

UNIVERSITY OF SZEGED

DOCTORAL SCHOOL OF EDUCATION

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**THE ASSESSMENT, MODERATED MEDIATING EFFECTS, AND  
INFLUENCING FACTORS OF CRITICAL THINKING DISPOSITION  
IN CHINESE UNDERGRADUATE STUDENTS**

DOCTORAL DISSERTATION SUMMARY

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## **Chapter 1. General Introduction**

### **The conceptualization of critical thinking (CT)**

From ancient times to the modern world, the concept of CT experienced various changes, (a) from the emphasis on what to do to how to critique, (b) from the usage in daily life first to specific domains and generic competence, and (c) from the property of fluctuation and vagueness to stability and clarity. Nevertheless, a consistent concept of CT cannot be achieved because of its abstract and complexity. However, owing to the development of the conceptualization of CT, the research on its framework summarized from the concepts and relevant studies were unfolded with frequent and deep analyses from the mid-to-late 20<sup>th</sup> century.

### **The framework of CT**

The development of the CT framework demonstrated its adequacy for its respective era context and the necessity for students' CT proficiency. Notwithstanding the relevance of the addition of critical thinking disposition (CTD), the earliness of the CT framework included just critical thinking skills (CTS) as its content may be the reason why researchers favored undertaking studies on CTS. The framework, which includes both CTS and CTD, is the foundation for contemporary studies on the CT concept, framework, assessment, component interactions, influencing variables, and classroom- or test-based CT ability with no proof for CT use in everyday life. As a result, the entire model, with CTD and CTS as theoretical inputs, PSs as practical outputs, and instructional interventions as upgrade pathways, should be accepted and improved in the near future.

### **The significance of CT facilitation**

Although the purposes of CT are different in the non-smart or smart world, the significance of CT facilitation is long-lasting and robust. Especially in the current era for undergraduate students, the knowledge learned in school is not enough to support their future work. Even if they do the best in their traditional courses and acquire adequate knowledge of history, math, physics, and so on, they cannot adapt to the new format of the workforce, identify the complex traps in the world of numerous fake news, and solve complicated problems with the challenge of AI machines that can memorize and calculate times better than humans, without CT ability. Thus, doing research on undergraduate students' CT is vital, especially today.

### **The research context**

The higher education of China, currently, is pursuing high-quality, student-centered, creative goals for the instructional outcomes of students, while, during this process, it ignored and lacked the focus on the base of this building (CT) that may cause the cost of more time and energy to achieve the expected goals. Consequently, the research regarding all aspects of CT within the context of China is necessary and significant to demonstrate the robust evidence for the inclusion of CT into the national educational policy and to provide clues, measures, and findings regarding students' CT characteristics for educators to develop CT courses and instructions in case of the achievement of the goal of fostering creative talents

### **The present dissertation**

As the complexity of CT, this dissertation cannot do research on all the aspects of CT. Thus, CTD was elected as the main construct in this dissertation. As the attitudinal disposition had been included in the concept of CT by Dewey (1910), CTD was also brought into the CT framework as aforementioned at almost the same time. However, CTD research was less

referred to than that of CTS, even till now, which may be caused by the lack of effective CTD instruments (Bravo et al., 2020; Quinn et al., 2020; Sosu, 2013) and by the dominant position of CTS as the ancestor of CT contents. Besides, the current consistent framework of CT consisting of both CTS and CTD is not enough and adaptable for the complex and fast-changing world. The current CTD and CTS assessments were more or less theorized only in the tests of schools without any evaluations of these abilities' suitability in daily life to solve scenario problems. In addition, the current CTD frameworks constructed with the building of its instruments can be summarized from three perspectives based on the review of the literature. They obtained inspiration from previous literature or studies, educators in or out of schools, and students without any opinions from the workforce.

Accordingly, this dissertation aims to (a) explore the effectiveness of problem-based learning methods (PBL, PSs) on CT and relationships between PBL and CT (both CTS and CTD) for the building of a new CT framework with both CTS and CTD and PSs, (b) design and validate a new CTD scale integrating the perceptions of employers and employees, (c) examine the relationships among each component of CTD including gender role in this process, and (d) the potential influencing factors of CTD.

### **The structure of this dissertation**

This dissertation will be organized according to the principle of the study-based thesis, in other words, the multi-study thesis. Six chapters will be listed in this dissertation. The first chapter (Chapter 1) and the last chapter (Chapter 6) are the general introductions, and the discussions and conclusions of this dissertation, respectively, and the main four chapters (Chapters 2 to 5) are the independent studies within the dissertation topic. All four papers included in this dissertation were all supervised by Dr. Attila Pásztor, and he is the co-author of all of them in charge of the supervision, funding acquisition, reviewing for revision, and editing.

## **Chapter 2. Study 1. Effects of problem-based learning instructional intervention on critical thinking in higher education: a meta-analysis**

### **Introduction**

CT, as certain higher-order thinking, has been regarded as a planned achievement of education in 2050 (International Commission on the Futures of Education Commission, 2021), which, when taught effectively, will promote logical problem-solving (Dwyer et al., 2011) and contribute to educational improvement, especially in higher education, and the job market. However, teaching CT to undergraduates is a major academic challenge (Kuhn, 1991; Willingham, 2010) because of the difficulties of embedding CT into an existing well-organized curriculum, infusing some valid tasks, and utilizing an effective teaching strategy (Dwyer et al., 2011). Problem-based learning (PBL), a student-centred approach, emphasizing learning by solving problems, has been suggested and used at the university level for developing CT in undergraduates. Most studies demonstrated the overall positive effects while some were negative. Thus, an elaborated literature review and meta-analysis are necessary to explore the inconsistency, overview the effectiveness, and detail the influencing factors of the effectiveness of interventions.

### **Literature Review**

CT has been considered one of the skills required in the 21st century (Trilling & Fadel, 2009), the facet of global competencies, and a core skill for 2030 (OECD, 2018). However,

providing a standard definition of CT is a challenging endeavour due to the complexity of CT as a psychological construct. However, various definitions outline similar broad dimensions. For example, CT, as reasoned, reflective thinking focused on deciding what to believe or do (Ennis, 2011), pertains to the capacity to evaluate statements (Lawson, 1999). In addition, it is deemed the purpose of instruction, in which students apply cognitive skills, such as forming hypotheses, designing, performing, and analysing a series of investigations (Dell'Olio & Donk, 2007; Gomez, 2002; Wiles & Bondi, 1989). Despite its complexity, most scholars (e.g., Elder & Paul, 2020; Ennis, 2011; Facione, 1990a; Halpern, 1998) agree that CT is dependent on skills and disposition.

Component skills that involve CT have been frequently discussed issues in the academe. The American Philosophical Association outlined six primary CT skills (Facione, 1990a): interpretation, analysis, evaluation, inference, explanation, and self-regulation. These skills laid the foundation for later versions, such as the dominantly proposed skills categories: (a) focusing on issues; analysing arguments; posing questions and answering; clarifying and challenging questions; judging the credibility of sources; and observing and judging assumptions (Ennis, 2011); (b) verifying hypotheses; providing verbal reasoning; identifying uncertainty and making decisions; and offering solutions to problems and creativity (Halpern, 1998); (c) utilizing creative thinking and CT; practicing decision-making; and solving everyday and mathematical problems (Perkins et al., 1993); and (d) conducting analysis, inference, induction, and evaluation (Adler, 2000). These skills are identified as crucial elements of CT.

Disposition, which is related to motivation and attitude toward acquiring CT skills, is regarded as a process that activates skills (Ennis, 2011; Norris, 2003; Perkins et al., 1993) and as attitudes or consolidated intellectual habits (Paul & Binker, 1990; Salomon, 1994). The consensus of the contents of disposition toward CT regards it as characterological or intellectual attributes, such as truth-seeking, open-mindedness, analyticity, systematicity, self-confidence, inquisitiveness, and maturity of judgment (Facione et al., 2000a, 2000b). Nevertheless, empirical studies on the disposition toward CT or the motivational aspects of this manner of cognition are scarce.

Several CT skills and disposition assessment tools have been formulated to evaluate and promote CT for undergraduates based on the dimensions above. Despite the existence of fruitful instruments, their effectiveness as used in different studies displayed varied results, which leads to the necessity to explore the effect size of each tool.

Education on CT remains controversial and confusing for many instructors (Bensley & Murtagh, 2012); however, consensus exists among researchers that CT can be taught and learned (Halpern, 2001). Students may improve their CT ability with the teachers' use of appropriate pedagogies and curriculum materials (Godzella & Masten, 1998; Halpern, 2001; McMillan, 1987), active learning strategies (Kim, 2009), and interactions among students and between students and instructors (Cooper, 1995; Howe & Warren, 1989). Thus, although most experts cannot demonstrate the effectiveness of specific approaches, instructional interventions are essential.

As a student-centered instructional approach, PBL mainly directs students' involvement in group study to solve ill-defined and open-ended problems using the following learning steps: analyzing problems, setting goals, collecting resources, summarizing ideas, and reflecting on problem-solving experiences (Lin et al., 2010). This process is designed to promote analytic

reasoning, problem-solving, and collaborative learning, which are components of CT. Thus, theoretically, PBL is regarded as a possible practical approach for developing CT due to the overlapping contents between PBL and CT. However, previous studies on the effect of PBL on CT in higher education demonstrated different results.

Several meta-analyses were also conducted to gain a general picture of the effect of PBL instructional intervention on CT in higher education, but the results were not consistent.

In summary, previous studies and meta-analyses exhibited different levels of effectiveness of PBL instructional intervention on CT, which may be due to the small samples, publication bias, or sensibility. Thus, a meta-analysis that focuses on a relatively large quantity of novel studies is necessary to obtain convincing and supportive evidence for the effectiveness of PBL on CT in higher education and the identification of influential factors.

This study, analyzing 58 effect sizes extracted from 50 studies published from the year 2000 to 2021, aims to collect articles about PBL intervention on CT cultivation in the 21<sup>st</sup> century to explore whether publication bias, heterogeneity, between-group variance, overall effectiveness, and sub-group effectiveness exist in these articles to provide a relative supplement and elaborated picture for future relevant research.

## **Methods**

Based on quantitative data, a meta-analysis can represent the general trend and forecast of recent, important empirical investigations. It is an effective method for summarizing and comparing empirical study findings (Card, 2015). Meta-analysis always begins with and incorporates systematic literature collecting. The systematic review and meta-analysis can provide summaries of the state of knowledge in a field, from which future research priorities can be identified; they can answer questions that individual studies would not be able to answer; they can identify problems in primary research that should be addressed in future studies; and they can generate or evaluate theories about how or why phenomena occur. As a result, systematic reviews yield varied forms of information for different review consumers (Gough et al., 2019; Gurevitch et al., 2018). Finally, 50 studies fulfilled the requirements Based on studies focusing on CT skills, CT disposition, or gender, we yielded 58 effect sizes with 5,210 participants from the 50 qualified studies.

## **Findings**

No evident publication bias was found (Egger's bias = 1.21,  $p > .05$ ). From the general perspective, the results demonstrate the high level of influence of PBL (Standardized Mean Difference [SMD] = .640,  $p < .001$ ) on CT with heterogeneity ( $I^2 = 82.9\%$ ) due to the adopted instruments, mixed methods, and target outcomes, and no difference was observed between influence on CT skills and disposition. Students' maturity, nationality, sample type, instruction type, and group size are influencing factors of overall CT. The effects of intervention for seniors, western students, randomized samples, online instruction, and groups with less than six members are better, whereas short-term intervention is ineffective. For CT skills, the treatments for juniors and groups with less than six members are ineffective, and sample type and instruction type are not influencing factors. However, the effect sizes of big sample sizes, seniors, other kinds of instruments, western students, Sciences as a discipline, more than ten members in a group, and long-term intervention are stronger. For CT disposition, sample type, instruction type, discipline, and intervention duration are influencing factors, in which randomized samples, online instruction, students in Medicine, and medium-term intervention

exerted a stronger effect than the other factors. In conclusion, although PBL is overall effective for promoting the acquisition of CT (skills and disposition), additional studies are also required to explore the effectiveness and influencing factors in other contexts, such as various learning or teaching strategies, environments, and scaffoldings, and scenario-problem-based tasks instead of only curriculum-based ones. These factors should also be considered to promote CT skills and disposition among undergraduates.

### **Chapter 3. Study 2. Design and validate the Employer-Employee-Supported Critical Thinking Disposition Inventory (2ES-CTDI) for undergraduates**

#### **Introduction**

The outbreak of the COVID-19 pandemic has caused a sharp decline in the global economy. This has been followed by increasing conflicts and slanders in politics, economy, and culture. Moreover, younger generations have been trapped by fake news. “The world needs critical thinkers now more than ever before, and not only is the sheer amount of information available to us undeniably overwhelming, but the accuracy of the information is suspect” (Butler & Halpern, 2020, p. 152). Accordingly, assessing CT to cultivate critical talents is imperative. In addition, employers throughout the world have been in search of those who exhibit CT (World Economic Forum, 2016). Ignorance at schools has resulted in inconsistency between students’ CT outcomes and labor market needs (Lane & Oswald, 2016; OECD, 2017). Cruz et al. (2021) found that CTD is more frequently mentioned (69%, and 39% respectively) in the workforce than CTS. Furthermore, employees, as the core of the labor market, have a clear understanding of dispositions of the market needs. However, there is a lack of instruments for assessing CT dispositions (Quinn et al., 2020). Moreover, consultation between employers and employees has not led to the development of such instruments. Consequently, it is crucial that a CT disposition assessment instrument be developed in accordance with employers’ and employees’ perceptions.

#### **Literature Review**

CT, a general term with the complexity and uncertainty of its definition, experienced three phases in the framework development: one-dimensionality of only cognitive skills, two-dimensionality of both cognitive skills and psychometric disposition, and a comprehensive model with skills and disposition as its input and problem-solving as its output. Although CT skills have dominated through the whole first phase, the disposition is regarded as the basis of skills. Despite mastering CTS, it is unlikely that they can be used without disposition (Valenzuela et al., 2011). However, studies have revealed the presence of the cognition-preferred bias that most scholars employ to assess CTS rather than disposition, which may result from the paucity of CTD assessment instruments (Bravo et al., 2020; Quinn et al., 2020; Sosu, 2013).

The dimensions in Delphi Report formed the basis of the CTD from which subsequent instruments were borrowed. However, ongoing discussions on components of CT dispositions are still prevalent. Differences related to categories of sub-dimensions and structure are evident. Although progress in the field has been made, the availability of reliable and valid CTD instruments remains limited. The procedure to develop a CTD inventory can generally be divided into three perspectives: literature-based, educator-based, and educator-student-based. While the first two perspectives have been dominant, instruments developed in consultation with employers and employees are lacking.

Accordingly, the purpose of this study was to design and validate a new CTD scale: The Employer-Employee-Supported Critical Thinking Disposition Inventory (2ES-CTDI).

### **Methods**

Intelligence accumulation (IA) was employed to synthesize the ideas from literature, 25 employers, 43 employees, and a six-person expert group. The interpretative structural model (ISM) was used to build the potential inventory. Validation data were collected from 661 undergraduate students (328 males, 49.6 %, Mean = 19.22, SD = 1.20 and 333 females, 50.4 %, Mean = 19.91, SD = 1.23) from China in 2021. Explorative factor analysis (EFA) was conducted for the consistency between the conceptual framework and data, confirmative factor analysis (CFA) and the common method variance (CMV) were adopted to check the model fit and structural validity, partial least squares structural equation modeling (PLS-SEM) was for identifying the mediating effects among CTD components, and item response theory (IRT) was utilized to evaluate the test endorsement and item discrimination.

### **Findings**

A three-factor 7-point CT disposition inventory was confirmed (three items in instant judgment, five items in self-efficacy, and 11 items in habitual truth-digging). The results revealed that the content and construct validities, as well as the model fit, were suitable for future use. The results further revealed that the inventory was appropriate to assess lower-average students' disposition. In addition, although the correlations between instant judgment and habitual truth-digging were not significant, they were mediated by self-efficacy.

## **Chapter 4. Study 3. Moderated mediating effects of gender among the components of critical thinking disposition in undergraduate students**

### **Introduction**

As a component of the CT framework, CTD is defined as the activation of critical thinking skills (CTS; Ennis, 2011; Norris, 2003; Perkins et al., 1993). Without the foundation of CTD, CTS cannot be mastered well. However, most studies preferred doing research on CTS to CTD because of its lack of assessment instruments. Furthermore, although some studies on CTD can be found, there are few studies on the relationships between CTD components and their gender-mediated effects. The exploration of the gender role is vital, which is an asset in all fields including education. Instructors should know if the gender difference exists in CTD instead of just the physiological difference to promote the CTD effectively. In addition, traditional group comparisons of latent means ignored the influence of scales, casting doubt on whether the difference is caused by scales or gender characteristic distinction. Thus, before performing comparisons, measurement invariance (MI) should be confirmed. Previous studies found fewer MI results for CTD inventories. Therefore, this study plans to determine the gender role in the relationships between CTD components in undergraduate students on the basis of MI results via a newly developed CTD tool.

### **Literature review**

CTD, the activation of the cognitive CTS (Ennis, 2011; Norris, 2003; Perkins et al., 1993), is the psychometric section of the CT framework. CTD can be regarded as the tendency, inclination, and willingness to think critically. Even while its framework varies throughout investigations, it largely maintains stability because practically all the CTD frameworks were drawn from the Delphi report (Facione, 1990b) and the California Critical Thinking Disposition Inventory (CCTDI; Facione & Facione, 1992).

Pintrich et al. (1993) built the Motivated Strategies for Learning Questionnaire that contained the subscale of CT, the intensive framework of which consisted of applying previous knowledge to new situations and giving evaluations. In his CTD questionnaire, Ricketts (2003) integrated the framework into innovation, maturity, and engagement. Yoon (2004) made a few adjustments to the framework of CCTDI, setting the framework into objectivity, prudence, systematicity, intellectual curiosity, intellectual fairness, healthy skepticism, and self-confidence. Sosu (2013) suppressed the framework into critical openness and reflective skepticism, establishing the critical thinking disposition scale (CTDS), and the adapted version of Bravo et al. (2020) proved better with the combination of Sosu's two domains into one factor.

The aforementioned frameworks were all influenced by earlier ideas, and two new frameworks were established that were not only based on literature but also input from students and teachers and employers and employees, respectively. Quinn et al. (2020) tested the framework in the Student–Educator Negotiated Critical Thinking Dispositions Scale, including reflection, attentiveness, open-mindedness, organization, perseverance, and intrinsic goal motivation. Liu and Pásztor (2022a) set up the framework of self-efficacy, instant judgment, and habitual truth-digging in their Employer–Employee–Supported Critical Thinking Disposition Inventory (2ES-CTDI), which is the newest CTD scale.

Therefore, even though the overall CTD results were obtained under different frameworks from different scales, they can still be considered collectively. However, since they have different subdimensions within the overall scale, the relationships among each subdimension will be completely distinct. Therefore, given the significance of the exploration of these relationships, this study will carry out the analysis within the newest scale 2ES-CTDI regarding the interactions among self-efficacy, instant judgment, and habitual truth-digging.

Most studies adopted CCTDI as the instrument to assess the gender difference in CTD for undergraduates. Some studies used other scales for CTD assessment, such as Ricketts' critical thinking disposition questionnaire (Ricketts, 2003), Yoon's critical thinking disposition scale (Yoon, 2004), Motivated Strategies for Learning Questionnaire (Pintrich et al., 1993), Critical Thinking Disposition Scale (Sosu, 2013), and 2ES-CTDI.

To sum up, just a few studies performed MI before comparing latent means, indicating the absence of MI testing in this sector, whereas most of the earlier studies investigated the gender difference in CTD without taking the MI into account, yielding a variety of results. Additionally, although there have been instances of inconsistencies, most studies have found that females performed better on both the sub-dimensional and overall CTD.

almost no studies explored the moderated mediating effects among the component of CTD with gender as the moderator. On the mediating and moderating effects among CTD components in undergraduate students, few studies have been conducted. Most earlier studies concentrated on how teaching strategies, psychological variables, or other abilities affected CTS and the overall CTD. In addition, previous studies demonstrated that emotional factors can affect human behavior so for a behavioral disposition (Damasio, 2000); the directions of these influences are different, positive or negative. Stedman and Andenoro (2007) found significant associations between emotional intelligence skills and CTD in undergraduate leadership students. Thus, this study assumed that the emotional factor (self-efficacy) could be set as the mediator among the components of CTD.

In light of the literature review, the current study intends to identify the gender role in the



whole and subdimensions of CTD via the instrument 2ES-CTDI based on MI. Accordingly, considering the necessity of the check of MI before gender difference and influence analyses, this study aims to investigate the reliabilities and model fits on the overall scale and across gender, determine the gender equality of the scale that was employed, explore the variation in latent CTD means across gender based on MI, and figure out the moderated mediating effects of gender across the CTD components.

## **Methods**

The study design consists of two phases: data collection and data analysis. The data collection was carried out in October 2021 in southwestern China. Four universities agreed to participate in this project. The selected scale was sent to the correspondent student counselors who are in charge of delivering the questionnaire to students via email, social media applications, or on-site in the classroom by scanning the QR code. The total distribution was around 800 undergraduate students, and 661 were submitted back. The rate of recovery was around 83%. The collected data then were retrieved from the online system for analysis.

Based on the research purpose regarding the gender role among the components of CTD, the data analysis procedure started from the exploration of the gender equality of the adopted scale via the MI method. While the invariance was obtained, the latent difference was investigated as the foundation of the moderating role of gender in the mediating effect model. Then, the mediating effect model was established and the influence of the moderator of gender was checked on each path.

## **Findings**

The results found that (a) the scale has high reliability and validity for measuring undergraduates' CTD. MI findings indicated that the configural and metric models were achieved, and the scalar model identified the partial invariance by freeing the intercepts of indicators A5, C7, and C8; (b) Females have stronger self-efficacy and habitual truth-digging disposition, whereas males have higher instant judgment; (c) Instant judgment has a negative influence on habitual truth-digging with self-efficacy as the competitive partial mediator, in which, gender moderated the relationship between instant judgment and self-efficacy. These findings, theoretically, proved the stability of the CTD framework of 2ES-CTDI, and practically, call for instructors to pay closer attention to the gender role in CTD cultivation.

## **Chapter 5. Study 4. Survey on the influential demographic factors of Chinese undergraduate students' critical thinking disposition: Evidence from plausible values**

### **Introduction**

The concept of CT is inconsistent because of its complexity, which can date back to Ancient Greece. With its evolvement, a comprehensive modern CT definition can be integrated into the deliberate and self-regulating judgment that resulted in interpretation, analysis, evaluation, and inference, as well as an explanation of the evidentiary, conceptual, methodological, criteriological, or contextual factors that underpinned that judgment (Facione, 1990b). Based on the abstract concept, a two-dimensional CT framework with CTS and CTD was established from the original one-dimensionality including only CTS. CTS, the competence-focused facet, generally comprises of the skills for interpretation, analysis, evaluation, inference, explanation, and self-regulation (Facione, 1990b). While CTD, the motivational and attitudinal facet of CT, is often regarded as the activation of CTS and the basis of CT (Valenzuela et al., 2011).

In addition, CT can be cultivated and improved via certain teaching methods, especially problem-based learning (Liu & Pásztor, 2022b), which requires instructors to pay more attention to the influencing factors of its effectiveness. Accordingly, Liu and Pásztor (2022a) extended the CT framework from the two dimensions of CTS and CTD to a comprehensive framework with CTD and CTS as the conceptual inputs and scenario problem-solving as the practical output (Liu & Pásztor, 2022a). This construct integrates effective instructional interventions to help students develop motivational disposition, mastery skills, and problem-solving skills. Although CTD and CTS, as the inputs, are both vital to solve problems, CTD is regarded as the basis of CTS, and, thus, CTS cannot be achieved without sufficient CTD (Valenzuela et al., 2011). Nevertheless, the level of CTD may be influenced by many factors which could affect the efficacy of CT interventions and development. Previous studies investigating the factors influencing CTD in undergraduate students yielded inconsistent results, often examining these factors based on raw scores without considering plausible values (PVs). Thus, this study explores the potentially influential factors (e.g., gender, year of study, major, parents' educational level, family income, residence, and type of university) on undergraduate students' CTD using PVs.

### **Literature review**

CTD, required for activating CTS, is a form of consolidated intellectual habit comprising the traits of inclination, propensity, tendency, and willingness to think critically (Ennis, 2011; Norris, 2003; Paul & Binker, 1990; Perkins et al., 1993; Salomon, 1994). Different frameworks are found in the literature. However, due to the problems of reliability and validity in previous studies, in both the original and adapted versions, the unified and shortened test versions were recommended (Liu & Pásztor, 2022a; Walsh & Hardy, 1997; Walsh et al., 2007).

The most frequently examined influencing factor on CTD in undergraduate students is gender, and participants involved in studies are medical students. However, the results are inconsistent. Other demographic factors were also explored.

For the single-factor variance analysis studies, Gezer et al. (2017) found no difference among nurses' ages, years of training, incomes, or educational levels via the CCTDI. Using Ricketts' critical thinking disposition questionnaire (Ricketts, 2003) with innovation, engagement, and maturity as subdimensions, no difference was identified across gender and marital status, but the statistical difference was found among year of study and interest in major in nursing students (Mousazadeh et al., 2021). Boonsathirakul and Kerdsomboon (2021) found no difference in gender and year of study via an adapted CCTDI. Similar results from Liu et al. (2019) demonstrated that no gender or age differences among nursing students.

However, the study by Park (2019) on nursing students via a self-developed scale found a gender difference in undergraduate students' CTD (Yeun et al., 2005). Yenice (2011) also identified a gender difference, although there was no difference by year of study level in preservice science teacher students. Walsh and Hardy (1999) found differences by gender in open-mindedness and maturity but not for overall CTD; additionally, there was a difference among majors, and nursing students performed better. Furthermore, a thorough meta-analysis by Liu and Pásztor (2022b) investigated the influence of gender, year of study, and major separately on CTD, and found no gender or year of study difference, while students in the Arts performed better than medical and science students.

For the multivariate regression and structural equation modeling studies, Wang et al. (2019)

performed a regression analysis by gender, age, and major, and found they significantly predicted CTD in medical undergraduate students, but only on some subdimension, such as open-mindedness, systematicity, and truth-digging. Zhang et al. (2010) conducted a regression analysis on the influence of gender, year of study, major, family information, census register, and another ten factors, finding that the basic five elements were unrelated to medicine and nursing students' CTD. Karahan and Iskifoglu (2020) conducted a prediction analysis of most demographic factors, concluding that mothers' educational level was predictive while age and fathers' educational level explained the smallest variance and family social level showed no influence among more than 1000 students from different majors. L. Huang et al. (2019) analyzed the influence of family socioeconomic status (SES) on medical undergraduate students' CTD finding that students from higher SES may have stronger CTD.

To summarize, the previous studies identified different results regarding the influencing factors of CTD based on the means of the raw scores without considering PVs. Thus, this study aims to explore the factors (gender, year of study, major, parents' educational level, family income, residence, and type of university) of potential influence on undergraduate students' CTD using PVs.

### **Methods**

This is a self-reported survey study in which formal agreement was received from both the research committee and the students. Following the recruitment of undergraduate students (661 Chinese undergraduate students with female students representing 50.4%), an online survey platform was used to collect data using a 7-point Likert scale (2ES-CTDI) with some demographic information items. After the re-coding of the raw scores of certain reversed questions, the instrument's reliability and validity were evaluated, and plausible values were created from the raw scores for further study based on the dependable measurement tool using the basic t-test, ANOVA, and linear regression models through dummy variable regression on the PVs.

### **Findings**

The findings revealed that when the factors were examined individually, CTD may vary by type of university, year of study, parents' educational level, and family income. However, when the factors were integrated into a comprehensive robust regression model, family income was identified as the unique factor influencing CTD, indicating that individuals from higher-income families exhibited higher CTD levels than students from lower-income families. Demographic factors accounted for 5%–10% of the variation. Future research should investigate additional factors that may substantially impact on college students' CTD. It is crucial for educators to acknowledge the disparities in CTD prevalence based on family income and devise an effective way to promote CTD among individuals from low-income backgrounds.

## **Chapter 6. General discussions and conclusions**

### **General discussions**

The systematic literature review and meta-analysis demonstrated fruitful results. The effectiveness of PBL can also be found in a previous meta-analysis by Liu et al. (2020) that PBL instructional intervention promotes both CTS and CTD effectively, though no between-group variance was checked in that study. Hence, the results from the study in this dissertation having conducted the variance exploration can be dependable and believable. In addition, the moderators also have been identified in the sub-group investigation in the meta-analysis. If

considered CT with both CTS and CTD together as a whole, the moderators were participants' maturity, nationality, instruction type, group size, and types of sample selection. Although no maturity results can be the support, common sense may provide a clue to prove the statement that the seniors' CT level was higher. The more experience in solving problems, the more CT can be acquired. The difference between Eastern and Western students may be caused by the emphasis on CT. The CT courses and assessments in Eastern countries are not regarded as a standard method embedded in their curricula (Leng & Lu, 2020; Li & Pan, 2019), especially currently, no such national emphasis on this issue in China. The online teaching method, as a new approach, may arouse more interest and enthusiasm in students to participate and study, which can be the reason why the CT level of students studying online was better. Group size decided the frequency of interactions while not the more, the better. The study found small and large group sizes were more effective than medium ones, which may be the reason that more time for interactions are for those in a small group and more peer collaborations are for those in a large group. Non-random samples may cause the basis bias that students in this sample may have a better CT basis, which was not easy to increase evidently. Thus, the large effect size of randomized samples can be understandable.

If considered separately, CTS and CTD should be the two different aspects, cognitive skills, and intellectual habit, respectively. For CTS, the moderators are maturity, nationality, instruments, discipline, group size, and intervention duration. The same tendency can be identified as that for CT regarding the moderators of maturity and nationality (Leng & Lu, 2020). The classic assessment instruments with a large number of investigations and robust structures can be understandable to function better for the evaluation of students' CTD as the same statement from Niu et al. (2013). Liu et al. (2020) examined 10 research and found no differences among the subjects. The current research, on the other hand, comprises 30 publications, which contended that students in sciences received slightly better treatment on CTS than students in arts and medicine. The explanation may be that students in sciences have greater expertise in logical thinking, which can help them acquire CT skills more effectively, but those in arts are adept at open-thinking, and the good effect size can be understood with the relatively lower start point of CT skills. Nevertheless, medical students' earlier focus tends to be operational skills rather than cognitive abilities, which may explain the lesser impact size. This study's findings on group size vary from that of Liu et al. (2020). Nevertheless, past studies on this topic lacked useful data due to a paucity of investigations. As a result, findings in this dissertation will be preliminary, demonstrating that a group with more than 10 members is superior for CTS development, the reason for which may be the same as that for CT. Just one study was included in the meta-analysis, the results cannot be generalized but it can be a clue that long-term intervention may be better for CTS, which was the same as the results in the study of Masek and Yamin (2011) but not Liu et al. (2020).

For CTD, sample type, instruction type, discipline, and treatment duration were found to be the moderators. It is the same inclination of CTD as those in CT and CTS for the results of sample type and instruction type, and accordingly, the reasons can be the same. While for majors, just one study existed on this issue, no generalization can be achieved. However, the students of arts performing better in CTD can be the same reason as aforementioned that this major leads people to emotional and intellectual enrichment which are within the scope of CTD. Besides, the result of the duration of intervention for CTD was quite different from CTS.

Oppositely to CTS, the medium one will be better and short ineffective for CTD, which is consistent with Liu et al. (2020)'s result. Possible explanations include the fact that, when compared to the results of CTS in terms of duration, the long-term intervention appears to be more effective; as a psychological disposition, longer treatment may consume this motivation; CTD cannot form during such a short intervention.

Based on the positive correlations between PSs and CT, the comprehensive CT framework was built with the CTD and CTS as the theoretical inputs and PSs as the practical output, among which, instructional interventions can be integrated into this model to enhance the acquirement. This CT framework was built driven by the fast-changing, globalized, and smart world, in which, students must master higher-order thinking in addition to using it in the real world for the avoidance of being replaced by AI machines. Based on the meta-analysis results, theoretically, this framework should work well. However, the practical model fit has not been checked in this dissertation because of the energy limitation as a Ph.D. candidate and the length requirement. Thus, the effectiveness of this model needs to be explored in future studies.

Regarding the complex CT framework, CTD was identified as the activation and stimulus of CTS with the paucity of its assessment instruments and without intelligence from the workforce. Thus, the 2ES-CTDI was built with good reliability, validity, and item and test endorsement from the perspectives of employers and employees for the usage in Chinese samples. This CTD framework, consistent with the scale structure including the need of the workforce, consisted of the inclination of CTD self-efficacy, instant judgment, and habitual truth-digging, which was agreed with the division of decision-making of Rutter and Brown (2019)'s and Kahneman (2011)'s. According to Rutter and Brown (2019), instant judgment is required to immediately reflect on issues, but additional thought is required to characterize the nature of these judgments, which testifies to the results of this dissertation that the competitive mediating effect of self-efficacy between instant judgment and habitual truth-digging. Furthermore, Self-efficacy, or inner self-confidence, is frequently generated by self-satisfaction, which may be favorably accumulated by rapid judgment, and vice versa (Leslie & Moilanen, 2010; Lugo et al., 2017). As a motivator, self-efficacy is positively related to routine truth-seeking, and increased self-efficacy may develop a high-level desire to seek the truth (Lei Huang et al., 2019). The act of seeking truth, which includes asking questions, discovering evidence, analyzing step by step, and assessing, is known as habitual truth-digging. It is a "time-consuming" approach that, theoretically, runs counter to immediate judgment and quick decision-making. This fight between instant judgment and habitual truth-digging needs to be balanced. Besides, CTD self-efficacy was also the content of CTD in previous studies like Quinn et al. (2020). Thus, although the CTD framework built in this study was new with the addition of knowledge of the workforce, with its acceptable model fit and validities, it can be concluded that this framework is stable and effective in Chinese samples.

With the support of the mediating effect of self-efficacy between instant judgment and habitual truth-digging, the study deepened its scope into the gender role in this relationship as a moderator. Ahead of the formal investigation, the gender equality of the scale via MI showed the partial scalar model could be achieved with the release of the intercepts of three items. To use this scale equally between gender, the item wording descriptions need to be careful in future studies since after investigation, the three items were found to be either impulsive or moderately temperamental, which may be recognized as a difference between females and

males. However, this partial scalar model can be enough for the analysis of gender differences and their moderated role. A probable explanation for the study's findings that females had a greater tendency in self-efficacy and habitual truth-digging while having a lesser disposition in quick judgment might be because females, in general, are dedicated, meticulous, and cautious. They can influence self-confidence and efficacy, which explains why males are more impulsive, and energetic, and do not pay as much attention to details, resulting in a greater quick judgment disposition, which is consistent with the statements in the studies of Lighthall et al. (2012), Reiter (2013), Tovmasyan (2020), and Singh et al. (2022). In addition, no gender moderation was identified in the linkages between immediate judgment and habitual truth-digging, or between self-efficacy and habitual truth-digging, but only in the route of instant judgment and self-efficacy. There are no previous studies for these non-significant moderation effects. However, gender differences have been examined in past research, such as the ones mentioned in this dissertation. Males may acquire more self-efficacy through the degree of instant judgment. However, females have a stronger disposition for self-efficacy and habitual truth-digging while lower in instant judgment. The same considerable gender influence may be discovered, as Lighthall et al. (2012) showed that males readily decided quickly, leading to sharply increased pleasure, indicating that males have a higher moderating effect on this path.

Jump out of the relationships among the components of CTD, this dissertation continued to explore the potential influencing demographic factors (family income, university property, parents' educational levels, residence property, major, grade, and gender) of the overall CTD. Despite the identification of university property, parents' educational level, and family income as the potential factors if considered separately, the results of the interactions of all the factors together may be closer to the truth. Eventually, the significant model with simply the element of family income as an influencer was determined. Previous research (e.g., L. Huang et al., 2019) indicated that students from higher-income households had stronger CTD among Chinese medical undergraduate students, indicating that the impact of family wealth is similar. Some research, however, found no difference in major demographic characteristics without investigating the impact of family wealth (e.g., Karahan & Iskifoglu, 2020; Zhang et al., 2010). The plausible explanations for why students from higher-income families will have stronger CTD are as follows: (a) Students from higher-income families can easily and instantly touch novel things, such as smart equipment or updated news, which can stimulate their disposition to recognize the value and effectiveness and promote their deep and logical thinking to solve the problems caused by these new things experiencedly; (b) Generally, the level of the society People with lesser status may be less confident in making a quick and proper assessment and decision, considering the prospective implications of having less money and giving it up; (c) Higher-order thinking training may begin sooner for students from higher-income families. Students have greater possibilities to learn about the necessity of critical thinking in the twenty-first century and may participate in thinking training throughout their early years.

### **General limitations and future directions**

This research discussed and guaranteed the effectiveness of PBL on CT promotion based on the summary of previous empirical studies, which can be regarded as evidence for the construction of the comprehensive CT framework including CTS, CTD, and PSs. However, limited by the energy of a Ph.D. candidate and the length of the dissertation, this dissertation cannot assess all three variables together to investigate this model fit and suitability.

Accordingly, if possible, future research can do a thorough study to collect data for the same participants on their CTD, CTS, and PSs to check the model to provide more information and evidence for the complex framework.

Besides, the classifications of moderators in the meta-analysis and regression analysis can be a point to be stated, though this may not be a limitation but a scientific fact especially for social sciences research to have consistency in the categories. Nevertheless, the notice should be emphasized for future research that it is better to cut the target into pieces while categorizing it based on previous studies instead of being maverick.

Moreover, the newly developed 2ES-CTDI, constructed with the intelligence from the workforce, has testified to be reliable and valid for the assessment of undergraduate students' CTD, whereas the employers, employees, and student participants were all from China. Although the validation in Hungarian undergraduate students has also been proved its dependence (Liu, Pásztor, & Molnár, 2023, under review), its adoption in different contexts in the future should be realized on the investigation of its suitability for students from different countries for the wider usage.

In addition, technically, the studies in this dissertation adopted both classical and probabilistic test theories (CTT and PTT), but the shortcomings of CTT can be seen. This is not to degrade the function of CTT since it does generate robust proofs for findings and can be understood and carried out easily despite its dependence on samples, the false independence between true and mean scores, and the linear relationships between true and observed scores. However, it is better to use PTT for future relevant research to avoid the effect of samples and keep objectivity that students' ability level must be independent of the tasks' difficulty level (Lord, 1980).

Furthermore, CTD should be paid more attention to as the foundation and activation of CTS. This dissertation only focused on some small tips of the iceberg regarding the relationships among CTD components, gender roles in this process, and the demographic influencing factors and moderators without any references to other elements, such as longitudinal research, an intervention, or other influential moderators and mediators. Thus, future studies can deepen the CTD exploration into more valuable perspectives to demonstrate more findings for educators to cultivate students' CTD.

## **General educational implications**

### ***Theoretical implications***

Two features can be described in terms of this dissertation's theoretical implications. One of them is the comprehensive CT framework built for adapting to the changing world and the other is the CTD framework constructed from the intelligence of the workforce.

This dissertation does not deny the significance of the consistent CT framework with both CTS and CTD but provides a new opinion or direction to reconsider the structure for the suitability of undergraduate students to assimilate into the smart and global era. As a fact, CTD and CTS assessments today are in the state of literalization which means that both are tested by the items described by words instead of the real skills for solving daily scenario problems. Therefore, this research regarded CTS and CTD as the literal input to enhance the theoretical competence of CT, and PSs as the output to demonstrate the true skills of CT adopted in the real world. Meanwhile, in this structure, instructional interventions have been proven effectively promote CT, which can be integrated into the model for positive recycling. Thus,

based on future checks on this model, this theoretically extensive CT framework may be upgraded.

For the framework of CTD, based on the previous studies, with the opinions from employers and employees, the three-factor model has been established consisting of disposition for self-efficacy, instant judgment, and habitual truth-digging. This new structure integrated the need of the workforce on what kind of undergraduates they would like to employ can fill the gap that the competence acquired in schools usually cannot be suitable for work. Thus, this framework can utilize for both undergraduate students and newly employed staff to assess the CTD that the workforce needs. Besides, in this framework, the instant judgment and habitual truth-digging that can be regarded as fast and slow thinking were put forward. According to the results of this study and Kahneman (2011)'s study, the balance between fast and slow thinking should be achieved in case one of them affected the other mostly. In this case, this framework clarified and categorized the CTD contents and left a thought for future studies to deepen.

### ***Practical implications***

Fruitful practical implications can be emphasized in this dissertation. Firstly, the meta-analysis, generally, showed the effectiveness of PBL on overall CT, CTS, and CTD, which provided robust evidence for instructors to adopt PBL in their courses for the promotion of students' CT. If the goal of future instructions is to enhance general CT, the intervention should be carried out in a small sample size (preferably less than 51) with groups of no more than six pupils. Also, if possible, online, or computer-assisted training can be useful ways. Furthermore, it is preferable to carry out this instructional activity with senior undergraduate students to cultivate CT. If the lessons are intended to improve CTS in particular, a large class (> 100) and large group size (> 10) are recommended. Also, the teaching time might be extended (one semester or more). Nonetheless, commencing the CTS therapy in the third year is preferable. If the intervention is intended to enhance CTD, a medium length (half a semester) is recommended. Also, if technically possible, online education can be explored.

Besides, the newly developed 2ES-CTDI has been testified with good reliability, validity, and item and test endorsement, indicating its usability in future educational assessments on undergraduate students' CTD. The results generated from this scale will give information regarding students' CTD and help teachers and administrators improve their instructional emphasis and policies, respectively. Additionally, regarding the relationships between instant judgment, self-efficacy, and habitual truth-digging, teachers must educate students to consider a balance of the three components to achieve an ideal CTD level. Furthermore, technically, this research may be used to help educators build and evaluate inventories (using ISM) as well as investigate the reliability and validity of their instruments using IRT and PLS-SEM.

Regarding the moderated mediating effects of gender among the CTD components, gender differences, and the moderating influence should be studied further. In view that males have lower CTD self-efficacy and habitual truth-digging levels, teachers can preserve their self-efficacy by encouraging or applauding them and fostering their patience to handle hard issues clearly and consistently. Self-efficacy has competing effects on the link between instant judgment and habitual truth-digging, showing that greater quick judgment and self-efficacy may diminish habitual truth-digging. As a result, teachers should keep a close eye on this to establish a balance that promotes students' CTD.

Finally, for the implications of the investigation of various demographic characteristics



that may impact undergraduate students' CTD, based on findings, educators must be well-versed in their students' backgrounds to recognize the distinctions between these individual and familial factors influencing students' CTD levels and to balance the emphasis on both high and low-CTD-level students. Because of the considerable effect of family income, educators must assist people from low-income homes in promoting their competence without prejudice or injury to their self-esteem because of their SES level. Furthermore, because educators are the people closest to students, they may know more about their cognitive abilities and personality than others. Hence, teachers are advised to seek out more aspects that may have an influence on students' CTD and, if feasible, do a related study on them to enhance students' CTD.

### **General conclusions**

The findings can be concluded that (a) PBL is effective for the promotion of the overall CT, CTS, and CTD, indicating a positive relationship exists between each other. (b) On the basis of this, a complex CT framework with CTD and CTS as the theoretical input and PSs as the practical output including instructional interventions among each path has been established. (c) Based on this framework, CTD, as the activation and basis of CTS, is chosen as the main construct, and a CTD structure with the perspectives from literature, instructors, students, employers, and employees, including CTD self-efficacy, instant judgment, and habitual truth-digging, has been built. (d) The CTD framework has been testified reliable and valid for assessing undergraduate students. (e) Self-efficacy will be the mediator between instant judgment and habitual truth-digging, but a competitive mediation exists between instant judgment and habitual truth-digging. Besides, with gender as a moderator in the mediating effect model, females performed better in self-efficacy and habitual truth-digging while males are more inclined to judge quickly, indicating a balance needs to be found among each component and gender differences. (f) Considering all existing factors in this study together, the potential influencing demographic factor is family income and those from the highest income family have a higher CTD than others, which requires society to put more attention to the students from lower-income families.

Despite fruitful findings generated from the whole dissertation, limitations and drawbacks can also be found as listed in the limitation sections. The future study can deepen into this field based on the studies in this dissertation to test the stability of the complex CT framework and CTD framework, especially in different contexts, to find more evidence on the relationships and influencing factors in CTD for more effective and equal promotion for undergraduate students, and if possible, to provide conductible and functional measures for instructors to promote CTD and balance the differences among different groups. All in all, the hope that researchers, instructors, parents, administrators, and the workforce need to work together for the avoidance of being replaced for students in the changing, complex, global, and smart world can be realized in the near future.

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## List of Related Publications

### Article publications [\*Correspondent Author]

- [1] Liu, Y.\*, & Pásztor, A. (2022). Effects of Problem-Based Learning Instructional Intervention on Critical Thinking in Higher Education: A Meta-Analysis. *Thinking Skills and Creativity*, 45, 101069. <https://doi.org/10.1016/j.tsc.2022.101069>
- [2] Liu, Y.\*, & Pásztor, A. (2022). Design and validate the Employer-Employee-Supported Critical Thinking Disposition Inventory (2ES-CTDI) for undergraduates. *Thinking Skills and Creativity*, 46, 101169. <https://doi.org/10.1016/j.tsc.2022.101169>
- [3] Liu, Y.\*, & Pásztor, A. (2023). Moderated Mediating Effects of Gender Among the Components of Critical Thinking Disposition in Undergraduate Students. *Heliyon*, 9(4), e14664. <https://doi.org/10.1016/j.heliyon.2023.e14664>
- [4] Liu, Y.\*, & Pásztor, A. (2023). Survey on the influential demographic factors of Chinese undergraduate students' critical thinking disposition: Evidence from plausible values. *Thinking Skills and Creativity*, 50, 101397. <https://doi.org/10.1016/j.tsc.2023.101397>

### International conferences

- [1] Liu, Y., Pásztor, A., & Molnár, G. (2023). Validation of the Hungarian Employer-Employee-Supported Critical Thinking Disposition Inventory, Abstract submitted to European Association for Practitioner Research on Improving Learning (EAPRIL), Belfast, UK, November 22-24, 2023, [accepted, in print].
- [2] Liu, Y., & Pásztor, A. (2023). Item and Test Endorsement of the Employer-Employee-Supported Critical Thinking Disposition Inventory, Abstract submitted to European Association for Practitioner Research on Improving Learning (EAPRIL), Belfast, UK, November 22-24, 2023, [accepted, in print].
- [3] Liu, Y. (2023). The assessment of critical thinking disposition in Hungarian undergraduate students: A multi-dimensional Rasch analysis. Abstract presented at XXIII. National Conference on Educational Science. Eötvös Loránd University, Budapest, Hungary, October 26-28, 2023. [accepted, in print].
- [4] Liu, Y. (2023). Moderated Mediating Effects of Gender in Critical Thinking Disposition Components for Undergraduates, Abstract presented at the European Association for Research on Learning and Instruction conference for junior researcher (EARLI-JURE 2023), Aristotle University of Thessaloniki, Thessaloniki, Greece, August 20-21, 2023, [PDF](#)
- [5] Liu, Y. (2023). Measurement Invariance of the Employer-Employee-Supported Critical Thinking Disposition Inventory (2ES-CTDI) Across Gender, Paper presented at 19th Conference on Educational Assessment. Committee of the Hungarian Academy of Sciences, Szeged, Hungary, April 20-22, 2023, p.29, [PDF](#)
- [6] Liu, Y. & Pásztor, A. (2022). The Influencing Factors of Undergraduate Students' Critical Thinking Disposition: The Evidence from Plausible Values of Rasch Modeling, Paper presented at 22<sup>nd</sup> Conference on Educational Sciences, Pécs, Hungary, November 17-19, 2022, p.424, [PDF](#)
- [7] Liu, Y. & Pásztor, A. (2022). Validate the Employer-Employee-Supported Critical Thinking Disposition Inventory for Undergraduates, Paper presented at SIG 1&4 (EARLI), Cadiz, Spain, June 27-30, 2022 [PDF](#)

- [8] Liu, Y. & Pásztor, A. (2022). Design the Employer-Employee-Supported Critical Thinking Disposition Inventory for Undergraduates, Paper presented at SIG 1&4 (EARLI), Cadiz, Spain, June 27-30, 2022 [PDF](#)
- [9] Liu, Y. & Pásztor, A. (2022). Mediating Effects Among the Components of Critical Thinking Disposition for Undergraduates: A PLS-SEM Analysis. In Fejes, J. B. & Pásztor-Kovács, A. (Eds.), 18th Conference on Educational Assessment. Programme and abstracts. University of Szeged, Szeged, April 21-23, 2022. p67. [PDF](#)
- [10] Liu, Y. & Pásztor, A. (2022). Impacts of demographic factors on critical thinking disposition among undergraduates. In Fejes, J. B. & Pásztor-Kovács, A. (Eds.), 18th Conference on Educational Assessment. Programme and abstracts. University of Szeged, Szeged, April 21-23, 2022. p20. [PDF](#)
- [11] Liu, Y. (2021). The Effectiveness and Influential Factors of Problem-Based Learning Intervention on Critical Thinking Skills for Undergraduates: A Meta-Analysis, Paper presented at 21st Conference on Educational Sciences, Szeged, Hungary, November 18-20, 2021, p.95, [PDF](#)
- [12] Liu, Y. (2021). The Effectiveness and Influential Factors of Problem-Based Learning Intervention on Critical Thinking Disposition for Undergraduates: A Meta-Analysis, Paper presented at 14th Training and Practice Conference on Educational Science, Kaposvár, Hungary, September 2-4, 2021, p.89, [PDF](#)