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Dispositions of Technological Knowledge in Teacher Candidates – an Analysis of Predictors

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ABSTRACT

In this paper, the impact of broader and more specific dispositions on technological knowledge (TK) in teacher candidates is analyzed. TK is the fundament on which the technological pedagogical and content knowledge (TPACK) model is built on. According to contemporary behavioral competence theory, the predictors will be tested as cognitive, affective and conative dispositions for TK. Thus, multiple regression models are utilized to test according predictors of performance based and self-reported TK as criteria (n = 460). In the first model, broader sense predictors such as general self-efficacy, basic motives, intelligence and personality are introduced as predictors. The second model adds more specific predictors such as technology commitment, motives, attitudes concerning information and communications technology (ICT). The third model adds private and study related technology use with different devices. A precedent base model controls for gender and age. For performance-based TK as dependent measure, the third model (R^2 = .261) indicates that intelligence (β = .197; p = .002), extraversion (β = -.143; p = .032), negative attitudes towards ICT (β = -.152; p = .033) and the private use of a PC (β = .176; p = .009) function as the most powerful predictors. In explaining self-reported TK, the second model (R^2 = .280) indicates that technology commitment (β = .330; p = .000) and negative attitudes towards ICT (β = -.142; p = .036) are predictors. In conclusion, the prediction pattern between performance-based and self-reported TK differs. An explanation might be a practice effect from actual technology use.

1. Introduction

The contemporary digital age demands according teaching practices to enable the next generation of citizens to safely and effectively navigate through the digital culture jungle. The widespread consensus to include Technological Knowledge (TK) in Shulman's model of pedagogical content knowledge (PCK) for teachers (Shulman, 1986, 1987) which is based on the TPACK Model (Mishra & Koehler, 2006) has led to the educational challenge to cultivate

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TK in teacher education curricula. TPACK stands for technological pedagogical and content knowledge and it represents the interface between technological pedagogical knowledge (TPK), technological content knowledge (TCK) and PCK (see figure 1). TK is theoretically conceptualized as a premise for TPK and TCK (Mishra & Koehler, 2006). As self-reports, this structure has also been empirically validated (Schmid et al., 2020). Therefore, TK seems crucial as a premise to facilitate successful integration of technology in teaching practices.

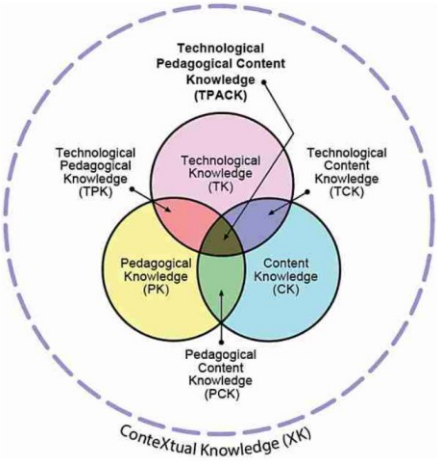

Figure 1: TPACK Structure
Source: Mishra (2019)

The definition of TK is threefold: (1) knowledge about standard technologies, (2) skills to use those standard technologies, (3) the ability to adapt to new technologies (Mishra & Köhler, 2006). Thus, TK is conceptualized multifaceted on cognitive, affective-motivational and behavioral levels. This is consistent with the contemporary competence as a continuum model (Blömeke et al., 2015). Therein, the analytic approach to measure competence by dispositions and the behavioral approach to measure competence by observable behavior are synthesized (see figure 2). This contribution is focused on an analytic approach in order to identify indicators for competence development optimization.

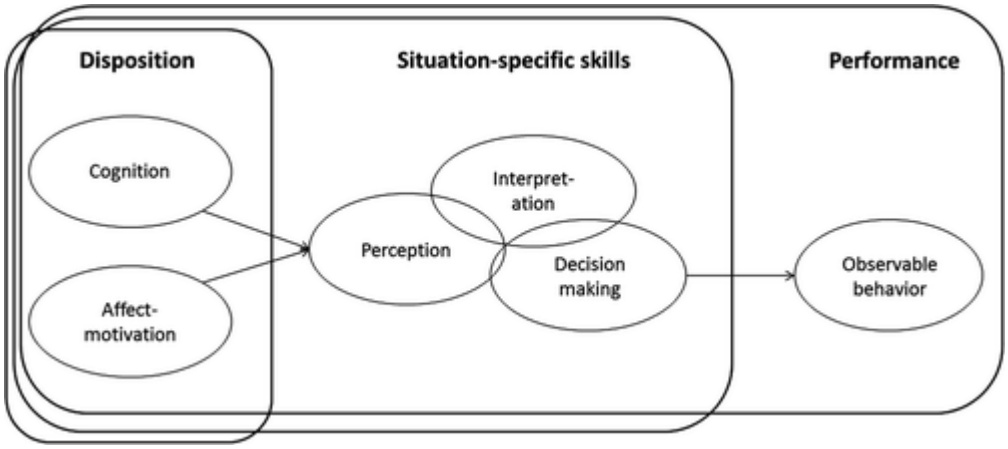

Figure 2: Competence as a continuum
Source: Blömeke et al. (2015)

The Will-Skill-Tool (WST) Model (Knezek et al., 2003) is used to predict the successful integration of technology in teaching practice with technological skills as a predictor (β = 1.08*). Attitudes towards technology predict the integration in comparison much weaker (β = .22*). Technological skills and attitudes are moderately related though (r = .51*). Drossel et al. (2018) support self-assessed digital teaching competencies as a predictor for the daily use

of digital media in teaching practice (β = .09*). Thus, it is evident that TK plays an important role for the successful use of digital media in the classroom.

However, there is a lack of research into the predictors of TK. One of the few studies, but also on students of the 7th grade rather than teacher candidates, found for example that ICT use at school (β = -.90***), perceived self-efficacy (β = .70***) and gender plays a role (β = .42***). In this contribution, general and specifically technological personal dispositions are analysed in their predictive power over self-reported and performance-based TK. As general personal dispositions, intelligence, general perceived self-efficacy, big-five, explicit basic motives were tested. As specific technological dispositions, technological commitment, computer related motive factors and general attitudes towards ICT.

1.1. Intelligence

Intelligence is a very controversial and complex construct with different scientific models of it. For our research, the Cattell-Horn-Carroll (CHC) model of intelligence was used. Hence, the focus was to observe the kind of intelligence that allows for problem solving independent of any prior knowledge. Within the CHC model of intelligence, this is Induction as a sub-domain of fluid reasoning. It is defined as "the ability to observe a phenomenon and discover the underlying principles of rules that determine its behavior" (Schneider & McGrew, 2012, p. 112). This kind of intelligence has been associated with training success, job performance and academic achievement (Heydash, 2014).

1.2. General Perceived Self-Efficacy

The general perceived self-efficacy construct contributes to performance independently of competence (Jerusalem & Schwarzer, 2002). It is defined as the subjective certainty to overcome new or difficult challenges that require effort and perseverance (Jerusalem & Schwarzer, 2002). It has also been associated with training success, job performance and academic achievement (Jerusalem, 2002). The similarity to self-reported competencies is controverse. Thus, self-reported competencies seem to only partially reflect actual knowledge or skill and are influenced by social desirability and potential metacognitive biases (Lachner et al., 2019). Therefore, analyses about the similarity between self-reported TK and performance-based TK will also be conducted.

1.3. Big-Five Model of Personality

The state-of-the-art personality model has five dimensions: extraversion, agreeableness, conscientiousness, emotional stability and openness to new experiences (Rammstedt, 2014). Singular dimensions and certain profiles have been found to be predicting many outcomes such as health, longevity, choice of career and job satisfaction (Rammstedt et al., 2014). Beyond, all except agreeableness are associated with basic literal and numerical competencies (Rammstedt et al., 2016; Rammstedt et al., 2017).

1.4. Explicit Basic Motives

Basic motives are thematically differentiated as referring to achievement, power and affiliation (McClelland et al., 1989). Also, there is a strong case for a fourth motive – autonomy (Alsleben, 2008). They are categorized into implicit and explicit. While implicit motives rather reflect unconscious stable needs, explicit motives rather reflect conscious unstable wants (McClelland et al., 1989). As for their predictive validity, implicit motives tend to predict general life choices such as the choice of a career whereas explicit motives tend to predict specific situational choices (Rothermund & Eder, 2011). Hence, the

achievement motive seems to be most closely related to competencies (Elliot & Dweck, 2013).

1.5. Technological Commitment

After Davis (1989) published the Technology Acceptance Model (TAM) that utilizes attitudes to predict the use of specific software, Neyer et al. (2012) adapt the TAM towards a personality-oriented disposition. Thus, they developed a three-dimensional scale: technology acceptance, technology competence and technology related locus of control. Now, the dimension of technology competence differs from competence self-reports in the way that it is operationalized through fear of use rather than a direct estimation of competence (e.g., "I'm afraid to fail when I use modern technology"). Studies on technological commitment reveal a close relationship with technological use (Neyer et al., 2016).

1.6. Computer Related Motive Factors

Senkbeil & Ihme (2017) conceptualized the computer related motive factors to bridge the gap between the software specific TAM and the atheoretical Uses-and-Gratifications Approach by Papacharissi & Rublin (2000). Thus, they categorized a variety of different uses into hedonistic and instrumental uses. The former are rather passive, less cognitively stimulating and for intrinsic purposes whereas the latter are rather active, more cognitively stimulating and for extrinsic purposes. The instrumental uses are associated with ICT literacy whereas the hedonistic uses are not (Senkbeil & Ihme, 2017).

1.7. General Attitudes towards ICT

According to studies about the TAM and WST model, technological attitudes are central for the prediction of media use (Scherer et al., 2019; Drossel et al., 2019; Pozas & Letzel, 2021). Within the WST model and also Rubach & Lazarides (2019) show that there is evidence of a relationship between digital competencies and attitudes. However, the analyses only considered self-reports and it has not been tested if there is a predictive relationship.

1.8. Hypotheses

According to the theoretical frameworks and empirical evidence, it is anticipated that self-reported TK and performance-based TK will differ in their prediction pattern as follows:

- H1: perceived self-efficacy, technology commitment and ICT attitudes are predictors of self-reported TK
- H2: intelligence, instrumental computer related motive factors, explicit achievement motive, technology commitment, general attitudes towards ICT and extraversion, conscientiousness, emotional stability and openness to new experiences are predictors of performance-based TK

2. Methods

2.1. Sample

In a cohort study design, a sample of teacher candidates enrolled in a teacher education program in Rhineland-Palatinate (Germany) is monitored. To date, N = 1248 participants are registered in the monitoring and will take part in three to four measurements. The analytic sample (n = 460) consists of those who took part in the first and the third measurement of the monitoring. This leaves about a year of time in between the measurements to identify

predictors. The majority of the subjects are between 18 and 22 years old, predominantly female, and studying to become primary or secondary school teachers (see figure 3).

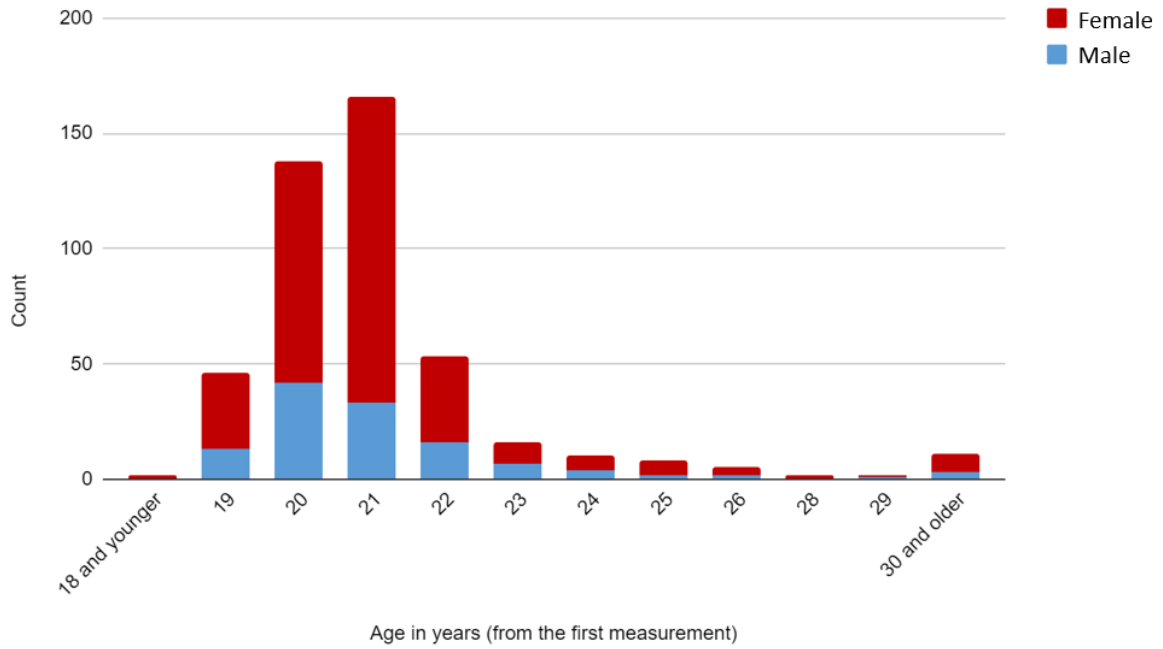

Figure 3: Sample Description

Comment: 360 are enrolled in the secondary school teacher program, 94 are enrolled in the primary school teacher program and 4 are enrolled in other teaching programs.

2.2. Instruments

2.2.1. Short Questionnaire for Measuring TPACK (TPACK.xs)

The 5-point likert scale for measuring TPACK by Schmid et al. (2020) consist of 28 items. It can be divided into 7 subscales: pedagogical knowledge, content knowledge, technological knowledge (e.g., "I keep up to date on important new technologies."), pedagogical content knowledge, technological pedagogical knowledge, technological content knowledge, technological pedagogical content knowledge. For further analysis, only the mean score of TK was used. The authors report a Cronbach's alpha of .90 for this subscale.

2.2.2. Technological Knowledge Performance Test

The performance test of technological knowledge is, alongside media didactics and media education, part of a project to model and measure media pedagogical competence by Herzig et al. (2015). The test consists of 26 items (e.g., "What information is stored in a Facebook activity log?"), each with 4 answer options and one "no answer" option. For further analysis, a sum score which indicates how many items were correctly answered was computed.

2.2.3. Hagen Matrices Test Short (HMT-S)

The short version of the Hagen Matrices Test consisting of 6 matrices by Heydasch et al. (2020) was applied. Respondents must identify the one missing piece of a 3x3 matrix by recognizing the underlying rules of a given pattern. The authors report an internal consistency of .62. For further analysis, a sum score indicating how many matrices were correctly completed was generated.

2.2.4. Scale for General Perceived-Self-Efficacy (SWE)

The 4-point likert scale used to measure general perceived self-efficacy expectancy by Jerusalem & Schwarzer (1999) consists of 10 items (e.g., "I can always manage to solve difficult problems if I try hard enough."). The authors report an internal consistency of Cronbach's alpha between .78 and .79. For further analysis, the items were then aggregated into a mean score.

2.2.5. Big Five Inventory (BFI-10)

The Big Five Inventory by Rammstedt et al. (2014) employed as a 5-point likert scale consists of 10 items. The retest reliability is between .49 and .84. For each of the five personality traits, namely, extraversion (e.g., "I see myself as someone who is outgoing, sociable."), agreeableness (e.g., "I see myself as someone who is generally trusting."), conscientiousness (e.g., "I see myself as someone who does a thorough job."), neuroticism (e.g., "I see myself as someone who gets nervous easily.") and openness to new experiences (e.g., "I see myself as someone who has an active imagination."), a mean score was calculated for further analysis.

2.2.6. Motive & Freedom Enactment Test (MET & FET)

The Motive and Freedom Enactment Test by (Kuhl, 2000; 2011) employed as a 4-point likert scale consists of 24 items. The test can be divided into four facets: affiliative motive (e.g., "I enjoy exchanging ideas with other people."), achievement motive (e.g., "When I have solved a difficult task, I like to look for the next challenge right away."), power motive (e.g., "Often, I really look for the confrontation with others."), and autonomy motive (e.g., "It is important to me to find personal meaning in everything I do."). For further analysis, a mean score for each of the subscales was generated.

2.2.7. Technology Commitment (TKB)

The 5-point likert scale for measuring technology commitment by Neyer et al. (2012) consists of 12 items. The scale includes three facets, namely technology acceptance (e.g., "I am very curious about new technical developments."), technology competence beliefs (e.g., "When dealing with modern technology, I am often afraid of failing."), and technology control beliefs (e.g., "Whether I am successful in using modern technology depends largely on me."), for which the authors report an internal consistency of Cronbach's alpha between .74 and .84. For further analysis, however, a mean score was created using all three subscales.

2.2.8. General Attitudes towards ICT

The 5-point likert scale for measuring general attitudes toward ICT was based on a scale based upon Vennemann et al. (2021). It was used in the International Computer and Information Literacy Study (ICILS). In the original, this scale contains 12 items, which we have shortened to 8. In addition, we adapted the item texts. It is divided into two subscales, measuring either positive (e.g., "digital technologies make life easier.") or negative attitudes (e.g., "Due to technological progress, we are losing too many jobs."). For further analysis, a mean score for each of the two subscales was generated.

2.2.9. Computer Related Motive Factors (FECAF)

The 4-point likert scale measuring computer related motive factors by Senkbeil and Ihme (2017) consists of 14 items. It can be divided into two subscales: hedonistic motives (consisting of entertainment, escapism, and social exchange; e.g., "I use computers and the

Internet to watch movies or videos.") and instrumental motives (consisting of information research, useful learn/work tools, and efficiency; e.g., "I use computers and the Internet to search for information on specific topics."). For further analysis, a mean score for each of the two subscales was generated.

2.2.10. Private and Study Related Media Use

Media use was surveyed in an item battery designed by us. For three types of digital devices (computer/laptop, mobile phone/smartphone, tablet), students were asked how frequently they used these devices study-related and privately ("On average, how many hours a day do you use the following digital devices in your studies and outside of your studies?"). The response scale ranges from "never", "up to 1h", gradually increasing to "up to 12h", to finally "more than 12h". Plausibility checks were used to check that device usages did not result in a day of more than 24 hours.

3. Results

To explore the predictors of teacher candidate's TK, hierarchical multiple regression analyses were calculated for (a) the self-reported and (b) the performance-based measurements. For each, four models were tested: (1) controlling for gender and age; (2) introduction of general personal dispositions; (3) introduction of specific technological dispositions; (4) introduction of device related media usage in private and study context.

3.1. H1: Self-Report Predictors

For self-reported TK, the multiple regression models revealed that age and gender as covariates in the regression equation explained a significant 3.2% of self-reported TK variance. General personal dispositions added a significant 8% of explained variance whereas the specific technological dispositions added very significant 16.8%. The actual media use only added an insignificant 2.2%. All predictors accounted for 30.2% of the self-reported TK variance (see table 1).

Concerning individual model predictors, gender and intelligence are the only significant predictors in the general second model. In the third model, the effect of gender is explained by technology commitment and negative attitudes. Furthermore, the explicit affiliative motive, extraversion and openness to new experiences are significant. Intelligence loses significance and magnitude. The addition of media use in the fourth model does not add significant R^2 value. However, it seems to account for all the general predictors since only technology commitment and negative attitudes remain as predictors of self-reported TK even though none of the media use variables turn out to be significant predictors.

3.2. H2: Performance-Based Predictors

As for performance-based TK, the multiple regression models show that age and gender as covariates in the regression equation explained a very significant 4.6% of performance-based TK variance. General personal dispositions added a very significant 13.3% of explained variance whereas the specific technological dispositions added an insignificant 3.4%. The actual media use only added a significant 4.8%. All predictors accounted for 26.1% of the performance-based TK variance (see table 2). It is noteworthy that the addition of the 3rd model shows suppression effects on big-five dimensions in both multiple regression analyses.

Table 1.
Standardized Regression Coefficients of Self-Reported TK predictors

n = 460	**Model 1**	**Model 2**	**Model 3**	**Model 4**
Gender	-.163*	-1.44*	n. s.	n. s.
Age	n. s.	n. s.	n. s.	n. s.
Perceived Self-Efficacy		n. s.	n. s.	n. s.
Affiliative Motive		n. s.	.142*	n. s.
Achievement Motive		n. s.	n. s.	n. s.
Power Motive		n. s.	n. s.	n. s.
Autonomy Motive		n. s.	n. s.	n. s.
Intelligence		.140*	.212***	n. s.
Extraversion		n. s.	-.138*	n. s.
Agreeableness		n. s.	n. s.	n. s.
Conscientiousness		n. s.	n. s.	n. s.
Neuroticism		n. s.	n. s.	n. s.
Openness		n. s.	.126*	n. s.
Technology Commitment			.330***	.297***
Positive ICT Attitudes			n. s.	n. s.
Negative ICT Attitudes			-.142*	-.138*
Hedonistic Motives			n. s.	n. s.
Instrumental Motives			n. s.	n. s.
Study Related Desktop Use				n. s.
Private Desktop Use				n. s.
Study Related Mobile Use				n. s.
Private Mobile Use				n. s.
Study Related Tablet Use				n. s.
Private Tablet Use				n. s.
R^2	.032	.112	.280	.302
ΔR^2	.032*	.080*	.168***	.022

Comment. * = p < .05; ** = p < .01; *** = p < .001

4. Discussion

The hypotheses based on previous research findings and theoretical frameworks referring to the prediction of competence could not be fully supported by our results. In case of H1, technology commitment and negative ICT Attitudes are significant predictors of self-reported TK but not perceived self-efficacy. This indicates that self-reported TK is not confounded with perceived self-efficacy. However, it could also mean that TK is not perceived as important by teacher candidates. For self-reported TK, the changes in model specific changes in R^2 indicates that specific technological dispositions are more crucial predictors than general personal dispositions. An implication is that for the facilitation of self-reported TK, the reduction of negative biases and anxiety to use ICT should be prioritized in teacher education. Hence, it seems that teacher candidates are still rather unenthusiastic about the use of digital media in general.

In case of H2, intelligence, explicit affiliation motive, extraversion, negative ICT attitudes and private desktop use are significant predictors of performance-based TK. On the one hand, instrumental computer related motive factors, the explicit achievement motive, technology

commitment, conscientiousness, emotional stability and openness to new experiences were contrary to expectations not predictive of performance-based TK. On the other hand, the affiliative motive and negative ICT attitudes are contrary to expectations predictors for performance-based TK. Intelligence, negative ICT attitudes and extraversion are the only predictors in accordance with the hypothesis.

Table 2.
Standardized Regression Coefficients of Performance-Based TK Predictors

n = 460	**Model 1**	**Model 2**	**Model 3**	**Model 4**
Gender	-.187**	n. s.	n. s.	n. s.
Age	n. s.	n. s.	n. s.	n. s.
Perceived Self-Efficacy		n. s.	n. s.	n. s.
Affiliative Motive		.128*	.142*	.132*
Achievement Motive		n. s.	n. s.	n. s.
Power Motive		n. s.	n. s.	n. s.
Autonomy Motive		n. s.	n. s.	n. s.
Intelligence		.245***	.212***	.196**
Extraversion		n.s.	-.138*	-.143*
Agreeableness		n. s.	n. s.	n. s.
Conscientiousness		n. s.	n. s.	n. s.
Neuroticism		n. s.	n. s.	n. s.
Openness		n. s.	.126*	n. s.
Technology Commitment			n. s.	n. s.
Positive ICT Attitudes			n. s.	n. s.
Negative ICT Attitudes			-.133*	-.152*
Hedonistic Motives			n. s.	n. s.
Instrumental Motives			n. s.	n. s.
Study Related Desktop Use				n. s.
Private Desktop Use				.176**
Study Related Mobile Use				n. s.
Private Mobile Use				n. s.
Study Related Tablet Use				n. s.
Private Tablet Use				n. s.
R^2	.046	.179	.213	.261
ΔR^2	.046***	.133***	.034	.048*

Comment. * = p < .05; ** = p < .01; *** = p < .001

In comparison to self-reported TK, the model specific changes in R^2 indicate that general personal dispositions are more crucial predictors for performance-based TK than specific technical dispositions. This could imply that certain personalities are more prone to performance-based TK than others. However, since personality is rather static, the implication for teacher education would be to select teacher candidates before their studies accordingly.

The explicit achievement motive and conscientiousness might not be predictive of performance-based TK because TK is not perceived as a relevant achievement domain. This would be in line with the lack of predictive power for perceived self-efficacy on self-reported TK. The explicit affiliative motive might be predictive of performance-based TK because TK might especially be the tool to affiliate in pandemic times. Instrumental computer related

motive factors might not be predictive because the reason as to why to use computers might not matter to performance-based TK in a time where the use of digital media is omnipresent.

It seems that these results support that TK self-reports only partially reflect TK ($r = .299$, $p < .001$) (Lachner et al., 2019). Even though it is more economic to use self-report scales in order to measure competence, it remains controversial to use it dominantly in order to research TK (Lachner et al., 2019). Additionally, given that practice makes masters, it is counterintuitive that actual media usage does not predict self-reported TK. However, there is also empirical evidence to support this observation (Lachner et al., 2019; van Ackeren et al., 2019).

5. Conclusion

In conclusion, a major difference in the prediction pattern of self-reported TK and performance-based TK was revealed. Thus, different implications arise to facilitate one or the other. Accordingly, teacher education may rid negative biases and anxiety to use ICT and optimize the selection of students for TK to flourish.

Further research could elaborate on these findings to (a) identify and differentiate higher and lower TK teacher candidate profiles for different treatments, (b) analyze the relationship between self-reported and performance-based TK and (c) test path analyses for a potential role of computer related motive factors in between private desktop computer use and performance-based TK.

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