Metacognition and Approaches Regarding Internet-Based Learning in Taiwanese University Students

Min-Hsien Lee*, Manuela Cantoia^, Paola Iannello°, Alessandro Antonietti°, Jyh-Chong Liang*, Chin-Chung Tsai*

* Program of Learning Sciences,
National Taiwan Normal University, Taiwan
e-mail: leemh@ntnu.edu.tw;
e-mail: aljc@ntnu.edu.tw;
e-mail: cctsai@mail.ntust.edu.tw.
^ Faculty of Psychology, eCampus University,
via Isimbardi 10, 22060 Novedrate (CO), Italy
e-mail: manuela.cantoia@uniecampus.it.
° Department of Psychology, Catholic University of the Sacred Heart,
Largo Gemelli 1, 20123 Milan, Italy
e-mail: paola.iannello@unicatt.it;
e-mail: alessandro.antonietti@unicatt.it.

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Abstract

While learning in Internet-based environments, students rely on metacognitive knowledge to organize, record, monitor, and review their learning path. In this experience, they may reveal either a “surface” or “deep” approach. In this study, 509 university students were administered the adapted versions of the ‘Metacognitive Knowledge regarding Internet-based Learning’ questionnaire and of the ‘Approaches to Internet-based Learning’ questionnaire. Positive correlations between metacognitive knowledge and approaches to Internet-based learning environments emerged: The metacognitive attitude was associated to a concerned and critical approach to learning whereas the negative attitude about Internet-based learning was associated to the surface approach.

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Students showed a global understanding of the peculiarities and opportunities of Internet-based learning environments rather than empathize a single cognitive or metacognitive feature.

Keywords: Internet-based Learning, Metacognition, Metacognitive Knowledge, Learning Approaches

Introduction

A huge amount of information from multiple sources and very heterogeneous perspectives is available in the Internet and it can be quickly accessed and downloaded. This led the Web to become an influential tool in education and Internet-based learning environments are increasingly widespread in instructional settings around the world, mostly for higher education (Mason et al., 2010; Chiu et al., 2013; Lee et al., 2014; Palvia et al., 2018; Shea & Bidjerano, 2009).

Metacognitive Knowledge for Internet-based Learning

Metacognition and self-regulation are critical in order to learn in open-ended technology-supported environments (Antonietti et al., 2008; Azevedo, 2005; Karatas & Arpaci, 2021; Lee & Tsai, 2011; Strømsø & Bråten, 2010) and predict learning outcomes (Ohtani e Hisasaka, 2018; Zhao & Ye, 2020). As non-linear learning environments, technological environments allow students to choose their own path of navigation, and, at the same time, support such an autonomous way of learning, thus enhancing motivation and self-regulation (Cho & Heron, 2015; Moos & Azevedo, 2008; Pieschl et al., 2008; Tsai & Chuang, 2005).

As metacognitive competence is concerned, literature shows that students possess specific sets of opinions and beliefs about how learning occurs when using technological tools, so that a sort of metacognitive knowledge can be identified at the basis of the use of such tools. For instance, learners posit that computers can enhance academic performance and that the Internet has potential as a learning tool (Zhu et al., 2020), but they can also differentiate the characteristics of specific tools and systems, such as Internet, multimedia presentations, hypertexts, virtual reality (Antonietti et al., 2008; Henderson et al., 2017). Students can also make distinctions and evaluations based on the potential benefits (Alqurashi, 2019), the specific goals and motivations (Bennett & Scholes, 2001; Gao & Lehman, 2003), and the mental processes elicited by technological tools (Antonietti & Giorgetti, 2004; Eltahir et al., 2019), as well as on the nature, the reliability, and the strategies to access information on the Web (Macedo-Rouet et al., 2019) or the processes activated by Internet-supported learning (Chuang & Tsai, 2005; Tsai, 2005).

Internet-based learning environments can thus be considered as metacognitive and epistemic tools (Binali et al., 2021). As a metacognitive tool, they allow students to organize by themselves their knowledge and to make connections with their previous knowledge and experiences, providing them with the opportunity to record, monitor, and review their general learning paths (Tsai, 2004). As an epistemic tool, the Internet provides the opportunities to evaluate information and knowledge (credibility, accuracy, veracity, conflicting information), and reveals a broader vision about learning, teaching, and Internet-based instruction (Celik et al., 2021).

The Approaches to Internet-based Learning

Since the widespread use of Internet technologies in education, many studies have attempted to investigate how students' characteristics may play a role in Internet-based learning environments (e.g., Antonietti & Giorgetti, 2004; Bråten & Strømsø, 2006; Chuang & Tsai, 2005). Besides metacognitive knowledge, the learning approach is one of the most relevant characteristics. Studies regarding approaches to learning originated from phenomenographic research. They referred to the way in which learners go about their academic work and attempted to investigate students' motives and strategies for learning (Biggs, 1994). Based on the observation that differences occur when students work on the same learning task, Marton and Säljö (1976) differentiated between a 'surface' and a 'deep' learning approach. The surface approach is focused on retention and application of notions; The deep approach aims at understanding concepts and being transformed as a person by what is learned.

As far as Internet-supported learning is concerned, Ellis and colleagues (2011) collected students' learning experiences in Internet search activities and identified four categories: "Critical focus and Evaluation", "Reflection and Integration", "Collecting and Summarizing", and "Replicating information". These four categories could be considered as various Internet-based learning strategies for students. "Critical focus and Evaluation" and "Reflection and Integration" could be regarded as deep approaches, while "Collecting and Summarizing" and "Replicating information" could be classified as surface approaches.

Questionnaires are usually employed to investigate students' learning approaches (Kember et al., 2004; Lee et al., 2008). They often include four factors: deep/surface motive and deep/surface strategies to learning. To investigate students' learning approaches in the Internet-based environment, on the basis of the four categories identified in Ellis and colleagues' (2011) study and to the factor structure found by Lee and colleagues' (2008) approaches to science learning instrument, Tsao and colleagues (2014) and Lee (2016) developed the Approaches to Internet-based Learning (AIL) questionnaire.

Aims of the Investigation

In the literature, several studies suggested that students' opinions and beliefs about how learning occurs influence significantly their learning approaches and their ensuing learning outcomes (e.g., Chin & Brown, 2000; Lee et al., 2008; Shen et al., 2016). Internet-supported learning, which refers to learning fully online or in a blended mode by the use of the Internet for different academic purposes (Bekele & Menchaca, 2008) (i.e. completing school work, downloading or reading online learning materials, having interactions with tutors or peers), is a distinct way to learn compared to learning in the traditional classroom context, thus researchers in the area of Internet-based learning have attempted to understand students' Internet-based learning profiles. Since as yet metacognitive knowledge about Internet-based learning and approaches to learning in an Internet-supported environment have been never associated with each other, the present study aimed at assessing the relations between students' metacognitive knowledge and approaches to Internet-based learning. In line with literature, our hypothesis is that metacognitive awareness would be related to deep approaches since it enhances reflection, sense-making, and self-regulation processes.

Methods

Participants

Five hundred and nine university students in North, central, Eastern, and South areas of Taiwan took part to the study. The convenience sample consisted of 39.7% men (N = 202) and 60.3% women (N = 307), ranging from 18 to 29 years old (Mean = 20.4 years old; SD = 1.75). Students were from different majors including humanities, education, social disciplines, science, engineering, and management. As it results from the demographic items of the questionnaires (i.e., "How many hours a day are you involved in activities through the Internet?"), the participants, on average, were involved in Internet-related activities about 6.3 hours a day. All participants have also experienced Internet-based learning activities in which they usually completed school work via the Internet.

Instruments

To assess the relations between students' metacognitive knowledge and approaches to Internet-based learning, two questionnaires were adopted as survey instruments: the Metacognitive Knowledge regarding Internet-based Learning (MKIL) questionnaire developed by Antonietti and colleagues (2008) and AIL.

To examine undergraduates' metacognitive knowledge about the psychological effects of different kinds of computer-supported instructional tools, Antonietti and colleagues (2008) have developed a questionnaire which addresses motivational and emotional aspects of learning, the behavior to have during the learning process, the mental abilities, and the style of thinking required, and the cognitive benefits. In this study, the questionnaire in question was adapted and modified to investigate learners' Internet-based learning.

Moreover, as few instruments attempt to fully investigate learners' learning approaches in the context of Internet-based learning, the validated Approaches to Internet-based Learning (AIL) questionnaire (Tsao et al., 2014; Lee, 2016) was adopted in this study.

Both MKIL and AIL questionnaires include statements to be rated on a scale ranging from 1 ("I definitely disagree") to 5 ("I definitely agree"). Three experts in education and psychology examined the content of the adapted versions of the questionnaires to ensure the validity of such instruments. The two questionnaires are provided in Appendix A.

MKIL Questionnaire

The questionnaire was devised to investigate what people think about the psychological correlates in the use of computer-supported instructional tools (Antonietti & Giorgetti, 2004, 2006). All the items originated from the opinions of international academic experts in the field of psychology or pedagogy of educational technologies, who had been asked to list features of computer-supported tools that affect students' learning. Two independent judges deleted synonyms and collapsed responses describing similar features into a single description. The list of items was preceded by an introduction explaining the aim of the instrument and what computer-supported instructional tools are. The introduction reported also the instructions to fill out the questionnaire.

In this study, a reduced version of the questionnaire was administered, and it consisted of 24 statements on the characteristics of technology-based learning. The items were organized according to the partition of metacognitive knowledge proposed by Flavell (1979):

- Personal attributes: one's own nature or the nature of another as a cognitive processor.
- Task: its demands, and how those demands can be met under varying conditions.
- Strategies: the cognitive strategies, the preferred style of thinking, the cognitive benefits, and learning outcomes.

AIL Questionnaire

To assess students' approaches to Internet-based learning, AIL questionnaire (Lee, 2016) was modified. Referring to the factor structure of Lee and colleagues' (2008) approaches to learning science questionnaire and to Ellis and colleagues' (2011) findings, AIL consists of the four factors: deep motive, deep strategy, surface motive, surface strategy. The former two factors could be categorized as "Deep approaches to Internet-based learning" and the latter two could be grouped into "Surface approaches to Internet-based learning."

AIL consists of a total of 22 items. A detailed description of the four factors, with a sample item for each, is presented below:

- Deep motive (DM): The student has an intrinsic interest for Internet-based learning, e.g., "I feel that learning topics can be highly interesting once I learn in the context of the Internet".
- Deep Strategy (DS): The student uses critical thinking, information evaluation, knowledge reflection, and integration in the context of Internet-based learning, e.g., "When I am learning on the Internet, I check different websites at the same time to judge information".
- Surface motive (SM): The student's aim is just to pass exams or meet the requirements of the course, e.g., "I use the Internet for learning in order to get a good grade".
- Surface Strategy (SS): Collecting, summarizing, and replicating information are the main strategies adopted in the context of Internet-based learning, e.g., "When I am learning in the context of Internet, I will focus on and memorize the information relating to the examination".

Data Analysis and Procedure

Exploratory factor analysis (EFA) with a Promax rotation and confirmatory factor analysis (CFA) were both conducted for each instrument. To this end, the participants were randomly split into two subsets. The first subset was used to conduct the EFA and the other subset for the CFA and the Structural Equation Modeling (SEM) technique. The dataset is presented in Table 1.

Tab. 1 - *The data set for the analyses*

	Male	Female	Total
Subset for EFA	98	160	258
Subset for CFA and path analysis	104	147	251
Total	202	307	509

EFA: exploratory factor analysis
CFA: confirmatory factor analysis

EFA was carried out with SPSS software version 23. Data screening and correlation analysis were also conducted using SPSS. SEM techniques were conducted to address the purpose of this study. CFA was conducted to investigate the fitness between the latent variables and the observed items of the two questionnaires. SEM was further used to explore the structural relationships between the aforementioned questionnaires. LISREL 8.80 was used to implement the CFA analysis and also to test the structural relationships by administering the full-model testing of SEM.

Results

EFA of MKIL and AIL

An exploratory factor analysis with a Promax rotation was performed to investigate the structure of MKIL. As a result, the cutoff value of 0.4 for the pattern coefficient (factor loading) of the items is considered to be ideal (Stevens, 1996). As a result, the final MKIL retained 17 items (as shown in Table 2) and grouped into the following four factors: Facilitating Metacognition (FM), Motivation/Impact (MI), Facilitating Cognition (FC), and Negative Effects (NE). The eigenvalues of the four factors were all higher than 1, while the factor loadings of 7 items lower than .40 were omitted from the analyses. The total variance explained was 60.74%.

Table 2 also presents the results of pattern and structure coefficients after completing the Promax (oblique) rotation (Thompson & Daniel, 1996). The means and the items' standard deviations are presented in table 2.

Tab. 2 - *Rotated factor pattern and structure matrices for the for the Meta Knowledge regarding Internet-based Learning questionnaire (N = 258)*

	Factor 1		Factor 2		Factor 3		Factor 4				
Item	P	S	P	S	P	S	P	S	M	SD	*Median*
Factor 1: *Facilitate Meta-cognition* (FM), α = 0.83											
FM1	**0.59**	0.73	-0.10	0.45	0.38	0.63	-0.04	0.08	3.57	0.73	4
FM2	**0.81**	0.83	0.02	0.50	0.02	0.46	-0.02	0.10	3.46	0.90	4
FM3	**0.88**	0.88	0.03	0.52	-0.03	0.46	0.01	0.15	3.56	0.85	4
FM4	**0.81**	0.80	0.13	0.51	-0.18	0.33	0.05	0.16	3.68	0.93	4
Factor 2: *Motivation/Impact* (MI), α = 0.85											
MI1	0.14	0.47	**0.66**	0.69	-0.09	0.35	-0.07	0.02	3.81	0.91	4
MI2	0.01	0.43	**0.75**	0.74	-0.03	0.39	0.02	0.10	3.98	0.89	4
MI3	0.03	0.46	**0.61**	0.72	0.16	0.51	-0.01	0.08	3.56	0.89	4
MI4	0.10	0.49	**0.76**	0.76	-0.10	0.37	0.01	0.10	3.60	0.89	4
MI5	-0.02	0.47	**0.70**	0.77	0.13	0.52	0.06	0.15	3.47	0.93	4
MI6	0.05	0.45	**0.62**	0.70	0.09	0.46	-0.07	0.01	3.62	0.84	4
MI7	-0.12	0.36	**0.72**	0.71	0.10	0.44	0.04	0.11	3.55	0.87	4
Factor 3: *Facilitate Cognition* (FC), α = 0.73											
FC1	0.02	0.45	0.00	0.45	**0.79**	0.80	0.05	0.14	3.37	0.93	3
FC2	-0.10	0.36	0.04	0.45	**0.84**	0.80	-0.01	0.07	3.79	0.88	4
FC3	0.00	0.44	0.17	0.53	**0.66**	0.75	-0.03	0.07	3.59	0.93	4
Factor 4: *Negative Effects* (NE), α = 0.67											
NE1	0.14	0.31	-0.01	0.22	0.13	0.27	**0.68**	0.72	2.98	1.07	3
NE2	0.04	0.09	-0.20	-0.05	0.07	0.08	**0.84**	0.83	3.01	1.06	3
NE3	-0.13	0.02	0.21	0.13	-0.17	-0.03	**0.79**	0.77	3.22	0.98	3

Total variance explained: 60.74%, overall α = 0.88
Note: P = Pattern coefficients; S = Structure coefficients; Pattern coefficients with absolute values of 0.40 or greater are in bold.

The FM factor reflects the metacognitive activities which students implement while learning. The MI factor refers to the role that Internet can play in supporting students' interest, curiosity, and willingness to learn. The FC factor consists of items which stress a few peculiar cognitive processes activated in Internet-based learning (memory, visualization, integration). The NE factor gathers items describing possible dysfunctional consequences produced by Internet use in an academic context.

The reliability (Cronbach's alpha) coefficients for the four scales, each constituted by the items of the corresponding factor, were, respectively, 0.83, 0.85, 0.73, and 0.67, and the overall alpha was 0.88, suggesting that these factors are reliable enough in assessing the students' metacognitive knowledge regarding Internet-based learning.

Similarly, EFA with a Promax rotation was conducted to explore the structure of AIL. As a result, the items were grouped into four factors: Deep motive (DM), Deep Strategy (DS), Surface Motive (SM), and Surface Strategy (SS). The eigenvalues of the four factors were all higher than 1, while 6 items with a factor loading lower than .40 were omitted. As a result, the final AIL retained 16 items (as shown in Table 3) and the total variance explained was 65.86%. Table 3 indicated the resulting factor pattern and factor structural coefficients, along with means and the items' standard deviations are presented.

The reliability (Cronbach's alpha) coefficients for the four factors were respectively 0.87, 0.87, 0.67, and 0.77 and the overall alpha was 0.79, suggesting that these factors had sufficient reliability in assessing the students' approaches to Internet-based learning.

Tab. 3 - *Rotated factor pattern and structure matrices for the for the Approaches to Internet-based Learning questionnaire (N = 258)*

	Factor 1		Factor 2		Factor 3		Factor 4				
Item	P	S	P	S	P	S	P	S	M	SD	Median
Factor 1: *Deep Motive* (DM), α = 0.77											
DM1	**0.85**	0.86	0.02	0.36	-0.01	0.20	0.06	0.15	3.55	0.80	4
DM2	**0.90**	0.88	0.00	0.36	-0.10	0.10	0.00	0.07	3.57	0.84	4
DM3	**0.69**	0.70	0.02	0.33	0.06	0.19	-0.12	-0.04	3.60	0.86	4
Factor 2: *Deep Strategy* (DS), α = 0.87											
DS1	0.26	0.54	**0.67**	0.78	0.01	0.16	0.03	-0.05	4.05	0.75	4
DS2	0.11	0.44	**0.81**	0.84	-0.10	0.05	0.08	-0.05	3.97	0.81	4
DS3	-0.09	0.27	**0.92**	0.87	-0.05	0.04	-0.01	-0.17	4.18	0.80	4
DS4	-0.06	0.26	**0.77**	0.75	0.00	0.09	0.02	-0.10	3.90	0.86	4
DS5	-0.11	0.26	**0.87**	0.85	0.05	0.11	-0.12	-0.25	4.14	0.77	4
DS6	0.18	0.43	**0.48**	0.58	0.22	0.33	0.02	0.02	3.67	0.78	4
Factor 3: *Surface Motive* (SM), α = 0.67											
SM1	-0.21	0.01	0.13	0.13	**0.71**	0.68	0.03	0.16	3.23	1.01	3
SM2	0.25	0.38	-0.09	0.11	**0.73**	0.77	-0.02	0.20	3.18	0.94	3
SM3	-0.04	0.14	-0.06	0.04	**0.86**	0.85	0.01	0.23	3.05	1.01	3

Factor 4: *Surface Strategy* (SS), α = 0.77											
SS1	-0.04	0.02	-0.08	-0.20	0.04	0.20	**0.74**	0.75	2.65	1.06	3
SS2	0.00	0.07	-0.07	-0.19	0.07	0.27	**0.86**	0.88	2.59	1.15	2
SS3	0.05	0.07	-0.12	-0.24	-0.07	0.14	**0.87**	0.87	2.48	1.18	2
SS4	-0.06	0.13	0.27	0.13	-0.01	0.21	**0.78**	0.73	3.25	1.08	3

Total variance explained: 65.86%, overall α = 0.79
Note: P = Pattern coefficients; S = Structure coefficients; Pattern coefficients with absolute values of 0.40 or greater are in bold.

CFA of MKIL and AIL

To confirm the structures of both MKIL and AIL which emerged from EFA, CFA was conducted with participants from the second data set. As a result, a total of 33 items (including MKIL with 17 items for four factors and AIL with 16 items for four factors) were retained for further analysis. The results of CFA for MKIL and AIL are presented in Table 4 and Table 5, respectively. The measurement model could be referred to Figure 1. Although the goodness of fit index (GFI = 0.81) was somewhat low, the value was still acceptable. The other fit indices (ratio of chi-square to degrees of freedom = 1.99, CFI = 0.94, RMSEA = 0.063, NNFI = 0.93) showed that the measurement model provided an acceptable fit to the data. Moreover, the factor loadings, average variance extracted (AVE), and composite reliability (CR) suggested to evaluate the convergent validity of the constructs (Hair et al., 2006). All the values of factor loadings were significant ($p < 0.05$). The AVE values were all higher than .40 (as shown in Table 4 and Table 5). Compared with the cutoff value of .60, the CR values of MKIL factors ranging from .66 to .83 and of AIL factors ranging from .67 to .84 indicated acceptable reliability of the factors (Bagozzi & Yi, 1988). The above results suggested that the convergent validity of the items for MKIL and AIL factors is adequate.

Tab. 4 - *The confirmatory factor analysis for the Meta Knowledge regarding Internet-based Learning questionnaire (N = 251)*

Construct and measurement items	Factor loadings	t-value	AVE	CR
Facilitate Meta-cognition (FM)	-------	-------	0.51	0.80
FM1	0.64	10.56*		
FM2	0.76	13.16*		
FM3	0.86	15.78*		
FM4	0.55	8.76*		
Motivation/Impact (MI)	-------	-------	0.42	0.83
MI1	0.52	8.27*		
MI2	0.57	9.25*		
MI3	0.70	12.13*		
MI4	0.71	12.22*		
MI5	0.70	12.01*		
MI6	0.68	11.73*		
MI7	0.62	10.36*		
Facilitate Cognition (FC)	-------	-------	0.43	0.69
FC1	0.66	10.11*		
FC2	0.65	10.03*		
FC3	0.65	9.92*		
Negative Effects (NE)	-------	-------	0.40	0.66
NE1	0.49	6.67*		
NE2	0.79	9.62*		
NE3	0.58	7.77*		

Notes: * Significant t-value, $p < 0.05$ AVE: Average variance extracted CR: Composite reliability

Tab. 5 - *The confirmatory factor analysis for the Approaches to Internet-based Learning questionnaire (N = 251)*

Construct and measurement items	Factor loadings	t-value	AVE	CR
Deep Motive (DM)	-------	-------	0.52	0.75
DM1	0.82	-------		
DM2	0.86	11.19*		
DM3	0.40	6.03*		
Deep Strategy (DS)	-------	-------	0.47	0.84
DS1	0.69	-------		
DS2	0.78	10.66*		
DS3	0.76	10.38*		
DS4	0.58	8.23*		
DS5	0.74	10.18*		

DS6	0.51	7.31*		
Surface Motive (SM)	-------	-------	0.42	0.67
SM1	0.48	-------		
SM2	0.66	5.78*		
SM3	0.76	5.62*		
Surface Strategy (SS)	-------	-------	0.49	0.79
SS1	0.59	-------		
SS2	0.79	8.52*		
SS3	0.81	8.55*		
SS4	0.57	7.02*		

Notes: * Significant t-value, $p < 0.05$ AVE: Average variance extracted CR: Composite reliability

Descriptive Statistics and Relationships Between MKIL and AIL

The descriptive statistics and the correlation coefficients of the variables of MKIL and AIL are presented in Table 6. For 251 participants' responses on MKIL, students gained high scores on the Motivation and Impact feature of Internet-based learning activities. With respect to AIL, students scored higher on Deep Motive than Surface Motive ($t = 9.26$, $p < 0.001$) and on Deep Strategy than Surface Strategy ($t = 18.12$, $p < 0.001$). The results revealed that students tended to follow the deep approaches in the context of Internet-based learning.

MKIL factors FM, MI, and FC were positively associated with the deep approaches to Internet-based learning (i.e., deep motive and strategy). The NF factor of MKIL was positively correlated with surface approaches (i.e., surface motive and strategy).

Tab. 6 - *The descriptive statistics and correlation results of the research variables (N = 251)*

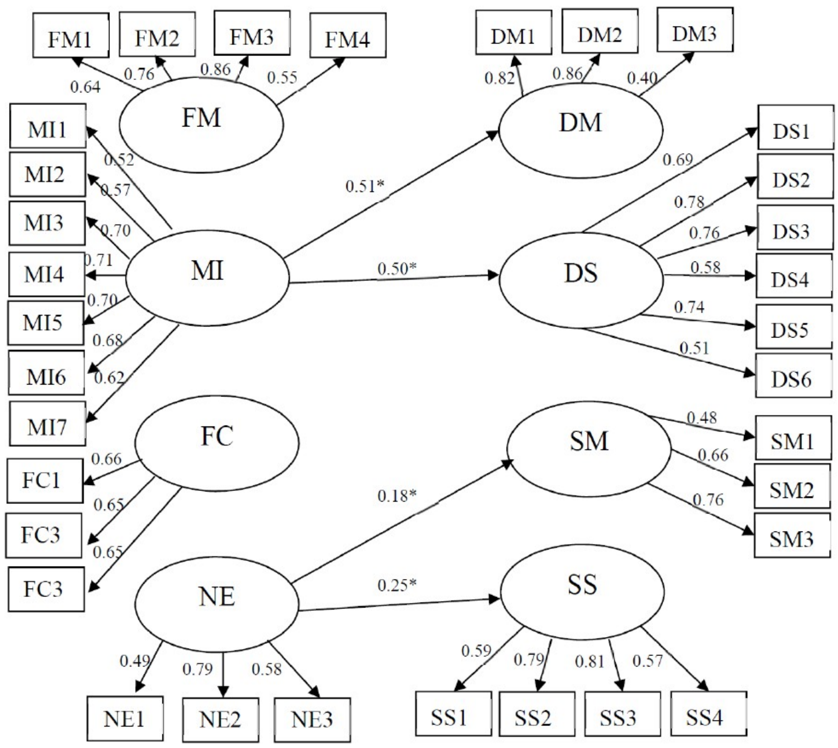
	Mean (S.D.)	1	2	3	4	5	6	7
FM	3.57 (0.65)							
MI	3.71 (0.58)	0.64^{**}						
FC	3.58 (0.67)	0.42^{**}	0.55^{**}					
NE	3.15 (0.71)	0.16^{*}	0.17^{**}	0.18^{**}				
DM	3.66 (0.60)	0.37^{**}	0.50^{**}	0.42^{**}	0.10			
DS	3.99 (0.54)	0.34^{**}	0.47^{**}	0.39^{**}	0.15^{*}	0.51^{**}		
SM	3.19 (0.71)	0.20^{**}	0.21^{**}	0.22^{**}	0.15^{*}	0.25^{**}	0.21^{**}	
SS	2.87 (0.80)	0.12	0.08	0.08	0.15^{*}	0.10	-0.01	0.43^{**}

Notes: * $p < 0.05$. ** $p < 0.01$.
FM: Facilitate Meta-cognition; MI: Motivation/Impact; FC: Facilitate Cognition; NE: Negative Effects; DM: Deep Motive; DS: Deep Strategy; SM: Surface Motive; SS: Surface Strategy.

Structural Relations Between MKIL and AIL

To explore more in details the relations between MKIL and AIL, path analysis was conducted using SEM analysis. The path coefficients that specified the relationships between the latent constructs (factors) are presented in Figure 1. The fit indices of the full model show that the model has an acceptable fit (the ratio of chi-square to degrees of freedom = 1.99, GFI = 0.81, CFI = 0.94, RMSEA = 0.063, NNFI = 0.93).

The structural relationships between MKIL and AIL are shown in Figure 1. The metacognitive knowledge regarding Internet-based learning as MI was the significant and positive factor in explaining the "Deep Motive," and "Deep Strategy" in AIL (γ = 0.51, and 0.50, $p < 0.05$). The NE factor of MKIL was the significant and positive factor associated with the "Surface Motive," and "Surface Strategy" in AIL (γ



Note: *p < 0.05; FM: Facilitate Meta-cognition; MI: Motivation/Impact; FC: Facilitate Cognition; NE: Negative Effects; DM: Deep Motive; DS: Deep Strategy; SM: Surface Motive; SS: Surface Strategy

Figure 1 - The path model for the Metacognitive Knowledge regarding Internet-based Learning and Approaches to Internet-based Learning (n = 251)

Discussion and Conclusions

The awareness of the mental processes which are involved in learning allows students to use technological tools in a more functional and productive way and, in turn, technological tools can improve metacognitive skills (e.g., Carvalho & Santos, 2022; Molin et al., 2020; Teng, 2021).

Findings from this study confirmed the hypothesis of a correlation between metacognitive knowledge and approaches to Internet-based learning environments. In detail, a general deep approach (both Deep strategies and Deep motivation) resulted to be related to students' metacognitive knowledge regarding Internet-based learning on the motivation/impact issues. In other words, a metacognitive attitude is associated with a critical approach to learning even in Internet-based environments. On the contrary, negative concerns lead to surface approaches in learning strategies and motivation.

It is worth noting that the correlations between the issues that we have defined as "motivation" in terms of both metacognitive knowledge and approach point out that students have well figured out the more effective attitude to deal with Internet-based learning environments. Rather than empathizing a single cognitive or a general metacognitive feature, they underline the peculiarities of such environments (being actively involved in knowledge building, taking part in a learning community, reaching a global overview, supporting motivation, figuring out possibilities and alternatives), which are the real quid of these technologies. Since they have earned a real understanding of internet-based learning environments, students are then likely to adopt deep, constructive strategies and behaviors.

In in these last years, due to the advancement of online and distance learning – which has been further accelerated by the pandemic – there have been some sudden and major changes in the relative weight that online learning tools have within learning processes. Hence, it seems to be particularly relevant to gain a better understanding of learners' knowledge and approach to online learning environments. In this regard the instrument which synthesizes the main features of both metacognitive knowledge and learning approach issues will allow teachers to consider not only the overt behavior of their students but also their beliefs on the effectiveness of the environments in which they are learning. Similarly, the administration of the new questionnaire will provide students themselves with the opportunity to reflect on their learning experience from a global perspective, further enhancing their metacognitive awareness.

Everyday technologies also allow us to overcome geographic boundaries and to discuss and to cooperate with people from all over the world. Nonetheless, in order to ensure the outcomes of these exchanges, we should mind cultural differences in learning approaches and representations. The awareness of others' perspectives and sense making processes could improve and empower metacognitive awareness on learning, as well as personal inventories of learning strategies. Creating the premises to intercultural cooperation entails to acknowledge potential differences and discuss them in a metacognitive effort to assume different perspectives.

Overall, the present paper provides researchers with an instrument which measures both metacognitive knowledge and learning approach, and offers further evidence for the importance of the relationship between epistemological beliefs and learning approaches, thus contributing to the existing literature.

This study has some limitations. The sample includes Taiwanese undergraduate students only. As suggested by recent research (see Chang, 2021), beliefs and perspectives on learning are strongly affected by cultural influences, with Western perspective that tend to favor individual, less structured peer learning, divergent thinking, creative, and open-ended learning, and low context-based learning; Eastern perspective that is more focused on collaborative learning, structured authority learning, abstract thinking, reasoning, and essential knowledge acquisition, and high context-based learning. Hence, findings from the present study would highly benefit from future research aimed at testing the pattern of relationships among metacognitive knowledge and learning approach in different (i.e. Western) countries.

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Corresponding author: Paola Iannello

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References

Alqurashi, E. (2019). Predicting student satisfaction and perceived learning within online learning environments. *Distance Education*, 40(1), 133-148.

Antonietti, A., Colombo, B., & Lozotsev, Y. (2008). Undergraduates' metacognitive knowledge about the psychological effects of different kinds of computer-supported instructional tools. *Computers in Human Behavior*, 24, 2172-2198.

Antonietti, A., & Giorgetti, M. (2004). Students' conceptions about learning from multimedia. In H. Niegemann, R. Brunken, & D. Leutner (Eds.), *Instructional design for multimedia learning* (pp. 249-265). Munster-New York: Waxmann.

Antonietti, A., & Giorgetti, M. (2006). Teachers' beliefs about psychological aspects of learning through multimedia. *Computers in Human Behavior*, 22, 267-282.

Azevedo, R. (2005). Using hypermedia as a metacognitive tool for enhancing student learning? The role of self-regulated learning. *Educational Psychologist*, 40, 199-209.

Bagozzi, R. P., & Yi, Y. (1988). On the evaluation of structural equation models. *Academic of Marketing Science*, 16(1), 76-94.

Bekele, T. A., & Menchaca, M. P. (2008). Research on Internet-supported learning: A review. *Quarterly Review of Distance Education*, 9(4), 373.

Bennett, L., & Scholes, R. (2001). Goals and attitudes related to technology use in a social studies method course. *Contemporary Issues in Technology and Teacher Education*, 1, 373-385.

Biggs, J. (1994). Approaches to learning: Nature and measurement of. In T. Husen, T. N. Postlethwaite (Eds.), *The international encyclopedia of education* (2 ed., Vol. 1, pp. 319-322). Oxford: Pergamon Press.

Binali, T., Tsai, C.C., & Hsin-Yi Chang, H.Y. (2021). University students' profiles of online learning and their relation to online metacognitive regulation and internet-specific epistemic justification. *Computers & Education*, 175, 104315. DOI: 10.1016/j.compedu.2021.104315.

Carvalho, A. R., & Santos, C. (2022). Developing peer mentors' collaborative and metacognitive skills with a technology-enhanced peer learning program. *Computers and Education Open*, 3, 100070. DOI: 10.1016/j.caeo.2021.100070.

Celik, I., Muukkonen, H., & Dogan, S. (2021). A model for understanding new media literacy: Epistemological beliefs and social media use. *Library & Information Science Research*, 43(4), 101125.

Chang, B. (2021). Incorporating Eastern and Western Learning Perspectives into a Western Learning Environment. *Journal of Interdisciplinary Studies in Education*, 10(1), 6-40. Retrieved from https://www.ojed.org/index.php/jise/article/view/2695.

Chin, C., & Brown, D. E. (2000). Learning in science: A comparison of deep and surface approaches. *Journal of Research in Science Teaching*, 37, 109-138.

Chiu, Y.-L., Liang, J.-C., & Tsai, C.-C. (2013). Internet-specific epistemic beliefs and self-regulated learning in online academic information searching. *Metacognition and Learning*, 8, 235-260. DOI: 10.1007/s11409-013-9103-x.
Cho, M.-H., & Heron, M.L. (2015). Self-regulated learning: The role of motivation, emotion, and use of learning strategies in students' learning experiences in a self-paced online mathematics course. *Distance Education*, 36(1), 80-99. DOI: 10.1080/01587919.2015.1019963.
Chuang, S.-C., & Tsai, C.-C. (2005). Preferences toward the constructivist Internet-based learning environments among high school students in Taiwan. *Computers in Human Behavior*, 21, 255-272.
Ellis, R. A., Goodyear, P., Bliuc, A. M., & Ellis, M. (2011). High school students' experiences of learning through research on the Internet. *Journal of Computer Assisted Learning*, 27, 503-515.
Eltahir, M., Al-Qatawneh, S., Al-Ramahi, N., & Alsalhi, N. (2019). The Perspective of Students and Faculty Members on the Efficiency and Usability of E-Learning Courses at Ajman University: A Case Study. *Journal of Technology and Science Education*, 9(3), 388-403.
Flavell, J. H. (1979). Metacognition and cognitive monitoring: A new area of cognitive-developmental inquiry. *American Psychologist*, 34, 906-911.
Gao, T., & Lehman, J. D. (2003). The effects of different levels of interaction on the achievement and motivational perceptions of college students in a Web-based learning environment. *Journal of Interactive Learning Research*, 14, 367-386.
Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E., & Tatham, R. L. (2006). *Multivariate Data Analysis* (6th ed.). New York: Prentice Hall.
Henderson, M., Selwyn, N., & Aston, R. (2017). What works and why? Student perceptions of 'useful' digital technology in university teaching and learning. *Studies in Higher Education*, 42(8), 1567-1579.
Karatas, K., & Arpaci, I. (2021). The role of self-directed learning, metacognition, and 21st century skills predicting the readiness for online learning. *Contemporary Educational Technology*, 13(3). DOI: 10.30935/cedtech/10786.
Kember, D., Biggs, J., Leung, D. Y. P. (2004). Examining the multidimensionality of approaches to learning through the development of a revised version of the Learning Process Questionnaire. *British Journal of Educational Psychology*, 74, 261-280.
Lee, M.-H. (2016). Exploring the relationships between Taiwan university students' perceived teacher authority toward Internet-based learning environments and their approaLeeches to Internet-based learning. Paper presented at the International Symposium on Emerging Technologies for Education (SETE'16), Roma: Italy.
Lee, M.-H., Johanson, R. E., & Tsai, C. C. (2008). Exploring Taiwanese high school students' conceptions of and approaches to learning science through a structural equation modeling analysis. *Science Education*, 92, 191-220.

Lee, W.-C., Chiu, Y.-L., Liang, J.-C., & Tsai, C.-C. (2014). Exploring the structural relationships between high school students' internet-specific epistemic beliefs and their utilization of online academic help seeking. *Computers in Human Behavior,* 36, 391-400. DOI: 10.1016/j.chb.2014.03.069.

Lee, S. W.-Y., & Tsai, C.-C. (2011). Students' perception of collaboration, self-regulated learning, and information seeking in the context of Internet-based learning and traditional learning. *Computers in Human Behavior*, 27, 905-914. DOI: 10.1016/j.chb.2010.11.016.

Macedo- Rouet, M., Potocki, A., Scharrer, L., Ros, C., Stadtler, M., Salmerón, L., & Rouet, J. F. (2019). How good is this page? Benefits and limits of prompting on adolescents' evaluation of web information quality. *Reading Research Quarterly*, 54(3), 299-321.

Marton, F., & Säljö, R. (1976). On qualitative differences in learning: I-outcome and process. *British Journal of Educational Psychology*, 46, 4-11.

Mason, L., Boldrin, A., & Ariasi, N. (2010). Epistemic metacognition in context: Evaluating and learning online information. *Metacognition and Learning*, 5(1), 67-90. DOI: 10.1007/s11409-009-9048-2.

Molin, F., Haelermans, C., Cabus, S., & Groot, W. (2020). The effect of feedback on metacognition-a randomized experiment using polling technology. *Computers Education*, 152, 103885. DOI: 10.1016/j.compedu.2020.103885.

Moos, D. C., & Azevedo, R. (2008). Exploring the fluctuation of motivation and use of self-regulatory processes during learning with hypermedia. *Instructional Science*, 36, 203-231.

Ohtani, K., & Hisasaka, T. (2018). Beyond intelligence: A meta-analytic review of the relationship among metacognition, intelligence, and academic performance. *Metacognition and Learning,* 13, 179-212. DOI: 10.1007/s11409-018-9183-8.

Palvia, S., Aeron, P., Gupta, P., Mahapatra, D., Parida, R., Rosner, R., & Sindhi, S. (2018). Online education: Worldwide status, challenges, trends, and implications. *Journal of Global Information Technology Management*, 21(4), 233-241.

Pieschl, S., Stahl, E., & Bromme, R. (2008). Epistemological beliefs and self-regulated learning with hypertext. Metacognition and Learning, 3, 17-37.

Shea, P., & Bidjerano, T. (2009). Community of inquiry as a theoretical framework to foster "epistemic engagement" and "cognitive presence" in online education. *Computers Education*, 52, 543-553.

Shen, K.-M., Lee, M.-H., Tsai, C.-C., & Chang, C.-Y. (2016). Undergraduate students' earth science learning: relationships among conceptions, approaches, and learning self-efficacy in Taiwan. *International Journal of Science Education*, 38, 1527-1547.

Stevens, J. (1996). *Applied multivariate statistics for the social science* (3rd ed.). Mahwah, NJ: Lawrence Erlbaum.

Strømsø, H. I., & Bråten, I. (2010). The role of personal epistemology in the self-regulation of internet-based learning. *Metacognition and Learning*, 5(1), 91-111. DOI: 10.1007/s11409-009-9043-7.

Teng, M. F. (2021). Interactive-whiteboard-technology-supported collaborative writing: Writing achievement, metacognitive activities, and co-regulation patterns. *System*, 97, 102426. DOI: 10.1016/j.system.2020.102426.

Thompson, B., & Daniel., L. G. (1996). Factor analytic evidence for the construct validity of scores: A historical overview and some guidelines. *Educational and Psychological Measurement*, 56, 197-208.

Tsai, C.-C. (2004). Beyond cognitive and metacognitive tools: The use of the internet as an' epistemological' tool for instruction. *British Journal of Educational Technology,* 35(5), 525-536. DOI: 10.1111/j.0007-1013.2004.00411.x.

Tsai, C.-C. (2005). Preferences toward Internet-based learning environments: High school students' perspectives for science learning. *Educational Technology and Society*, 8, 203-213.

Tsai, C.-C., & Chuang, S.-C. (2005). The correlation between epistemological beliefs and preferences toward Internet-based learning environments. *British Journal of Educational Technology*, 36, 97-100.

Tsao, Y.-C., Wu, C.-L., & Lee, M.-H. (2014). Development and validation of an instrument for exploring Taiwanese undergraduates' approaches to Internet-based learning. International Conference on Computers in Education (ICCE), Nara, Japan.

Zhao, L. & Ye, C. (2020). Time and performance in online learning: Applying the theoretical perspective of metacognition. *Decision Sciences Journal of Innovative Education*, 18(3), 435-455. DOI: 10.1111/dsji.12216.

Zhu, Y., Zhang, J.H., Au, W., & Yates, G. (2020). University students' online learning attitudes and continuous intention to undertake online courses: a self-regulated learning perspective. *Education Tech Research Dev*, 68, 1485-1519. DOI: 10.1007/s11423-020-09753-w.

Appendix A

Metacognitive Knowledge regarding Internet-based Learning questionnaire

Facilitate Metacognition (FM)

FM1: Make notion comprehension better.

FM2: Induce students to think differently than other people do.

FM3: Induce students to find relations between notions.

FM4: Allow students to express their own opinions.

Motivation/Impact (MI)

MI1: Lead students to take part to a learning community.

MI2: Allow students to reach a global overview.

MI3: Support students' motivation.

MI4: Prompt students to figure out possibilities and alternatives.

MI5: Allow students to be actively involved in knowledge building.

MI6: Induce students to negotiate their point of view.

MI7: Prompt students to be curious.

Facilitate Cognition (FC)

FC1: Make notion memorization better.

FC2: Induce students to think visually.

FC3: Make notion integration easier.

Negative Effects (NE)

NE1: Emotionally involve students too much.

NE2: Are physically and mentally tiring.

NE3: Confuse and/or mislead students.

Approaches to Internet-based Learning questionnaire

Deep Motive

DM1: I find that studying in the Internet learning environment makes me feel really happy and satisfied

DM2: I feel that learning topics can be highly interesting once I learn in the context of the Internet.

DM3: When I am learning on the Internet, I always have questions in mind that I want to know the answers.

Deep Strategy

DS1: I try to compare and judge varied information in the Internet when I have questions.

DS2: When I am learning on the Internet, I try to evaluate various information to make the question clear and focused.

DS3: When I am learning on the Internet, I check different websites at the same time to judge information.

DS4: When I am learning on the Internet, I can select accurate information through comparing and critically evaluating varied information from different websites.

DS5: When I am learning in the context of Internet, I try to integrate various information sources from different websites.

DS6: I try to relate what I have learned on the Internet to what I learned for other subjects in regular classrooms.

Surface Motive

SM1: I worry that my performance in the context of Internet-based learning may not be able to meet the teacher's expectation.

SM2: I use the Internet for learning in order to get a good grade.

SM3: I want to have a good performance in the Internet-based learning in order to please the teacher.

Surface Strategy

SS1: When I am learning on the Internet, all I have to do is to collect the information which seems to match questions. It's no need to waste my time to deal with it.

SS2: When I use the Internet for learning, I think the best way to get a good grade is to memorize the answers to relevant questions.

SS3: When I am leaning in the context of Internet, I find the best way to get high grades is to try to replicate the relative information for the examination.

SS4: When I am learning in the context of Internet, I will focus on and memorize the information relating to the examination.