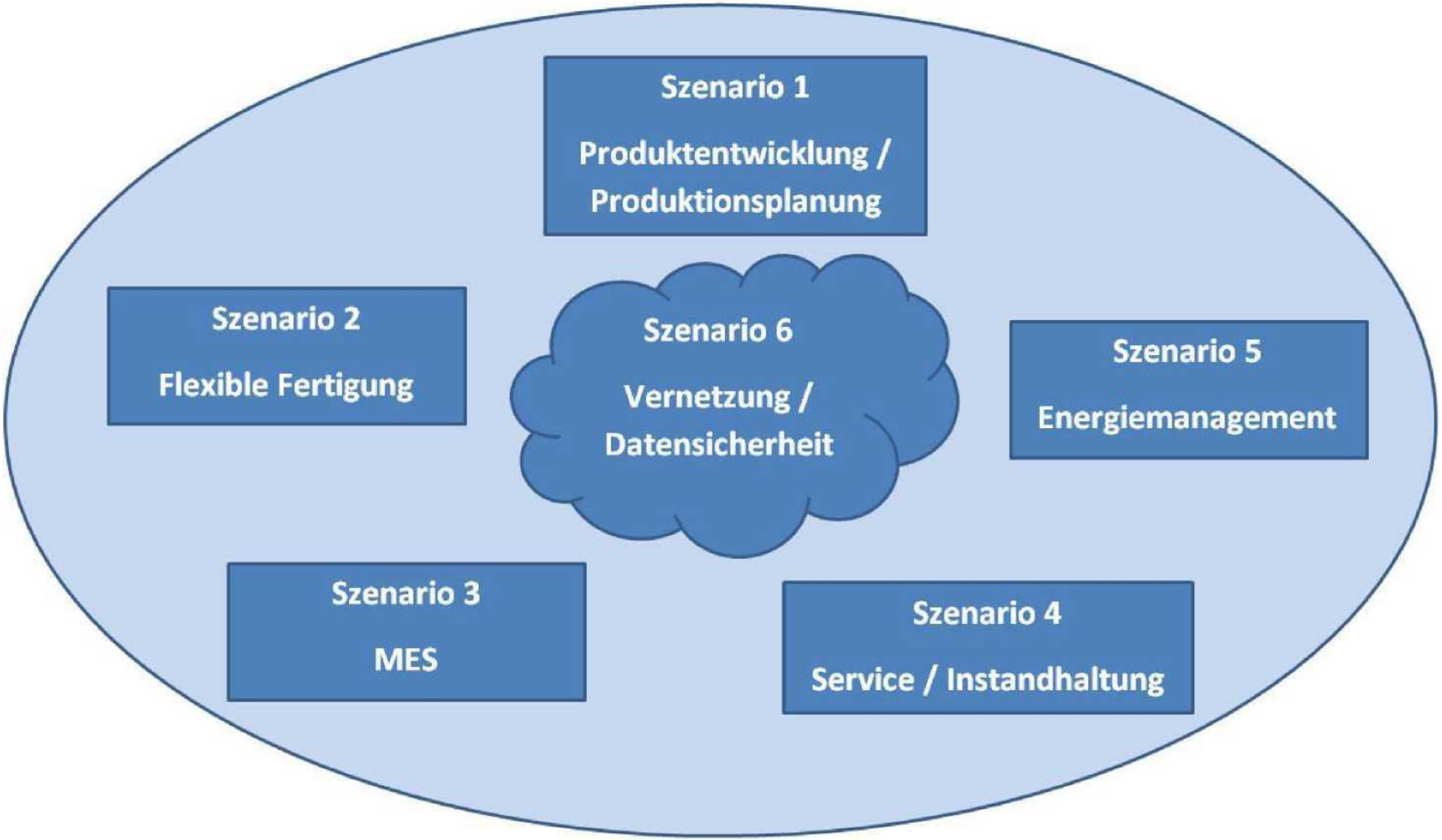
Landesgruppe Lernfabrik 4.0

to Coordination solution

Provisioning from Teaching materials

Provision of teaching materials

- Drawing on scenarios of guidance 4.0
- Objective:
  - 6 scenarios in each of 3 requirements areas
  - Open-tech formulation (also for non-LF4.0 schools)
  - Recommendation for equipment (also for non-LF4.0 schools)
  - Uniform format


Szenario 1
Produktentwicklung /
Produktionsplanung
Szenario 2
Flexible Fertigung
Szenario 6
Vernetzung /
Datensicherheit
Szenario 5
Energiemanagement
Szenario 3
MES
Szenario 4
Service / Instandhaltung

Scenarios	Scenario 1			Scenario 2			Scenario 3			Scenario 4			Scenario 5			Scenario 6		
Areas of Requirement	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Professions and school type																		
Industrial mechanic	X			X						X			X					
Production technologist	X				X		X				X		X			X		
Mechatronics technician	X				X		X				X		X			X		
Electronics automation technology	X				X			X			X			X			X	
Electronics company technology				X						X			X			X		
Specialist informatics	X							X		X								X
Technical school of metal technology			X		X		X				X		X			X		
Technical School of Electrical Engineering		X				X			X			X			X		X	
Technical School of Automation/Mechatronics		X				X		X				X			X		X	
Technical School of Information Technology		X							X	X			X					X

Vocational school as Learning Factory 4.0

Outlook:

- greater involvement of commercial professions/locations
- Intensification of regional learning site cooperation
- Further development of teacher training

Window

lernfabrik.kultus-bw.de

Learning factories 4.0

bltOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOO
OOOO

Bringing Industry 4.0 to Schools

Bringing Industry 4.0 to Schools

The aim of the learning factories is to prepare specialists and junior staff for the requirements of digitalisation. The learning factories replicate modern industrial automation solution in the construction and equipment. Mechanical engineering, electrical engineering and information technology are linked by professional production control systems. At the learning factories, basics for application-oriented processes are learned. Commercial aspects are also taken into account.

In 2016, 16 learning factories were set up at vocational schools in the state of Baden-Württemberg. As of 2018, another 21 learning factories were added. These learning factories were funded by the Ministry of Economics, Labour and Housing. Some other schools have set up a learning factory without this funding.

The locations of all learning factories can be found on the > Lernfabriken-Scite.

INDUSTRY 4.0 BW LEARNING FACTORIES

Publication (2021)

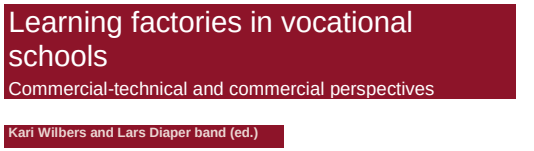
- Theoretical Foundations of the Learning Factory Concept

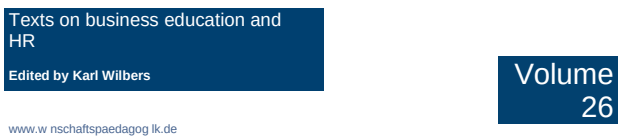
- Strategies of the countries
  - Baden-Württemberg
  - Bavaria
  - Niedersachsen

- Examples outside VET

- Examples of successful **combination** of **commercial and commercial and technical** vocational training

FRIEDRICH-ALEXANDER UNIVERSITY-NÜRNBERG
DEPARTMENT OF ECONOMICS AND SOCIAL SCIENCES





https://www.pedocs.de/volltexte/2021/21245/pdf/Wilbers_Windelband_2021_Lernfabriken_an_beruflichen.pdf

Thank you for your attention