Enterprise Resource Planning (ERP) systems in vocational schools
- a German perspective along Curriculum, Instruction, and Assessment

Christian Mayer, M.Sc., University of Mannheim, Chair of Economic and Business Education – Professional Teaching and Learning (Prof. Dr. Jürgen Seifried)

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Agenda

Introduction

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Introduction
Enterprise Resource Planning (ERP) systems

- Enterprise Resource Planning (ERP) systems consist of various modules that integrate data from different departments into a common database to manage business processes (Nwankpa, 2015)
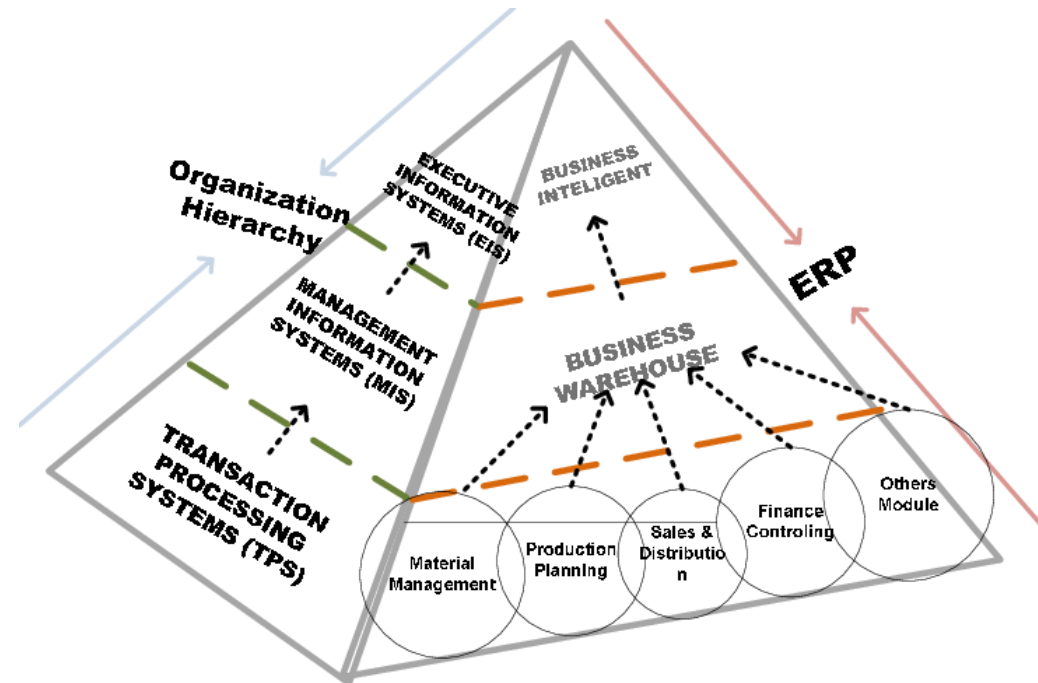
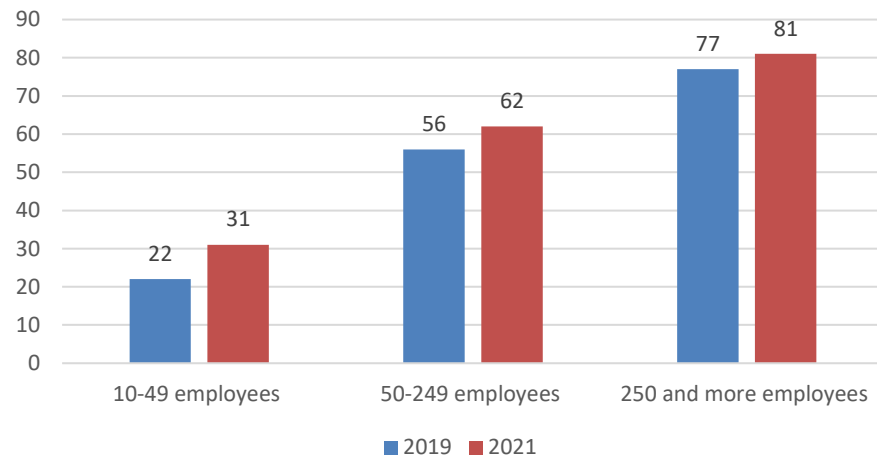ERP and Organization Maturity Level (Dantes & Hasibuan, 2009)

Introduction
Relevance of ERP systems for VET

- More and more software is used at office workplaces for organizational operations and decision making (Billett, 2021)

- Workplace skills are linked to "electronically mediated tasks and work roles" (Billett, 2021, p. 1)

- Changes in the occupational profile at the learning site of companies ...

Companies with internal ERP software (2019-2021), in %, by company size, excluding companies with 1 to 9 employees.

	2019	2021
10-49 employees	22	31
50-249 employees	56	62
250 and more employees	77	81

(Statistisches Bundesamt (Destatis), 2023, Federal Statistical Office table code 52911)

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Introduction
Relevance of ERP systems for VET

- … needs to be addressed in vocational schools and training.

- ERP-systems in VET might foster learning about business processes. Apprentices need to:
  - be allowed to make mistakes and should be able to learn from them (Metcalfe, 2017)
  - develop a deeper understanding of business processes across several departments by using ERP systems (Pongratz, Tramm & Wilbers, 2009)

- In addition, ERP skills might foster employability (Seifried et al., 2019)

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Why have ERP systems not yet fully arrived
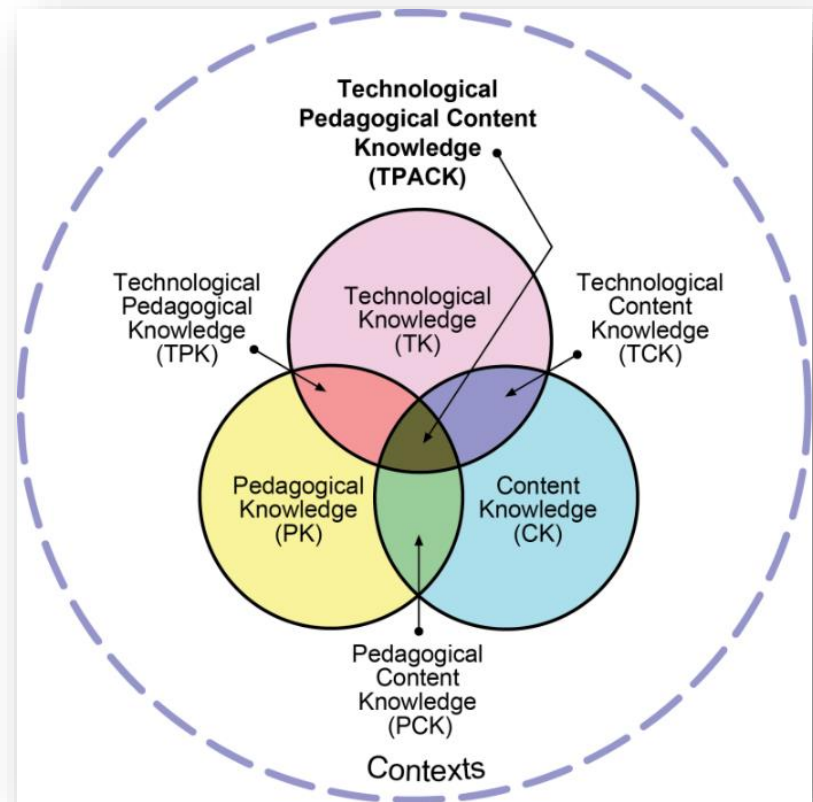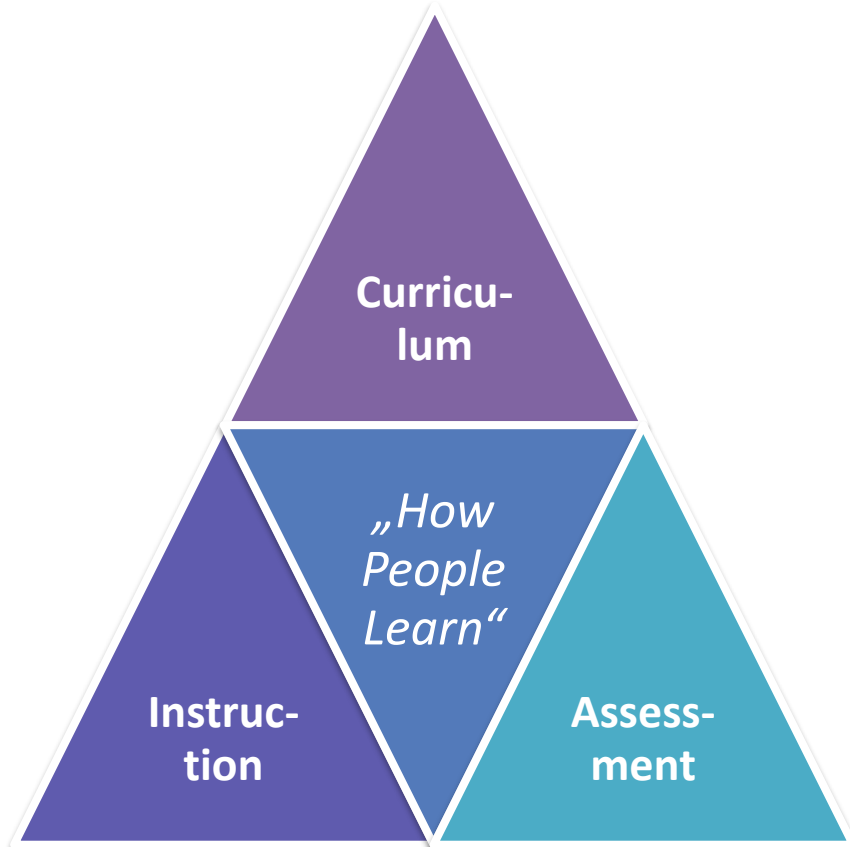in vocational schools and apprenticeship training?

*« One reason for the scarce integration of
software into lessons may be that teachers still
lack of qualification themselves. «*
(Knigge et al., 2017, p. 7).

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Theoretical background
CIA triad & TPACK model
(Koehler & Mishra, 2009; Mishra & Koehler, 2006; Pellegrino, 2006)

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Theoretical background
CIA triad & TPACK model
(Koehler & Mishra, 2009; Mishra & Koehler, 2006; Pellegrino, 2006)

Triangle diagram with: **Curriculum** (top), *„How People Learn"* (center), **Instruction** (bottom left), **Assessment** (bottom right)

- Curriculum for IT system management clerks:

  Example of learning area 12: Carrying out and monitoring sales processes: "You document the entire sales process with the support of software (integrated company software)" (Kultusministerkonferenz, 2019 p. 12).

- Instruction example:

  Example of a simplified typical sales procedure in the style of SAP4school material ('SAP4school IUS', 2023).

  Customer inquiry → Quotation → ... → receipt of payment

- Performance (Assessment) in the ERP

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Theoretical background
CIA triad & TPACK model
(Koehler & Mishra, 2009; Mishra & Koehler, 2006; Pellegrino, 2006)

- There are great benefits in using ERP as part of apprenticeship training, at school and the workplace. For apprenticeship teachers and in-company trainers to make the proper use of ERP, they need to:

  - … know about training media and technological applications and underlying technological concepts.
  - … know about using such systems to accomplish professional tasks.
  - … know about typical errors and misconceptions of learners and hurdles during learning and skill acquisition.

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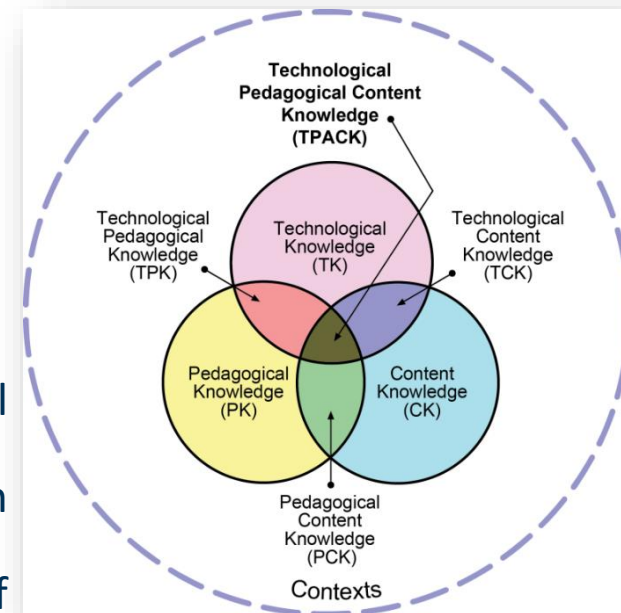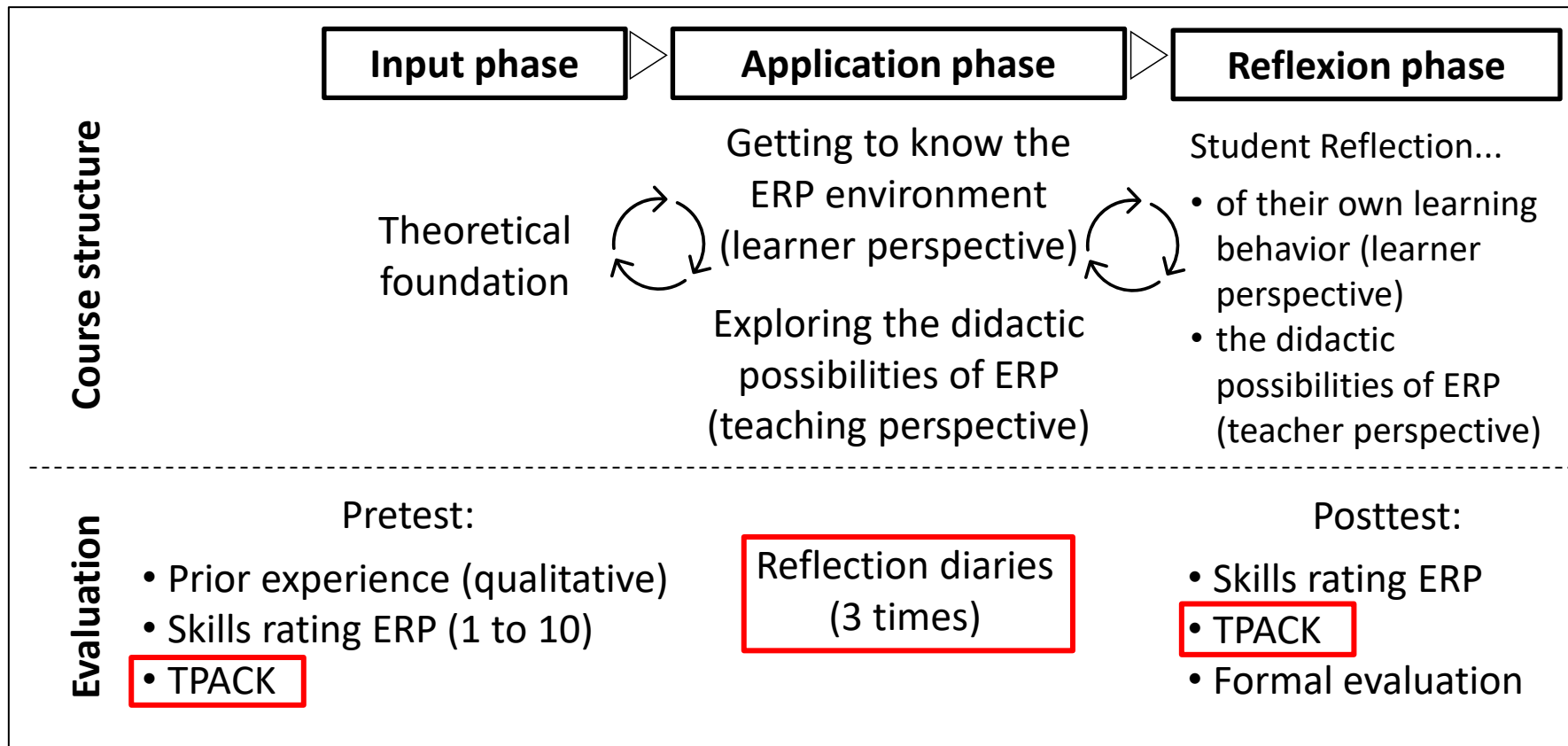
Research Questions

- The purpose of this study is (1) to identify typical student errors and problems in learning with ERP systems and (2) to investigate student teachers' self-reported competence development.

- RQ1: What are typical problems student teachers face when learning with ERP systems?

- RQ2: Does a course offering (in this case, a seminar on SAP ERP) promote technological, pedagogical and content knowledge (TPACK) of business education students?

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Methods
Course design and sample (n = 20)

	Input phase	Application phase	Reflexion phase
Course structure	Theoretical foundation	Getting to know the ERP environment (learner perspective) Exploring the didactic possibilities of ERP (teaching perspective)	Student Reflection… • of their own learning behavior (learner perspective) • the didactic possibilities of ERP (teacher perspective)
Evaluation	Pretest: • Prior experience (qualitative) • Skills rating ERP (1 to 10) • TPACK	Reflection diaries (3 times)	Posttest: • Skills rating ERP • TPACK • Formal evaluation

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Results RQ1

- Examples of typical procedural problems:
  - *"The **procedure for the entire task was completely unclear** to me at first. Only after watching the video was the processing path apparent and understandable. **Lack of knowledge in the area of automatic order planning,** which would have been good for understanding the task.* **Problems with how to get to the Performance Assistant***. **Problems with switching from the Heidelberg plant to the Hamburg plant when examining the unrestricted-use stock***." (Problem 005, Task: Examining material master data)
  - "I didn't know what to enter for material master records in Task 3.3.2 when I set the organization level. Plant and sales organization were clear to me, **but I couldn't figure out the distribution channel exactly**." (Problem 021, Task: Create a quote to a customer)

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Results RQ1

- Examples of typical procedural problems:

    - *"Chapter 3 from Part 1; **I didn't realize I had to reference the quote,** I overlooked or didn't think of something like that. **I did know that it was a quote that matched the previously entered request, but I didn't know that I could reference it in the system**. In the solution notes, the reference to it is easy to miss because it is right under the process steps."* (Problem 030, Task: Create a quote to a customer)

    - "The task was clear [...]: Supplier **32123934 was created for company accounting circle DE08.** When I wanted to continue the task and call up my stored posting, I could not find it. It was not deposited. " (Problem 044)

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Results RQ2
Course satisfaction and ERP skill self-report

- Overall, very satisfied with the seminar:
  - Overall, I am very satisfied with the lecturer (M = 1.1). Overall, I am very satisfied with the course (M = 1.5). I learned a lot in this course (M = 1.6).

- The analysis of the assessment of one's own skills in dealing with ERP systems yields the following result:
  - The value is significantly higher after the seminar than before ($M0$ = 2.2 vs. $M1$ = 6.5, V = 210, $p < .001$, n = 20). The effect size is r = .88 and corresponds to a strong effect according to Cohen (1992).

- To analyse the TPACK dimensions, a mean was calculated for each subscale and a pre-post-test was performed.
  - Overall, the TK dimension showed a significant effect (V = 114.5, $p < .05$). The effect size was r = .41 (moderate effect).

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Results

- **RQ1: Typical problems and misconceptions are related** to
  - a lack of basic domain-specific content knowledge,
  - **a lack of knowledge related to the functioning and structure of the ERP system,**
  - **and a lack of knowledge related to the application of the process in the ERP system.**

- **RQ2: Technological Knowledge** dimension showed **significant improvements**.

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Discussion

→ Limitations:

    → Small sample size, convenience sample (self-selection bias), Generalizability might not be given (one university, sample restrictions)

    → Self-reports (social desirability bias), need for authentic assessments for TPACK and teaching / learning with ERP-systems.

→ Research Implications:

    → create authentic assessment scenarios that consider the lack of content knowledge and typical misconceptions in order to promote *pedagogical content knowledge* in teaching and learning with ERP systems.

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Discussion

→ Implications for educational policy makers:

→ In curriculum design:

    → we have to take into account the changes in the world of work

    → recommend a stronger mandatory (not optional) digitalisation of apprenticeship training (e.g., by integrating ERP systems).

→ From a resource perspective:

    → we need to ease funding for vocational schools by reducing bureaucratic barriers

    → reduce resource constraints by funding internal IT support teams and providing dedicated software for all apprentices.

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Statistisches Bundesamt (Destatis), Genesis-Online; Datenlizenz by-2-0; own calculation / own presentation.

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Thank you for your attention!

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Appendix

- Backup slides

- Material example

- Coding Manual

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Introduction
Relevance of ERP systems for VET

- In courses of business information or administration the examination of ERP systems is often obligatory (Brand et al. 2021)

- Despite the relevance for VET, the empirical evidence on teaching and learning with ERP systems is rather limited:

→ **How to design and assess an effective training course for student teachers on teaching and learning with ERP systems? (Research gap)**

→ Learning effectiveness: Process-oriented conception (action- and problem-oriented), instead of a function-oriented design of materials (Hommel, 2019), medium effect size (d = .57) for knowledge acquisition (Spener & Schumann, 2020)

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Theoretical background
Simulation-based learning

- Simulation-based learning refers to any:
  „educational tool or device with which the learner physically interacts to mimic real life" and in which they emphasize *"the necessity of interacting with authentic objects"*
  (Cook, p. 876; Chernikova et al., 2020).

- Simulation-based learning in higher education fosters the learning of complex skill acquistions (Chernikova et al., 2020)
  → A Meta-analysis on simulation-based learning environments (n = 145) promoting complex skills (e.g., medical diagnosis) reports a large effect size (Hedges g = 0.85)

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Theoretical background
Problem-solving approaches

	Approaches based on mental models	**Approaches based on real-world experience**
Development of one's own approach	Reflecting (e.g., mental simulation, interpolation, analogy, abstraction, reduction)	Trying out (e.g., experimentation, trial and error learning)
Adoption of someone else's approach	Consulting competent others (e.g., assistance, guidance, instruction) Consulting codified information (e.g., guidelines, manuals)	Observing competent others (e.g., observing role models)

Approaches to problem solving in the workplace (Rausch, 2011, p. 98; Rausch et al., 2015, p. 452)

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Methods

TPACK scales (Koehler & Mishra, 2009; Mishra & Koehler, 2006)

- TPACK questionnaire (Schmid, Brianza, and Petko, 2020): 28 items (4 items per TPACK dimension).

- A sample item of the PK dimension is: *"I can adapt my teaching to what learners currently understand and what they do not understand."*

- A sample item of the TPCK dimension is: *"I can select technologies to use in my classroom that enhance what I teach, how I teach, and what students learn."*

- Likert scale from *"1 = strongly disagree"* to *"5 = strongly agree"*; Cronbach's α = .67 to .90

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Methods
Materials – Reflection diaries

Beschreiben Sie *größten Probleme/Hürden/Schwierigkeiten* (max. 3) bei der Bearbeitung der (Teil-)Module der heutigen Sitzung

Problemart (bitte ankreuzen, Single Choice)	Kurzbeschreibung des Problems	Wie schwierig war das Problem? 0 = gar nicht schwierig 4 = sehr schwierig	Lösungsansatz (bitte ankreuzen, Multiple Choice)	Beschreibung des Lösungsvorgehens	Wie befriedigend war der Lösungsansatz? 0 = gar nicht befriedigend 4 = sehr befriedigend
☐ Aufgabe unklar ☐ Vorgehen unklar z.B. Eingaben inkorrekt ☐ Technischer Art z.B. Systemfehler ☐ Sonstiges: Klicken oder tippen Sie hier, um Text einzugeben.	Klicken oder tippen Sie hier, um Text einzugeben.	Klicken oder tippen Sie hier, um Text einzugeben.	☐ Nachdenken / gezieltes Vorgehen *(systematisch)* ☐ Experimentieren *(eher unsystematisch)* ☐ Befragung anderer ☐ Beobachtung anderer ☐ Recherche ☐ Sonstiges: Klicken oder tippen Sie hier, um Text einzugeben.	Klicken oder tippen Sie hier, um Text einzugeben.	Klicken oder tippen Sie hier, um Text einzugeben.

Rough distinction of problems and problem-solving approaches by students, recoded by two independent coders.

(Cohens Kappa for problem types: k = .86; and for solving approaches: k = .89; almost perfect agreement according to Landis & Koch, 1977)

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Qualitative results

- 129 problems were identified and matched to different solving approaches:

	Consulting others	Observing others	Trying out (un-systematic)	Reflection (systematic)	Codified information	Other solving attempt
Instructions unclear	2				2	
Other problems	3	1	1	5	4	
Technical problems	5	1	23	7	1	2
Procedure unclear	**7**	**7**	**14**	**13**	**30**	**1**

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Qualitative results

- The reflection diaries contain references to aspects that are more likely to be characterized as careless mistakes. The following statement can stand as an example:

  - *"In the second part of the task, **I did not create an offer, but an inquiry. Therefore, I was only shown the offer type AF, which surprised me a lot.** I mixed up the inquiry and the quotation in the logistics part."*

- On the other hand, fundamental knowledge gaps are also addressed. Participating study participants express themselves in this regard as follows:

  - *"Regarding **missing theoretical knowledge**, a corresponding research was made on the Internet."*

  - *"There is a **lack of background knowledge**. Deeper understanding of **taxes, for example. When is it full taxation or reduced?** Or how list prices are calculated. What are CpD accounts?*

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Quantitative results
TPACK

	All participants (n = 20)			Group 1 Lower self-assessment (n = 11)			Group 2 Higher self-assessment (n = 9)		
	t_0	t_1	Sign.	t_0	t_1	Sign.	t_0	t_1	Sign.
PK	3.8	3.8	ns	3.5	3.6	ns	4.1	3.9	ns
CK	3.9	3.8	ns	3.6	3.5	ns	4.2	4.1	ns
TK	**3.7**	**4.0**	*****	**3.1**	**3.9**	******	4.3	4.2	ns
PCK	3.7	3.7	ns	3.6	3.6	ns	3.8	3.9	ns
TPK	3.8	4.0	ns	3.7	3.8	ns	3.9	4.2	ns
TCK	3.3	3.5	+	**3.0**	**3.3**	*****	3.8	3.8	ns
TPCK	3.8	4.0	ns	3.4	3.8	+	4.2	4.1	ns

*** = $p < .001$, ** = $p < .01$, * = $p < .05$, + = $p < .1$, ns = not significant

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Quantitative results
TPACK

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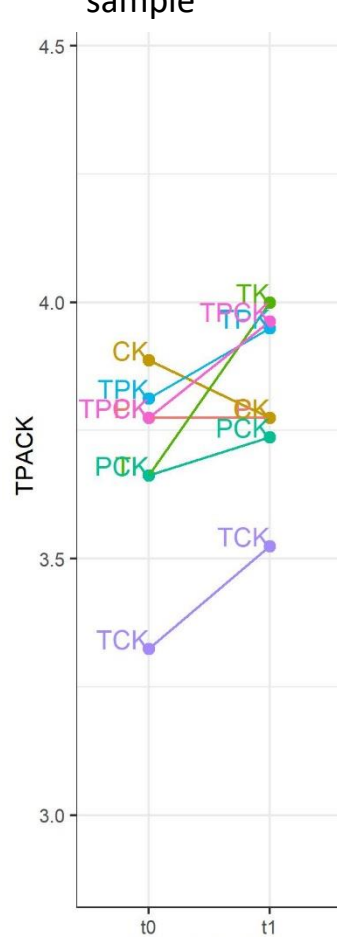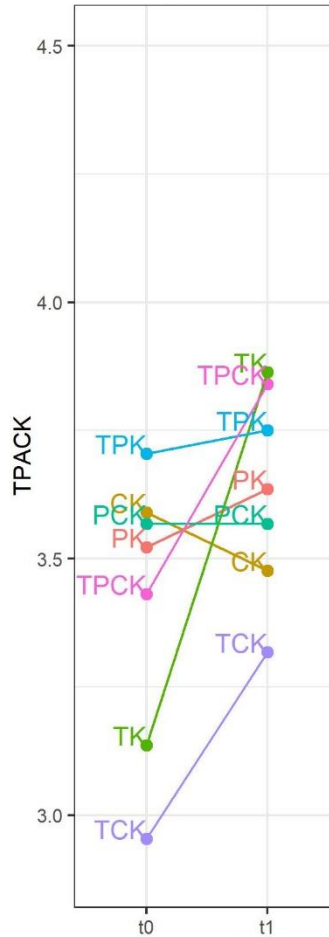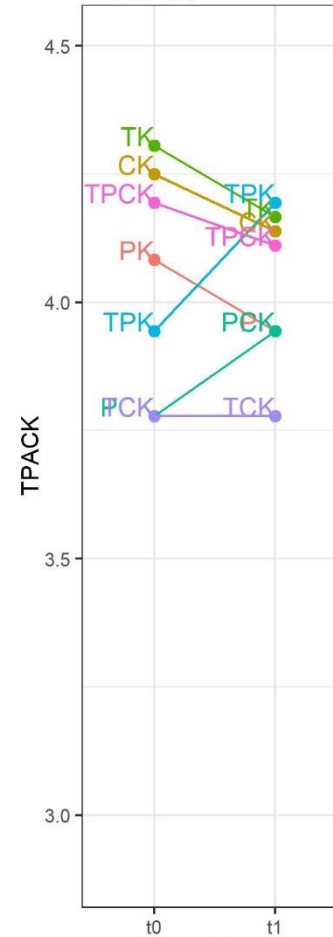
Methods
Materials SAP4school IUS

https://sap4school-ius.integrus.de/ueber-sap4school-ius/materialangebot.html

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3 Angebot an einen Kunden erstellen

Situation:

Ihre Vorgesetzte bittet Sie, aus der bereits eingepflegten Anfrage der NeckaRad GmbH (siehe Kapitel 2. Kundenanfrage bearbeiten) ein Angebot zu erstellen. Sie teilt Ihnen weiter mit, dass Angebote bei der Global Bike Deutschland GmbH grundsätzlich eine Gültigkeit von einem Monat haben.

Aufgaben:

1 Welche rechtliche Bedeutung hat ein Angebot, das an einen Kunden übermittelt wird?

2 Erfassen Sie das Angebot im SAP-System der Global Bike Deutschland GmbH und lassen Sie sich das Angebot als Druckansicht auf Ihrem Bildschirm anzeigen. Beachten Sie die Lösungshinweise auf den folgenden Seiten.

Lösungshinweise:

Angebot an Kunden im SAP ERP System erfassen
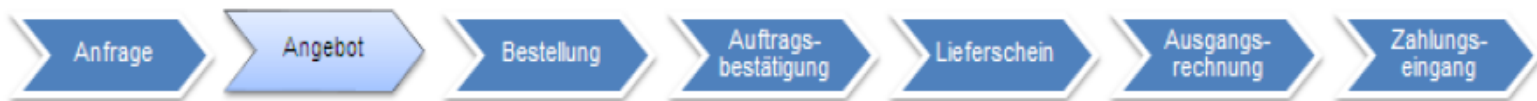
Die Transaktion zur Erfassung von Kundenangeboten befindet sich im Menüpfad

Logistik ▶ Vertrieb ▶ Verkauf ▶ Angebot

▶ Anlegen

Im Eröffnungsbildschirm der Transaktion

Appendix
Coding Manual Problem types

Problem type	Definition / Coding rule	Example
Instructions unclear	Problem description refers to task instruction.	*"Teil 2, Kapitel 1.2 Aufgabe 3. Ich weiß nicht, wonach genau ich hier suchen muss, also welche Änderung im Belegfluss ist hier wichtig? Ich weiß, wie man den Belegfluss anzeigt, aber ich weiß nicht, wonach ich dort suchen muss."*
Technical problems	Problem description refers to technical issues.	*"Bei der Anmeldung am SAP-System wurde das Passwort mehrmals falsch eingegeben."*
Procedure unclear	**The problem description refers to the uncertainty about the application or the next process steps.**	**"Aufgabe: Materialstammdaten - Der Ablauf der gesamten Aufgabe war mir zunächst völlig unklar. Erst nach dem Anschauen des Videos war der Bearbeitungsweg ersichtlich und verständlich. Fehlende Kenntnisse im Bereich der automatischen Bestellplanung, die für das Verständnis der Aufgabe sicherlich gut gewesen wären. Probleme bei der Umstellung vom Werk Heidelberg auf das Werk Hamburg bei der Prüfung des frei verwendbaren Bestandes".**
Other	Everything else.	*„Füge nur DE ein und bei mir kommt dann bei IBAN rauslassen DE25 und bei ihm DE47. Kein Problem, mehr eine Unklarheit."*

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Appendix
Coding Manual Solving Approaches

Solving Approaches	Definition /Coding rule	Example
Reflecting (systematic approach)	Problem-solving approach refers to a process of reasoning or systematic reflection.	*"Ich bin langsam durch alle Spalten gegangen, habe selektiv gelesen und alle Spalten, die mit V anfingen, länger gezogen, bis ich die Versandstelle gefunden hatte."*
Consulting competent others (e.g., assistance, guidance, instruction)	Problem-solving approach refers to other participants.	*"Ich habe eine Kommilitonin gefragt, worauf ich hier genau achten muss, weil ich es selbst nicht herausfinden konnte und es in den Bögen überhaupt keine Hinweise gab. Sie hatte sich die Videos zu der Aufgabe angeschaut und wusste daher genau, was gefordert war."*
Consulting codified information (e.g., guidelines, manuals)	Problem-solving approach refers to additional material like the instructions or videos.	*"Das ERP-System sagte mir, dass ich das Feld für die Steuerklassifizierung ausfüllen müsse. In dem Video wurde darauf hingewiesen, dass die Steuerklassifizierung für das System sehr wichtig ist.*
Trying out (e.g., experimentation, trial and error learning)	Problem-solving approach refers to a more random and unsystematic approach	*„Neu einloggen, und Browser neustarten. Problem bestand dann aber weiter. Pause eingelegt und dann später weitergearbeitet, dann war Maske identisch."*
Observing competent others (e.g., observing role models)**.**	Problem solving approach refers to the class instructor.	*"Ich habe die Tipps von Herrn Mayer befolgt, wie man durch eine relativ einfache Abfrage die generierten Belegnummern herausfinden kann."*

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Table 2

Descriptive statistics (*M, SD*), corrected item discrimination (*r*) and reliabilities (α/ω) of the final TPACK.xs questionnaire (28 items).

		M	SD	r	α/ω
Please rate the following statements.					
pk1	I can adapt my teaching based upon what students currently understand or do not understand.[a]	3.78	0.80	.71	
pk2	I can adapt my teaching style to different learners.[a]	3.64	0.88	.74	
pk3	I can use a wide range of teaching approaches in a classroom setting.[a]	3.72	0.84	.63	
pk4	I can assess student learning in multiple ways.[a]	3.51	0.88	.61	
PK.xs		**3.66**	**0.70**		.84/ .86
Please rate the following statements in relation to the subject in which you have written the lesson plan.*					
ck1	I have sufficient knowledge about my teaching subject.[b,c]	4.25	0.89	.60	
ck2	I can use a subject-specific way of thinking in my teaching subject.[b]	4.32	0.77	.59	
ck3	I know the basic theories and concepts of my teaching subject.[d]	4.32	0.70	.62	
ck4	I know the history and development of important theories in my teaching subject.[d]	3.78	0.94	.53	
CK.xs		**4.17**	**0.64**		.77/ .79
Please rate the following statements regarding digital technologies (computers, tablets, mobile phones, Internet, etc.).					
tk1	I keep up with important new technologies.[a]	3.38	1.19	.77	
tk2	I frequently play around with the technology.[a]	2.85	1.29	.82	
tk3	I know about a lot of different technologies.[a]	3.35	1.12	.82	
tk4	I have the technical skills I need to use technology.[a]	3.78	1.09	.72	
TK.xs		**3.34**	**1.03**		.90/ .92
Please rate the following statements with regard to teaching in which you do not use any special technologies or media.					
pck1	I know how to select effective teaching approaches to guide student thinking and learning in my teaching subject.[b,c]	3.80	0.78	.61	
pck2	I know how to develop appropriate tasks to promote students complex thinking of my teaching subject.[c]	3.84	0.79	.69	
pck3	I know how to develop exercises with which students can consolidate their knowledge of my teaching subject.[c]	3.93	0.77	.68	
pck4	I know how to evaluate students' performance in my teaching subject.[c]	3.80	0.86	.46	
PCK.xs		**3.84**	**0.63**		.79/ .82
Please rate the following statements.					
tpk1	I can choose technologies that enhance the teaching approaches for a lesson.[a]	3.68	0.93	.74	
tpk2	I can choose technologies that enhance students' learning for a lesson.[a]	3.55	0.96	.75	
tpk3	I can adapt the use of the technologies that I am learning about to different teaching activities.[a]	3.64	1.00	.73	
tpk4	I am thinking critically about how to use technology in my classroom.[a]	4.14	0.80	.32	
TPK.xs		**3.75**	**0.74**		.81/ .89
Please rate the following statements in relation to the subject in which you have written the lesson plan.*					
tck1	I know how technological developments have changed the field of my subject.[c]	3.48	1.10	.80	
tck2	I can explain which technologies have been used in research in my field.[c]	3.43	1.19	.85	
tck3	I know which new technologies are currently being developed in the field of my subject.[c]	2.97	1.24	.80	
tck4	I know how to use technologies to participate in scientific discourse in my field.[c]	3.10	1.15	.73	
TCK.xs		**3.25**	**1.04**		.91/ .92
Please rate the following statements in relation to the subject in which you have written the lesson plan.*					
tpck1	I can use strategies that combine content, technologies, and teaching approaches that I learned about in my coursework in my classroom.[a]	3.29	0.95	.70	
tpck2	I can choose technologies that enhance the content for a lesson.[a]	3.56	0.96	.73	
tpck3	I can select technologies to use in my classroom that enhance what I teach, how I teach, and what students learn.[a]	3.46	0.89	.79	
tpck4	I can teach lessons that appropriately combine my teaching subject, technologies, and teaching approaches.[b,c]	3.62	0.85	.65	
TPCK.xs		**3.48**	**0.77**		.87/ .90

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