



Heiko Holz, Can Küplüce, Angelin Gaißert, Ayesha Sadaf, Moritz Seibold, Luzia Leifheit | 30<sup>th</sup> German-American Research Symposium

# Development and Validation of a German Version of an Extended Intelligent-TPACK: The German Gen-Intelligent TPACK



Pädagogische Hochschule  
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# Development and Validation of a German Version of an Extended Intelligent-TPACK: The German Gen-Intelligent TPACK



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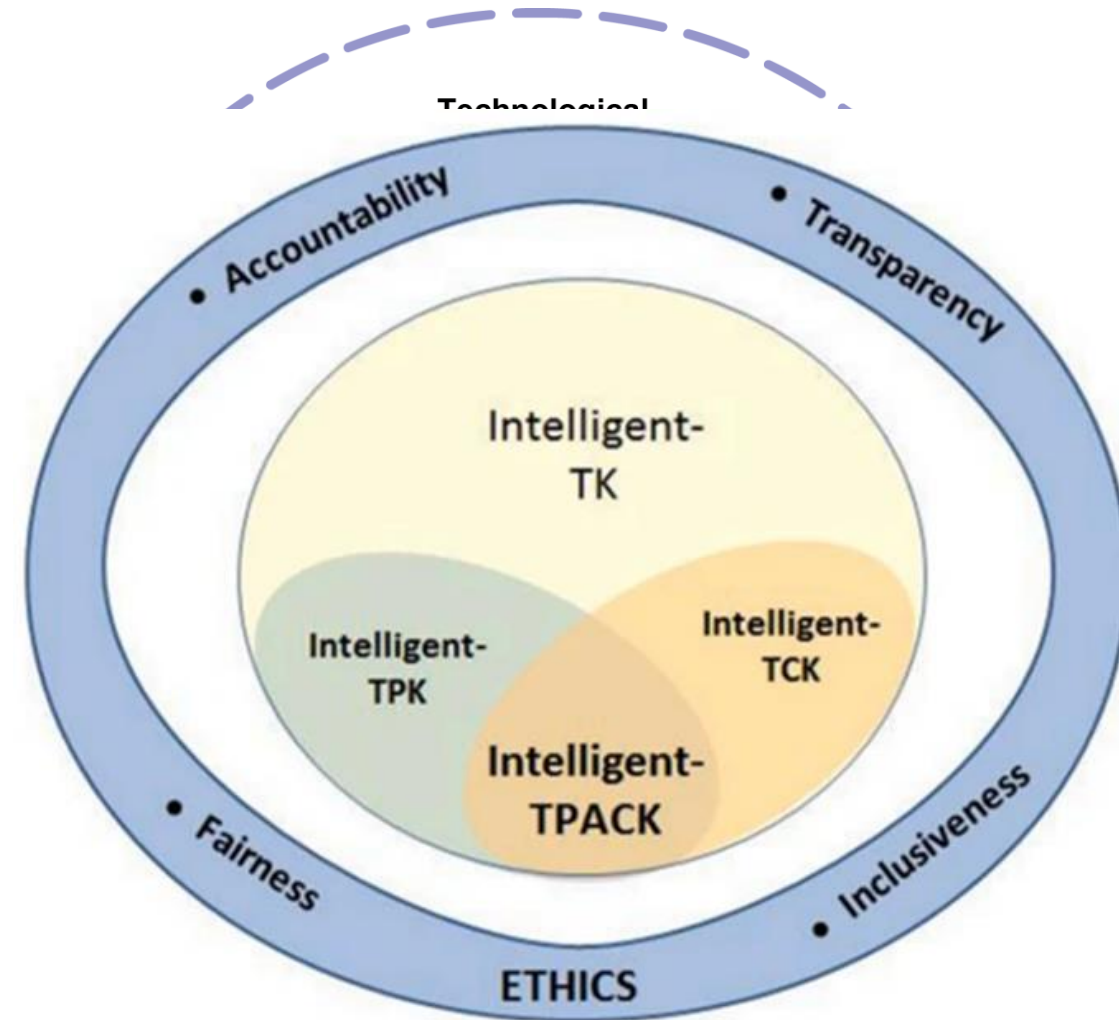
# What is the Intelligent-TPACK?

Intelligent-TPACK builds upon traditional TPACK principles:

- Technological Knowledge (TK)
- Pedagogical Knowledge (PK)
- Content Knowledge (CK)



- ethical and effective integration of AI-based tools in educational contexts
- deeper understanding of how AI technology interacts with subject-specific content knowledge and pedagogy



reference: Celik, 2023

# Background Intelligent-TPACK

extract

| title                                                                                                                                                            | source                              | focus                                                                                                        | languages                       |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|--------------------------------------------------------------------------------------------------------------|---------------------------------|
| Towards Intelligent-TPACK: An empirical study on teachers' professional knowledge to ethically integrate artificial intelligence (AI)-based tools into education | Celik, I. (2023)                    | teachers (29 - 38 years old, one large city) with experience in using EBA-platform (included AI-based tools) | Turkish translated into English |
| When TPACK meets artificial intelligence: Analyzing TPACK and AI-TPACK components through structural equation modelling                                          | Karataş, F.& Ataç, B. (2024)        | English preservice teachers                                                                                  | Turkish/English                 |
| Modeling teachers' acceptance of Generative Artificial Intelligence use in higher education: the role of AI Literacy, Intelligent TPACK and Perceived Trust      | Al-Abdullatif, A. M. (2024)         | university teachers                                                                                          | Arabian                         |
| Teachers' AI-TPACK: Exploring the relationship between knowledge elements                                                                                        | Ning, Y. et al. (2024)              | teachers that received systematic training in national AI technology                                         | Chinese                         |
| Preservice Teachers' Readiness Towards Integrating AI-Based Tools in Education: A TPACK Approach                                                                 | Bautista, A. et al. (2024)          | preservice teachers                                                                                          | English (Philippines)           |
| Analysis of factors affecting Intelligent-TPACK in the faculty of economics and business lecturers                                                               | Muhaimin, A.D. & Pahlevi, T. (2024) | lecturers (faculty of economics and business) of the State University of Surabaya (Indonesia)                | English (Indonesia)             |



There is no German version.

# Research Goals

- **Goal 1: Translation and Validation** of a German Version of the Intelligent-TPACK (Celik, 2023)
- **Goal 2: Extend** the German Intelligent-TPACK with items targeting GenAI



# TRANSLATING THE INTELLIGENT TPACK

TURKISH ↔ ENGLISH ↔ GERMAN

[voting.dots](https://voting.dots)

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We applied the **‘Modified Direct Translation’** that includes translators and experts discussing the wording until reaching agreement (Behling & Law, 2000)

1. Seven researchers and experts in AI ED translated the items independently
  - one English teacher
  - one student teacher (Computer Science and English)
2. Comparing all translations and marking the items that received different translations
3. Dot voting translations and discussing discrepancies in a group workshop
  - → a final version was agreed on
  - three items that were marked as questionable by the group were further discussed with a native Englisher teacher who teaches at the LUE

# Independent Translation

| Scale           | Item  | Original                                                                              | German Translation                                                                                          | Inspired By        |
|-----------------|-------|---------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------|--------------------|
| Intelligent TK  | Intro | Rate your confidence in using AI tools in your future classroom as a teacher:         | Bitte schätze deine Zuversicht ein, KI-Tools in deinem zukünftigen Schulalltag als Lehrkraft einzusetzen    |                    |
|                 | TK 1  | Technological Knowledge                                                               | Technologisches Wissen                                                                                      |                    |
|                 | TK 2  | I know how to interact with AI-based tools in daily life.                             | Ich weiß, wie ich mit KI-Tools im Alltag umgehen kann                                                       |                    |
|                 | TK 3  | I know how to execute some tasks with AI-based tools.                                 | Ich weiß, wie man einige Aufgaben mit KI-basierten Tools ausführt                                           |                    |
|                 | TK 4  | I know how to initialize a task for AI-based technologies by text or speech.          | Ich weiß, wie man eine Aufgabe für KI-basierte Technologien durch Text oder Sprache initialisiert / startet |                    |
|                 | TK 5  | I have sufficient knowledge to use AI-based tools.                                    | Ich verfüge über ausreichende Kenntnisse, um KI-Tools zu verwenden                                          | Godau et al., 2018 |
|                 | TK 6  | I am familiar with AI-based tools and their technical capacities and limitations.     | Ich bin mit KI-basierten Tools und ihren technischen Möglichkeiten und Grenzen vertraut                     |                    |
| Intelligent TPK | TPK 1 | I can understand the pedagogical contribution of AI-based tools to my teaching field. | Ich kann den pädagogischen Beitrag/Mehrwert von KI-basierten Tools für meine Fächer einschätzen             |                    |
|                 |       |                                                                                       |                                                                                                             |                    |

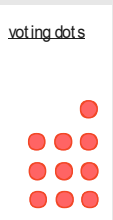
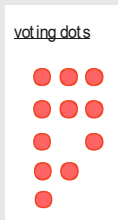


# Intelligent TPACK

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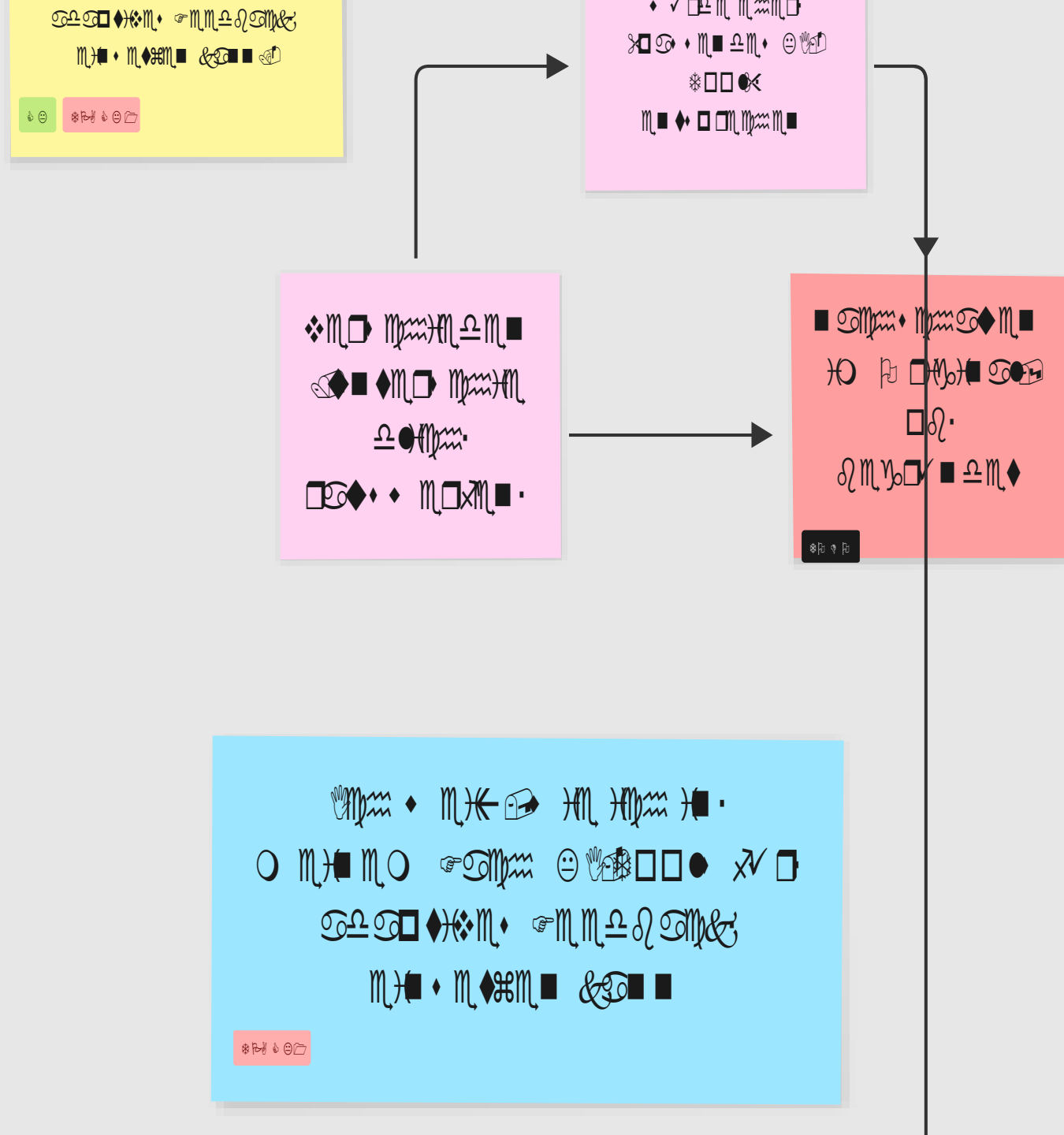
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voting dots



# Final Translation for Pre-Study

| Factor            | Item   | English “Original”                                                                                             | German Translation v1                                                                                                 |
|-------------------|--------|----------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------|
| Intelligent TPACK | TPACK1 | In teaching my field, I know how to use different AI-based tools for adaptive feedback.                        | Ich weiß, wie ich in meinem Fach KI-Tools für adaptives Feedback einsetzen kann.                                      |
|                   | TPACK2 | In teaching my field, I know how to use different AI-based tools for personalized learning.                    | Ich weiß, wie ich in meinem Fach KI-Tools für individualisiertes Lernen einsetzen kann                                |
|                   | TPACK3 | In teaching my field, I know how to use different AI-based tools for real-time feedback.                       | Ich weiß, wie ich in meinem Fach KI-Tools für unmittelbares Feedback einsetzen kann.                                  |
|                   | TPACK4 | I can teach a subject using AI-based tools with diverse teaching strategies.                                   | Ich kann ein Thema mithilfe von KI-Tools mit verschiedenen Lehr-Lernmethoden unterrichten                             |
|                   | TPACK5 | I can teach lessons that appropriately combine my teaching content, AI-based tools, and teaching strategies.   | Ich kann Unterricht gestalten, der meinen Fachinhalt, KI-Tools und Lehr-Lernmethoden sinnvoll miteinander verbindet   |
|                   | TPACK6 | I can take a leadership role among my colleagues in the integration of AI-based tools into our teaching field. | Ich kann in meinem Kollegium als Multiplikator oder Multiplikatorin agieren, um KI-Tools in unser Fach zu integrieren |
|                   | TPACK7 | I can select various AI-based tools to monitor students’ learning in my teaching process.                      | Ich kann KI-Tools auswählen, um den Lernfortschritt der Lernenden in meinem Unterricht zu verfolgen                   |

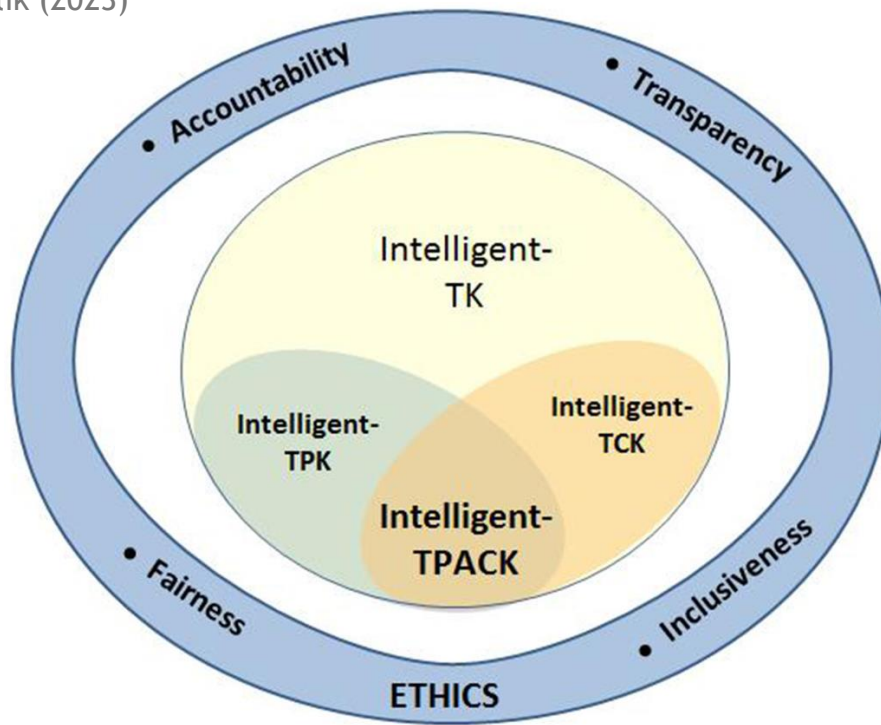


Fig. 4. Intelligent-TPACK Framework and its components.

# VALIDATION OF THE TRANSLATION

## VALIDATING THE GERMAN INTELLIGENT-TPACK

# Sample

- **N=259** pre-service teachers enrolled at universities in Baden-Württemberg  
– primarily LUE and SGUE

| Variable          | UNCC Study<br>N = 259     | UNCC Study + WoLKE Seminar<br>N = 405 |
|-------------------|---------------------------|---------------------------------------|
|                   | <b>M (SD) /<br/>N (%)</b> | <b>M (SD) /<br/>N (%)</b>             |
| <b>Age</b>        | 22.2 (4.3)                | 23.16 (5.5)                           |
| <b>Gender</b>     |                           |                                       |
| female            | 215 (83%)                 | 306 (76%)                             |
| male              | 42 (17%)                  | 95 (23.5%)                            |
| non-binary        | 0                         | 1 (0.2 %)                             |
| <b>Semester</b>   | 4.3 (2.8)                 | 5.2 (3.3)                             |
| <b>Studies</b>    |                           |                                       |
| BA                | 222 (86%)                 | 302 (75%)                             |
| MA                | 31 (12%)                  | 89 (22%)                              |
| BA Primary School | 165 (64%)                 | 177 (43.7%)                           |
| BA SEN            | 35 (13.5%)                | 35 (8.6%)                             |
| BA Sec 1          | 22 (8.5%)                 | 90 (20.2%)                            |
| MA Primary School | 12 (4.6%)                 | 34 (8.4%)                             |
| MA Sec 1          | 17 (6.6%)                 | 52 (12.8%)                            |
| MA SEN            | 2 (0.8%)                  | 3 (0.7%)                              |



# CFA of the German Intelligent-TPACK

- The CFA reached significance,  $X^2(314) = 784.16$ ,  $p = <.001$ .
- According to the model fit indices, the sample has an acceptable fit to the original five factor model.

| Model Fit Index | Value (ML) | Value (WLMSV) | Interpretation            |
|-----------------|------------|---------------|---------------------------|
| $X^2/df$        | 2.5        | 2.3           | good fit                  |
| RMSEA           | 0.076      | 0.071         | acceptable fit            |
| AGFI            | 0.92       | 0.98          | good fit                  |
| CFI             | 0.88       | 0.94          | moderate / good fit       |
| TLI             | 0.87       | 0.94          | marginal / reasonable fit |

# CFA of the German Intelligent-TPACK

- Composite reliabilities (CR) > 0.7 and average variance extracted (AVE)  $\gtrsim$  0.5 indicate convergence validity.
- Cronbach's  $\alpha \geq .7$  indicates acceptable scale for all translated factors
- Fornell-Larcker matrix indicates that
  - TK, TPK, and ETH can be discriminated well
  - TCK and TPACK not distinct enough

Discriminant validity of the German Intelligent\_TPACK: AVE and shared variances of the scales.  
Bold entries mark the highest AVE/covariance of each scale.

|       | TK           | TPK          | TCK          | TPACK        | ETH          |
|-------|--------------|--------------|--------------|--------------|--------------|
| TK    | <b>0.701</b> |              |              |              |              |
| TPK   | 0.322        | <b>0.589</b> |              |              |              |
| TCK   | 0.453        | 0.401        | 0.484        |              |              |
| TPACK | 0.376        | 0.506        | <b>0.529</b> | <b>0.651</b> |              |
| ETH   | 0.268        | 0.358        | 0.331        | 0.47         | <b>0.639</b> |

| Factor | Item      | $\beta$ | SE   | Cronbach's $\alpha$ | CR         | AVE        |
|--------|-----------|---------|------|---------------------|------------|------------|
| TK     | TK_01     | 0.85    | 0.03 | <b>.89</b>          | <b>.90</b> | <b>.70</b> |
|        | TK_02     | 0.90    | 0.02 |                     |            |            |
|        | TK_03     | 0.80    | 0.03 |                     |            |            |
|        | TK_04     | 0.82    | 0.03 |                     |            |            |
|        | TK_05     | 0.81    | 0.03 |                     |            |            |
| TPK    | TPK_01    | 0.66    | 0.04 | <b>.87</b>          | <b>.92</b> | <b>.59</b> |
|        | TPK_02    | 0.66    | 0.04 |                     |            |            |
|        | TPK_03    | 0.82    | 0.03 |                     |            |            |
|        | TPK_04    | 0.82    | 0.02 |                     |            |            |
|        | TPK_05    | 0.76    | 0.03 |                     |            |            |
|        | TPK_06    | 0.83    | 0.03 |                     |            |            |
|        | TPK_07    | 0.80    | 0.03 |                     |            |            |
| TCK    | TCK_01    | 0.75    | 0.03 | <b>.71</b>          | <b>.77</b> | <b>.48</b> |
|        | TCK_02    | 0.54    | 0.05 |                     |            |            |
|        | TCK_03    | 0.72    | 0.04 |                     |            |            |
|        | TCK_04    | 0.75    | 0.04 |                     |            |            |
| TPACK  | TPACK_01  | 0.85    | 0.02 | <b>.90</b>          | <b>.92</b> | <b>.65</b> |
|        | TPACK_02  | 0.84    | 0.02 |                     |            |            |
|        | TPACK_03  | 0.82    | 0.02 |                     |            |            |
|        | TPACK_04  | 0.76    | 0.03 |                     |            |            |
|        | TPACK_05  | 0.75    | 0.03 |                     |            |            |
|        | TPACK_06  | 0.76    | 0.03 |                     |            |            |
|        | TPACK_07  | 0.86    | 0.02 |                     |            |            |
| ETHICS | ETHICS_01 | 0.89    | 0.02 | <b>.79</b>          | <b>.90</b> | <b>.64</b> |
|        | ETHICS_02 | 0.89    | 0.02 |                     |            |            |
|        | ETHICS_03 | 0.76    | 0.04 |                     |            |            |
|        | ETHICS_04 | 0.64    | 0.06 |                     |            |            |

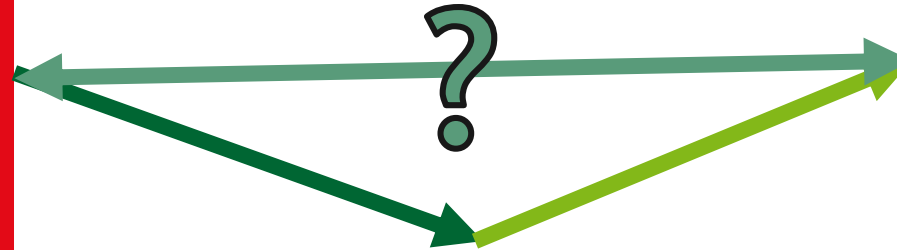
# Comprehensibility

| Item           | English “Original”                                                                                             | German Translation v1                                                                                                 | N <sub>V</sub> (%) | N <sub>T</sub> (%) |
|----------------|----------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------|--------------------|--------------------|
| <b>TPK 6</b>   | I can understand alerting (or notification) from AI-based tools to scaffold students’ learning.                | Ich kann Benachrichtigungen von KI-Tools verstehen, um das Lernen der Lernenden zu unterstützen.                      | 24 (9.3%)          | 27 (6.7%)          |
| <b>TPACK 1</b> | I can take a leadership role among my colleagues in the integration of AI-based tools into our teaching field. | Ich kann in meinem Kollegium als Multiplikator oder Multiplikatorin agieren, um KI-Tools in unser Fach zu integrieren | 26 (10%)           | 27 (6.7%)          |
| <b>TPACK 6</b> | In teaching my field, I know how to use different AI-based tools for adaptive feedback.                        | Ich weiß, wie ich in meinem Fach KI-Tools für adaptives Feedback einsetzen kann.                                      | 25 (9.7%)          | 31 (7.7%)          |

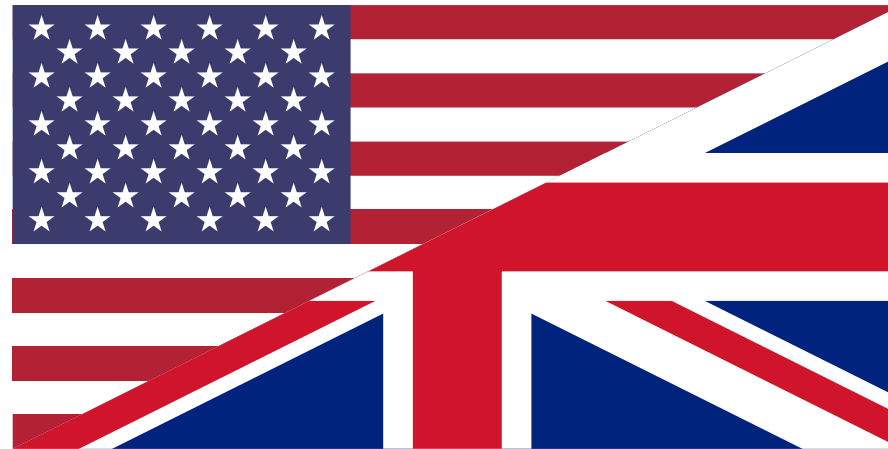
# Discussion



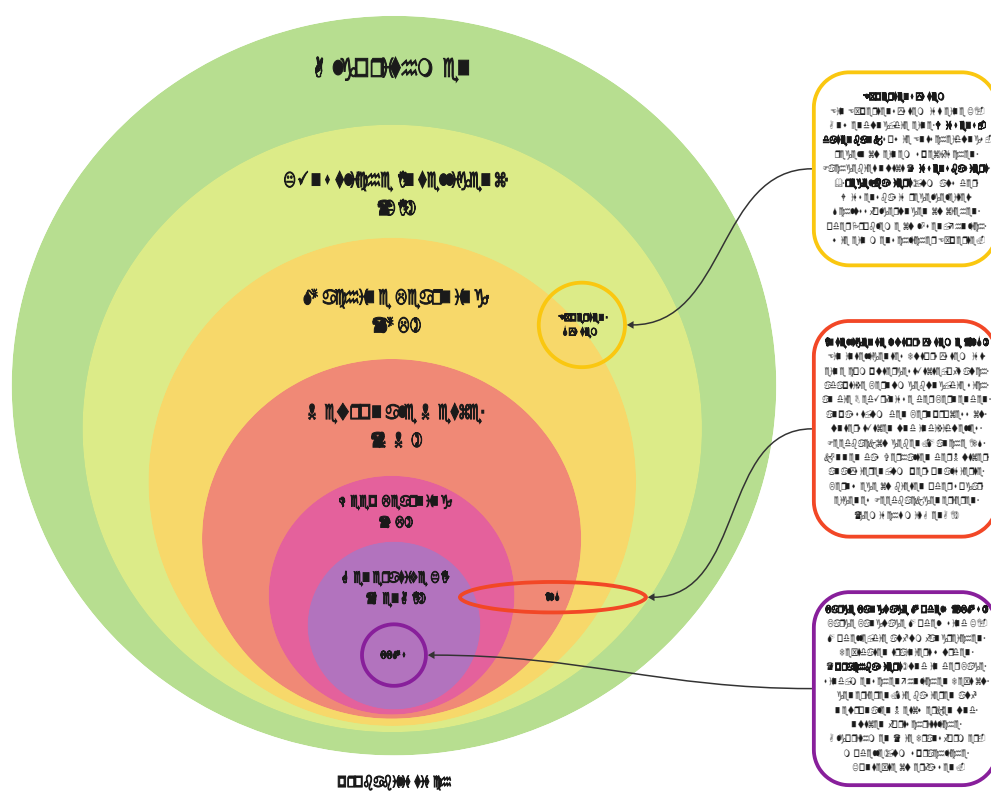
Validated in 2022  
in Turkish and English  
with Teachers in Turkey



Published in 2023



Translated in 2025



Pädagogische Hochschule  
Ludwigsburg  
University of Education

# EXTENDING INTELLIGENT-TPACK

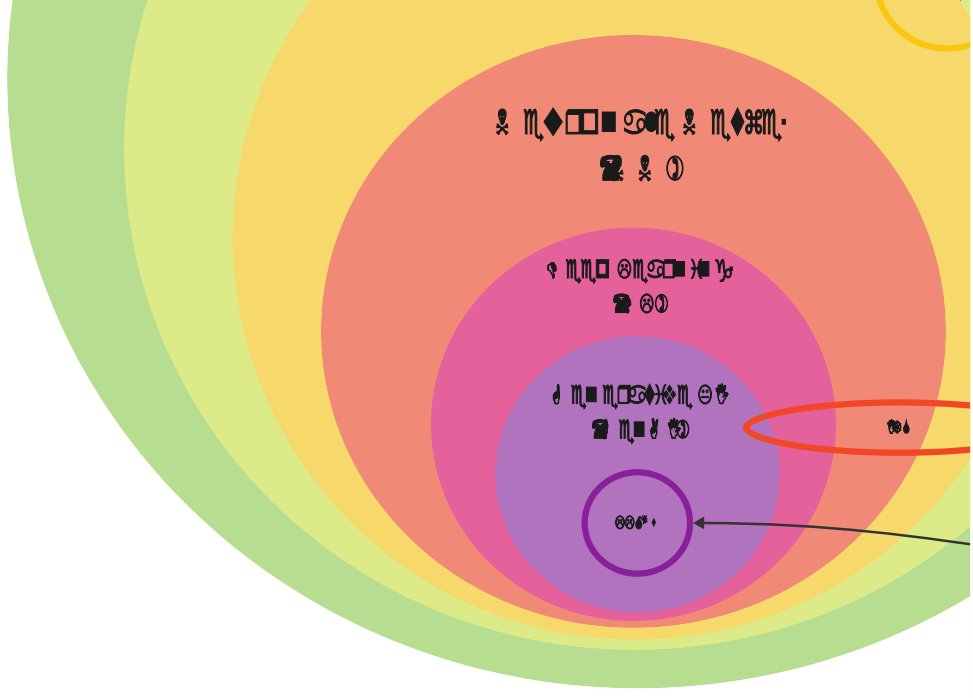
## DEVELOPMENT AND EVALUATION OF THE GERMAN GEN-INTELLIGENT-TPACK

මූලික මට්ටමේ දැනුම සහ අවබෝධය  
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# EXTENDING INTELLIGENT-TPACK

## DEVELOPMENT AND EVALUATION OF THE GERMAN GEN-INTELLIGENT-TPACK

# Extension of the Intelligent-TPACK

## German GenAI-Intelligent-TPACK

| Factor            | Item     | Original Scale     | English (Original / Translation)                                                                              | German Item                                                                                                                |
|-------------------|----------|--------------------|---------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------|
| Intelligent TCK   | TCK 5    | NEW                | I can assess to what extent the content generated with AI-based tools are correct and trustworthy.            | Ich kann beurteilen, inwieweit die von KI-Tools generierten Inhalte fachlich korrekt und vertrauenswürdig sind.            |
| Intelligent TPACK | TPACK 8  | NEW                | In teaching my field, I know how to use different AI-based tools to create teaching and learning material     | Ich weiß, wie ich für mein Fach KI-Tools zur Erstellung von Lehr- Lernmaterial einsetzen kann.                             |
|                   | TPACK 9  | NEW                | In teaching my field, I know how to use different AI-based tools to create exams and assignments.             | Ich weiß, wie ich für mein Fach KI-Tools zur Erstellung von Leistungsüberprüfungen einsetzen kann.                         |
|                   | TPACK 10 | NEW                | In teaching my field, I know how to use different AI-based tools for the assessment of exams and assignments. | Ich weiß, wie ich in meinem Fach KI-Tools zur Bewertung von (Prüfungs-) Leistungen einsetzen kann.                         |
| Ethics            | ETHICS 5 | Chiu et al. (2024) | I can teach students ethics related to AI use.                                                                | Ich kann Lernenden ethische Aspekte im Zusammenhang mit der Nutzung von KI-Tools vermitteln.                               |
|                   | ETHICS 6 | Chiu et al. (2024) | I can protect sensitive content from AI tools (e.g., exams, students' grades and personal data).              | Ich kann sensible Informationen (z.B. Prüfungen, Noten und weitere persönliche Daten der Lernenden) vor KI-Tools schützen. |
|                   | ETHICS 7 | Chiu et al. (2024) | I can teach students how to behave safely and responsibly when learning with AI tools.                        | Ich kann den Lernenden beibringen, wie sie sicher und verantwortungsvoll mit KI-Tools lernen können.                       |
|                   | ETHICS 8 | NEW                | I can assess to what extend AI-based tools reproduce bias                                                     | Ich kann beurteilen, inwieweit KI-Tools gesellschaftliche Vorurteile reproduzieren.                                        |



# CFA of the German Gen-Intelligent-TPACK

Similar results to the “core” Intelligent-TPACK

- According to the model fit indices, the sample has an acceptable fit to the original five factor model.
- Composite reliabilities (CR) > 0.7 and average variance extracted (AVE) > 0.5 indicate convergence validity.
- Fornell-Larcker matrix indicates that
  - TK, TPK, and ETH can be discriminated well
  - TCK and TPACK not distinct enough

| Model Fit Index | Core TPACK | Extended TPACK | Interpretation |
|-----------------|------------|----------------|----------------|
| $\chi^2/df$     | 2.3        | 2.8            | good fit       |
| RMSEA           | 0.071      | 0.084          | acceptable fit |
| AGFI            | 0.98       | 0.97           | good fit       |
| CFI             | 0.94       | 0.92           | good fit       |
| TLI             | 0.94       | 0.91           | reasonable fit |

Discriminant validity of the German Gen-Intelligent-TPACK: AVE and shared variances of the scales. Bold entries mark the highest AVE/covariance of each scale.

|        | TK         | TPK         | TCK          | TPACK        | ETHICS       |
|--------|------------|-------------|--------------|--------------|--------------|
| TK     | <b>0.7</b> |             |              |              |              |
| TPK    | 0.326      | <b>0.59</b> |              |              |              |
| TCK    | 0.47       | 0.407       | 0.441        |              |              |
| TPACK  | 0.375      | 0.488       | <b>0.519</b> | <b>0.647</b> |              |
| ETHICS | 0.31       | 0.346       | 0.382        | 0.434        | <b>0.533</b> |

# CFA of the German Gen-Intelligent-TPACK

## Factor loadings

- Composite reliabilities (CR) > 0.7 and average variance extracted (AVE) > 0.5 indicate convergence validity.
- Cronbach's  $\alpha \geq .7$  indicates acceptable scale for all translated factors

| Factor | Item     | $\beta$ | SE   | Cronbach's $\alpha$ | CR  | AVE |
|--------|----------|---------|------|---------------------|-----|-----|
| TK     | TK_01    | 0.85    | 0.00 | .89                 | .90 | .70 |
|        | TK_02    | 0.91    | 0.08 |                     |     |     |
|        | TK_03    | 0.79    | 0.07 |                     |     |     |
|        | TK_04    | 0.81    | 0.09 |                     |     |     |
|        | TK_05    | 0.82    | 0.09 |                     |     |     |
| TPK    | TPK_01   | 0.67    | 0.00 | .87                 | .92 | .59 |
|        | TPK_02   | 0.68    | 0.11 |                     |     |     |
|        | TPK_03   | 0.82    | 0.11 |                     |     |     |
|        | TPK_04   | 0.81    | 0.13 |                     |     |     |
|        | TPK_05   | 0.76    | 0.13 |                     |     |     |
|        | TPK_06   | 0.82    | 0.13 |                     |     |     |
|        | TPK_07   | 0.80    | 0.12 |                     |     |     |
| TCK    | TCK_01   | 0.73    | 0.00 | .73                 | .79 | .44 |
|        | TCK_02   | 0.53    | 0.10 |                     |     |     |
|        | TCK_03   | 0.69    | 0.09 |                     |     |     |
|        | TCK_04   | 0.72    | 0.09 |                     |     |     |
|        | TCK_05   | 0.62    | 0.08 |                     |     |     |
| TPACK  | TPACK_01 | 0.82    | 0.00 | .92                 | .97 | .65 |
|        | TPACK_02 | 0.82    | 0.09 |                     |     |     |
|        | TPACK_03 | 0.80    | 0.08 |                     |     |     |
|        | TPACK_04 | 0.76    | 0.09 |                     |     |     |
|        | TPACK_05 | 0.76    | 0.09 |                     |     |     |
|        | TPACK_06 | 0.75    | 0.08 |                     |     |     |
|        | TPACK_07 | 0.86    | 0.07 |                     |     |     |
|        | TPACK_08 | 0.76    | 0.10 |                     |     |     |
|        | TPACK_09 | 0.84    | 0.08 |                     |     |     |
|        | TPACK_10 | 0.85    | 0.08 |                     |     |     |

| Factor | Item      | $\beta$ | SE   | $\alpha$ | CR  | AVE |
|--------|-----------|---------|------|----------|-----|-----|
| ETHICS | ETHICS_01 | 0.85    | 0.00 | .85      | .92 | .53 |
|        | ETHICS_02 | 0.85    | 0.09 |          |     |     |
|        | ETHICS_03 | 0.72    | 0.08 |          |     |     |
|        | ETHICS_04 | 0.63    | 0.10 |          |     |     |
|        | ETHICS_05 | 0.63    | 0.10 |          |     |     |
|        | ETHICS_06 | 0.58    | 0.12 |          |     |     |
|        | ETHICS_07 | 0.77    | 0.09 |          |     |     |
|        | ETHICS_08 | 0.75    | 0.10 |          |     |     |

# Exploratory Factor Analysis (EFA) German Gen-Intelligent-TPACK

- We computed an exploratory factor analysis (EFA) on the items of the German Gen-Intelligent-TPACK, assuming five factors
  - TK (TP01) and Ethics seem to load on distinct factors
  - TPK (TP02) and TPACK (TP07) seem to load on the same factor
    - → higher-order factor?
  - TP03 (TCK) loading on multiple factors
  - poor communality for some items
- requires further investigation and possibly model re-specification

|           | ML1  | ML2  | ML3  | ML5   | ML4  | h2   |
|-----------|------|------|------|-------|------|------|
| TK_01     |      | 0.70 |      |       |      | 0.57 |
| TK_02     |      | 0.70 |      |       |      | 0.65 |
| TK_03     |      | 0.72 |      |       |      | 0.56 |
| TK_04     |      | 0.92 |      |       |      | 0.72 |
| TK_05     |      | 0.83 |      |       |      | 0.64 |
| TPK_01    | 0.31 |      |      |       |      | 0.38 |
| TPK_02    | 0.31 |      |      |       |      | 0.39 |
| TPK_03    | 0.61 |      |      |       |      | 0.54 |
| TPK_04    | 0.82 |      |      |       |      | 0.59 |
| TPK_05    | 0.59 |      |      |       |      | 0.47 |
| TPK_06    | 0.75 |      |      |       |      | 0.56 |
| TPK_07    | 0.63 |      |      |       |      | 0.53 |
| TCK_01    |      |      |      | 0.41  |      | 0.49 |
| TCK_02    |      |      |      |       |      | 0.22 |
| TCK_03    |      | 0.30 |      | 0.47  |      | 0.51 |
| TCK_04    | 0.52 |      |      |       |      | 0.40 |
| TCK_05    |      |      | 0.31 |       |      | 0.38 |
| TPACK_01  | 0.83 |      |      |       |      | 0.66 |
| TPACK_02  | 0.72 |      |      |       |      | 0.63 |
| TPACK_03  | 0.79 |      |      |       |      | 0.59 |
| TPACK_04  | 0.47 |      |      | 0.53  |      | 0.58 |
| TPACK_05  | 0.43 |      |      | 0.48  |      | 0.56 |
| TPACK_06  | 0.56 |      |      |       |      | 0.49 |
| TPACK_07  | 0.70 |      |      |       |      | 0.67 |
| TPACK_08  |      |      |      | 0.50  |      | 0.63 |
| TPACK_09  | 0.35 |      |      |       | 0.63 | 0.81 |
| TPACK_10  | 0.53 |      |      |       | 0.66 | 0.82 |
| ETHICS_01 | 0.32 |      | 0.75 | -0.34 |      | 0.69 |
| ETHICS_02 | 0.31 |      | 0.74 | -0.34 |      | 0.71 |
| ETHICS_03 |      |      | 0.47 |       |      | 0.40 |
| ETHICS_04 |      |      | 0.49 |       |      | 0.30 |
| ETHICS_05 |      |      | 0.67 |       |      | 0.46 |
| ETHICS_06 |      |      | 0.62 |       |      | 0.34 |
| ETHICS_07 |      |      | 0.59 |       |      | 0.52 |
| ETHICS_08 |      |      | 0.74 |       |      | 0.59 |

# DISCUSSION & OUTLOOK



The German Gen-Intelligent-TPACK confirmed the five-factor model and showed valid psychometric properties.

## Discriminant validity

- TPK and TPACK seem to load on the same factor
  - higher-order factor?
  - EFA for the German Gen-Intelligent-TPACK suggests further investigation
- **Lost in translations**
  - Did we lose information in the translation process from Turkish → English → German?

“From the teacher’s perspective, the accountability consideration requires teachers to **understand who the responsible people developing the AI-based technologies.**” (Celik, 2023, p. 4)

I can understand who the **responsible developers** are in the design and decision of AI-based tools.

Ich kann nachvollziehen, wer die **Verantwortlichen** hinter der Entwicklung von KI-Tools sind.

# Limitations & Outlook

## Limitations

- Sample: predominantly BA student teachers
- Answer scale: Celik (2023) used a 7-point Likert scale, whereas we only used a 5-point scale
- No back-translation into English, as the main goal was that the constructs are represented correctly in German

## Outlook

1. Collect data from MA student teachers.
2. Further analyze the German Gen-Intelligent-TPACK.
  - Item reduction?
  - Performing CFA with re-specified models including higher-order factors?
3. Write that paper!



# Outlook: AI (Ed) Literacy for elementary schools

PhD project (Angelin Gaißert)

## There is an AI for that - AI (Ed) Literacy:

a study on the use of Artificial Intelligence and AI Literacy  
in elementary school

- Development of an *AI Ed Literacy test*
- Survey and testing of elementary school teachers in Germany
- Interviews with elementary school children
- Development of recommendations for action



contact me

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# Summary

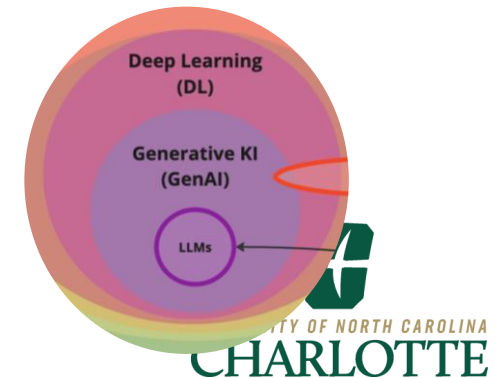
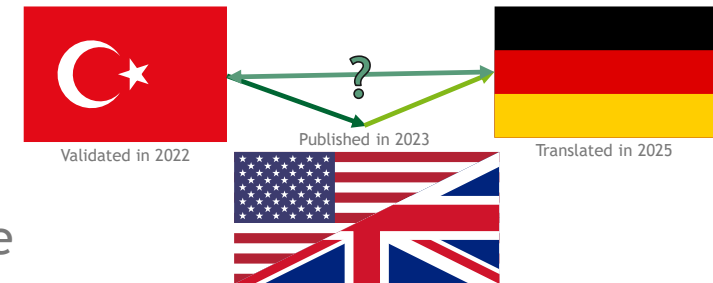
1. The Intelligent-TPACK by Celik (2023) is widely used to assess teachers' knowledge for pedagogical and ethical AI use based on the TPACK framework.
  - However, empirically validated translations of the Intelligent-TPACK are sparse, limiting its use among non-English researchers.





# Summary

1. The Intelligent-TPACK by Celik (2023) is widely used to assess teachers' knowledge for pedagogical and ethical AI use based on the TPACK framework.
  - However, empirically validated translations of the Intelligent-TPACK are sparse, limiting its use among non-English researchers.
2. The German Intelligent-TPACK seems a valid and reliable scale to assess (pre-service) teachers' TPACK about integrating (generative) AI into teaching in German-speaking samples
  - While model fit, internal consistency and convergent validity were acceptable, discriminant validity showed room for improvement.
3. The German Gen-Intelligent-TPACK, an extension covering competencies regarding GenAI, shows similar results.
  - Future analyses needed, specifically to investigate item validity and model specification



# References

- Boyle, E. A., Hainey, T., Connolly, T. M., Gray, G., Earp, J., Ott, M., Lim, T., Ninaus, M., Ribeiro, C., & Pereira, J. (2016). An update to the systematic literature review of empirical evidence of the impacts and outcomes of computer games and serious games. *Computers & Education*, 94(Supplement C), 178-192. <https://doi.org/10.1016/j.compedu.2015.11.003>
- Csikszentmihalyi, M. (1975). Beyond Boredom and Anxiety. *The Jossey-Bass Publishers*. <https://doi.org/10.2307/2065805>
- Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011). From Game Design Elements to Gamefulness: Defining „Gamification“. *Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments*, 9-15. <https://doi.org/10.1145/2181037.2181040>
- Dever, D. A., Sonnenfeld, N. A., Wiedbusch, M. D., Schmorow, S. G., Amon, M. J., & Azevedo, R. (2023). A complex systems approach to analyzing pedagogical agents' scaffolding of self-regulated learning within an intelligent tutoring system. *Metacognition and Learning*, 18(3), 659-691. <https://doi.org/10.1007/s11409-023-09346-x>
- Hainey, T., Connolly, T. M., Boyle, E. A., Wilson, A., & Razak, A. (2016). A systematic literature review of games-based learning empirical evidence in primary education. *Computers & Education*, 102, 202-223. <https://doi.org/10.1016/j.compedu.2016.09.001>
- Holz, H. (2020). *Design, Development, and Evaluation of Research Tools for Evidence-Based Learning: A Digital Game-Based Spelling Training for German Primary School Children* [Doctoral Thesis, University of Tübingen]. <https://doi.org/10.15496/publikation-51623>
- Holz, H., Ninaus, M., Schwerter, J., Parrisius, C., Beuttler, B., Brandelik, K., & Meurers, D. (2023). A digital game-based training improves spelling in German primary school children—A randomized controlled field trial. *Learning and Instruction*, 87(October 2023), 101771. <https://doi.org/10.1016/j.learninstruc.2023.101771>
- Liew, T. W., Mat Zin, N. A., & Sahari, N. (2017). Exploring the affective, motivational and cognitive effects of pedagogical agent enthusiasm in a multimedia learning environment. *Human-centric Computing and Information Sciences*, 7(1), 9. <https://doi.org/10.1186/s13673-017-0089-2>
- Meurers, D., De Kuthy, K., Nuxoll, F., Rudzewitz, B., & Ziai, R. (2019). Scaling Up Intervention Studies to Investigate Real-Life Foreign Language Learning in School. *Annual Review of Applied Linguistics*, 39, 161-188. <https://doi.org/10.1017/S0267190519000126>

# References

- Mohanty, A. (2016). Affective Pedagogical Agent in E-Learning Environment: A Reflective Analysis. *Creative Education*, 7(4), 586-595. <https://doi.org/10.4236/ce.2016.74061>
- Plass, J. L., Homer, B. D., & Kinzer, C. K. (2015). Foundations of Game-Based Learning. *Educational Psychologist*, 50(4), 258-283. <https://doi.org/10.1080/00461520.2015.1122533>
- Przybylski, A. K., Rigby, C. S., & Ryan, R. M. (2010). A Motivational Model of Video Game Engagement. *Review of General Psychology*, 14(2), 154-166. <https://doi.org/10.1037/a0019440>
- Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist*, 55(1), 68-78. <https://doi.org/10.1037/0003-066X.55.1.68>
- Vygotsky, L. S. (1986). *Thought and language*. MIT Press.



Thank You!



## Questions?

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