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Information and communication technology and critical thinking in university students

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Abstract

The 21st century is referred to as the digital age, which places demands not only on the ability to work with information but also on being able to understand them as well as evaluate its relevance. The aim of this paper was to find out how ICT competences affect the individual domains of critical thinking in university students. The sample consisted of 624 university students. The data were collected using the Critical Thinking Disposition Inventory (CTDI) and the Information and Communication Technology Competence (ICTC). The results of the correlation analyses revealed weak to medium relationships among all of the observed domains. The subsequent linear regression models showed that all of the domains of critical thinking were affected by ICT competences. In this context, the most interesting was the effect of ICT competences on open mindedness while the effect on the remaining factors of critical thinking was weaker.

Keywords: critical thinking; CTDI; ICTC; information and communication technology; university students

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1. Introduction

The 21st century is a period of dynamic changes. The world is evolving under the influence of three main trends: revolutionary development of information and communication technology (ICT), transition to knowledge society and the new way of learning of the Net Generation. These trends emphasise the shift in the educational paradigm which calls for the need to develop new competences for individuals in knowledge-based societies (Lee, 2013). The pace of these changes has transformed the traditional role of the teacher who had previously been the only source of knowledge. The impact of the internet (and information and communication technology as such) on education supports the vision of open, global and flexible learning. In this educational environment the role of the teacher is to function as a guide to ensure a comprehensive learning process through modern technology and to manage the learning process using new educational models in the newly created virtual environments. Obviously, these trends require changes in the teaching and learning paradigm (Husain, 2010).

Information and communication technology allows the implementation of communication and education strategies and introduce new ways of teaching and learning by means of advanced management concepts (Díaz, Pérez, & Florido, 2011). ICT competences can be characterized as confident, critical and safe use of digital technology; these competences are associated with logical and critical thinking, high-level information management skills and well-developed communication skills (Hwa, 2016; cf. National Institute for Education, 2018; Torres-Gastelú & Kiss, 2016; Punie & Cabrera, 2006). Critical thinking is considered as an important skill necessary for (not only) higher education and at the same time as one of its objectives. A number of experts are convinced (for example Halpern, 2002; Pakdel & Ashrafi, 2019; Edwards, Snyder, & Sanders, 2016; Nickname & Royafar, 2019) that teaching critical thinking should be central to universities and that individual education programmes, activities, and the development and implementation of higher education policy in general should be centred around this skill.

The importance of this skill continues to increase in the 21st century, mainly in the context of the dramatically increasing amount of information (especially in relation to ICT) in the public as well as scientific space (for example Nickname, Royafar, 2019; Facione, 2015; Foundation for Critical Thinking, 2019; Meredith & Steele, 2010). The construct of critical thinking can be defined for example as a mindset that involves combining, analysing and evaluating information (Bailin et al., 1999), as a comprehensive assessment of what to do or what to believe (Facione, 2000) or as a form of reflective thinking to analyse and evaluate existing communication, information and arguments, particularly through logic and reason (Browne & Keeley, 2011, also Ennis, 2016). To date, a number of definitions and concepts of critical thinking have been developed, for example Facione (2000), Fisher (2001), Ennis (2016) and Klooster (2001) which, despite their differences, offer some common elements such as clarify meaning, analyse arguments, evaluate evidence, judge whether a conclusion follows, draw warranted conclusions (Hitchcock, 2017). In the context of education, it is then desirable to search for definitions that reflect the attributes of the education process. In this case, an appropriate concept seems Bloom's taxonomy of educational objectives, particularly its revision by Anderson (2013) who in the context of the progressing cognitive levels identified the two main dimensions: the basic knowledge domain (facts, concepts and procedures) and particularly the higher domain of cognitive processes including for example the capability of analysis, synthesis, evaluation and subsequent applications.

1.1. Purpose of study

As has already been mentioned, the 21st century places considerable demands not only on the ability to work with information and communication technology but also on the ability of an individual to understand the great influx of information, assess its relevance, truthfulness and usability. It can be assumed that the links between ICT competences and critical thinking in the field of education are

unquestionable and have been repeatedly confirmed by a number of research studies, see for example McMahon (2009), Rumpagaporn, Darmawan (2007), Topor (2017), Valencia-Molina, Serna-Collazos, Ochoa-Angrino et al, 2016, Methodological Portal of the Ministry of Education (2020) or Ahmad, Karim, Din, and Albakri (2013). However, there is a considerable space for further research in this dynamically developing area, whether in relation to the development of diagnostic methods, variability of respondent groups, other intervening variables or the applicability of the knowledge in practice, including the diversity of findings across countries and their policies in this area. The objective of the present paper is to identify the effect of ICT competences on critical thinking in university students. Specifically, the research focused on the effect of the different domains of ICT competences on the factors of critical thinking.

2. Method

2.1. Participants

The research sample consisted of undergraduate students of teaching professions and related disciplines. Specifically, the sample included 624 university students aged 19–55 (M=23±6) years of whom 528 were women (84.7%) and 96 were men (15.3%).

2.2. Data collection tool

The Critical Thinking Disposition Inventory (CTDI**;** Wang, Sun, Huang et al., 2019) is an instrument that measures the dispositions to students' critical thinking. The method includes 18 statements assessed on a 5-point Likert scale using 3 factors – open mindedness, systematicity/analyticity and truth seeking. The reliability of the CTDI was acceptable with α = .67, .59 and .64 for open mindedness, systematicity/analyticity and truth seeking, respectively.

The Information and Communication Technology Competence (ICTC, Torres-Gastelú & Kiss, 2016) is a 14-item questionnaire with a 4-point Likert scale that examines students' qualification in ICT using three factors (basic competences, application competences and ethical competences). The reliability of the ICTC was acceptable with α = .57, .71 and .68 for basic, application and ethical competences, respectively. The presence of individual competences (i.e., when students were perceived as competent) was defined as a score of 3 and more.

2.3. Analysis

The data were analysed using descriptive statistics, Pearson correlation analysis and multiple linear regression (forward method). Any 2-sided *P*<.05 was considered as statistically significant. The statistical analyses and data visualizations were performed using SPSS (v.21) and R (v.3.6.3) using ggplot2 (v.1.0.12) and ggpubr (v.0.4.0) packages. The research was conducted in accordance with the applicable ethical principles and the research statutes defined by the Ethics Commission.

3. Results

3.1. Sample characteristics

The basic characteristics of the sample are shown in Table 1.

Table 1: *Basic characteristics of the research sample*

		No	%
Sex			
	males	96	15.3
	females	528	84.7
Study type			
	teaching	358	57.4
	non-teaching	266	42.6

Study form			
	full-time	525	84.2
	Distant	99	15.8

3.2. Mean values for critical thinking and information and communication technology

The distributions of the ICT competences (ICTC) questionnaire and critical thinking (CTDI) questionnaire are shown in Table 2.

Table 2: *Mean values for critical thinking and information and communication technology*

	Mean ±SD
ICT competencies	
Core comp.	3.31 ±.39
Application comp.	2.42 ±.61
Ethical comp.	3.49 ±.45
Critical thinking	
Open mindedness	3.75 ±.52
Systematicity/analyticity	3.78 ±.51
Truth seeking	3.37 ±.57

3.3. Relationships between ICT competences (ICTC) and critical thinking (CDTI

The basic correlation analysis revealed significant relationships between all of the observed factors of critical thinking and ICT competences (see Table 3). The strength of the correlations varied between weak and medium.

Table 3: *Relationships between ICT competences (ICTC) and critical thinking (CDTI)*

	ICT competencies		
	Core	**Application**	**Ethical**
Critical thinking			
Open mindedness	.260**	.231**	.246**
Systematicity/analyticity	.248**	.280**	.157**
Truth seeking	.238**	.280**	.156**

***Correlation is significant at a level of .01.*

3.4. Effect of ICT competences on individual domains of critical thinking

Then a series of linear regression analyses (with ICT competences (ICTC) as the independent variable and critical thinking (CTDI) as the dependent variable) were performed (see Table 4 and Figure 1). The results showed that open mindedness was affected by ethical and core ICT competences while systematicity/analyticity and truth seeking were affected by application and core ICT competences. In this context, the most interesting was the effect of ICT competences on open mindedness (9.8% of explained variance). All non-standardized ß-coefficients were positive which means that with increasing ICT competences the degree of critical thinking increased as well. The effect of ICT competences on the remaining factors of critical thinking was weaker (8.4–8.7% of explained variance).

Table 4: *Effect of ICT competences on individual domains of critical thinking*

	R2	Adj. R2	F	P	Constant	Gradient	t	P
DV: Open mindedness								
Model	.102	.098	15.751	<.001	2.250			
Ethical ICT comp.						.191	3.280	.001
Core ICT comp.						.183	2.415	.016
Application ICT comp.						.093	1.998	.046
DV: Systematicity/analyticity								
Model	.091	.087	20.865	<.001	2.773			
Application ICT comp.						.172	3.705	<.001
Core ICT comp.						.178	2.437	.015
Ethical ICT comp.						.059	1.174	.241
DV: Truth seeking								
Model	.089	.084	20.195	<.001	2.292			
Application ICT comp.						.200	3.830	<.001
Core ICT comp.						.179	2.185	.029
Ethical ICT comp.						.062	1.234	.222

3.5. Regression lines with standard errors of effects of ICT competences on individual domains of critical thinking

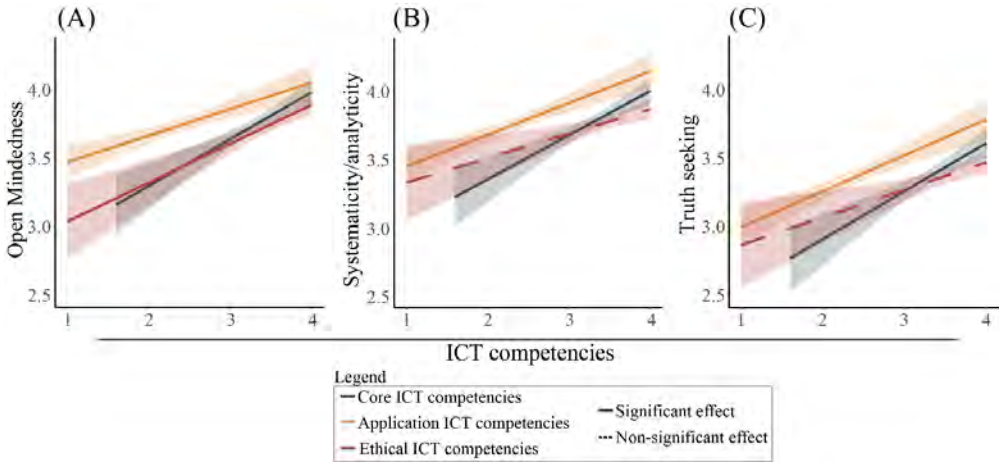

Figure 1. Regression lines with standard errors of effects of ICT competences on individual domains of critical thinking

4. discussion

The results show that the monitored constructs of ICT competences and critical thinking are closely correlated in virtually all of the domains. In this respect, our study confirms the findings of a number of other research studies that focused on these associations using different methodological approaches (type of research, research methods, research sample, etc.). It should also be noted that in some theoretical concepts of ICT competences, critical thinking appears as their inseparable part which in itself confirms the association between these constructs. The findings of this study point to the fact that the domains of critical thinking are affected not only by core ICT competences but also application and ethical ICT competences with the weakest correlation observed for ethical competences. At the same time, the degree of explained variance for the domains of the constructs is

relatively small (between 9.8% and 8.4%). It is therefore obvious that although the effect of ICT competences on critical thinking is indisputable, it does not reach the expected level. In this context, attention should be given to the designing of the methods that assess respondents' perceived level of ICT competences and critical thinking (for more information see the limitations).

At the same time, no data are available that would allow a comparison in the context of respondents' age or education (elementary, secondary or tertiary). In this context, it can also be assumed that the capability of critical thinking in university students is relatively robust (compared with students in lower levels of education) and is not so much affected by other factors including for example ICT competences. On the other hand, it should also be taken into account that in the case of most teaching disciplines (except for example teaching of technical (IT) subjects) and related disciplines (nursing, leisure time education, speech-language pathology, special education, etc.), university study does not place so much emphasis on thorough mastery of competences in the area of information and communication technology, which may be another reason for the relatively low effect of these competences on critical thinking (Edwards, Snyder & Sanders, 2016). After all, the analysis of ICT competences alone in the monitored sample of students suggested an average score of 3, which represents the lower limit indicating a sufficient presence of ICT competences (Křeménková, 2021). In this context, it would be interesting to make a comparison with for example technical or science disciplines. The above suggests that ICT competences can be seen as one of the prerequisites for the development of critical thinking with a number of other factors contributing to its overall level. At the same time, this relationship is likely to be influenced by the actual degree of achievement of both ICT competences and critical thinking skills.

5. Conclusion

There are several limitations of the study. The research sample consisted of undergraduate students of both teaching and non-teaching disciplines. The specific features of this research sample include the markedly disproportional gender structure with a high prevalence of women (however, this relatively precisely reflects the feminisation of Czech education), the structure of the courses taught and the professional profile of the students (prevailing humanities, social sciences and languages). This is also related to a certain "personality type" or "presence of specific personality attributes" in the students (predominance of heuristic rather than logical way of thinking and problem solving, greater emphasis on prosociality, etc.) who apply for these disciplines. The results of the study should therefore be related to this specific sample. Another limitation is related to the methods used, both of which assess the monitored areas of ICT competences or critical thinking based on respondents' self-assessment. In order to verify the results of the study, it would be desirable to analyse the constructs using other/additional methods that would allow a realistic assessment of their capabilities in these areas. Finally, the data are of a cross-cutting nature and do not allow a deeper analysis of the correlations or their transformations over time.

Considering the results of the current research, below are some recommendations for future studies and researchers. Regarding the results of the present study, further research should focus on additional factors that contribute to the development of critical thinking. In this sense, interesting results could be reached by analyses related to other types of thinking (reasoning), learning styles, structure of attitudes or selected personal characteristics (such as conscientiousness). Other recommendations have been mentioned above. These include particularly greater diversification of the research sample, whether in terms of the disciplines studied at higher education institutions or inclusion of lower levels of education (elementary and secondary schools). It would also be desirable to balance the research sample in terms of gender. At the same time, those methods should be included that allow the identification of more real "performance" or the condition in the monitored areas. The overarching concept and benefit would of course be the application of a longitudinal or at least semi-longitudinal research design.

The present study brought several findings. In the first place it confirmed the conclusions of a number of other research studies in the sense that there is a correlation between ICT competences and critical thinking. At the same time, it suggested the nature of these correlations and revealed that ICT competences affected critical thinking. A surprising finding was that the degree of explained variation was only below 10%. Generally, ICT competences are one of the factors, albeit not too strong, of critical thinking. In practice, these results mean that it is necessary to a) analyse in detail the relevant areas of the university environment and specific fields of study, b) develop students' ICT competences as well as the requirements for these competences defined by academics, c) develop critical thinking through other ways than only/primarily ICT competences.

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