



Studies in Second Language Learning and Teaching

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SSLT 8 (2). 2018. 471-495

doi: 10.14746/ssl.t.2018.8.2.13

<http://pressto.amu.edu.pl/index.php/ssl.t>

Strategies in technology-enhanced language learning

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Abstract

The predominant context for strategy research over the last three decades has focused on language learning situated in a conventional classroom environment. Computer technology has brought about many changes in language learning and has become ecological and normalized rather than a supporting tool in the language classroom. Consequently, the landscape of language learning has been rapidly and largely changed with the normalization of technologies in people's daily communication. The pervasive use of mobile technologies and easy access to online resources require that digital language learners understand and employ appropriate learning strategies for learning effectiveness and that their teachers are able and willing to teach these strategies as needed. This article provides an overview of the state-of-the-art research into technology-enhanced language learning strategies. The strategies under review include those for language learning skill areas, language subsystems, and self-regulated learning. At the end, we discuss the pressing issues that Digital Age language learning has posed to learners, teachers, and researchers and propose considerations for strategy research in digital realms.

Keywords: language learning strategies; self-regulated language learning; strategy instruction; strategy assessment; technology enhanced language learning

1. Introduction

Consciously or at least partially consciously, almost all language learners use tools, take actions, or self-regulate their behaviors to make their language learning or language use more effective or more efficient (Cohen, 2011; O'Malley & Chamot, 1990; Oxford, 1990). Oxford's (1990) landmark book on language learning strategies (LLS) and O'Malley and Chamot's (1990) volume on LLS in the cognitive information-processing model fostered strategy assessment and strategy instruction, leading to updated theorizations in recent years (e.g., Cohen, 2011, 2018; Griffiths & Oxford, 2014; Oxford, 2011, 2017). However, the rapid technological changes of the 21st century (e.g., computer-assisted language learning, data-driven technology, online and blended learning approaches, and emerging technologies such as online games, virtual and augmented reality, immersive classroom, and telepresence) are changing the landscape of second and foreign language (L2) teaching and learning. Knowledge and practices of LLS are still essential for successful learning, even in the Digital Age, and strategies relevant to various digital learning challenges do exist (Oxford & Schramm, 2007). Yet we do not fully know how learners and/or teachers can optimally understand and harness strategies in technology-enhanced, innovative language learning (Becker, Rodriguez, Estrada, & Davis, 2016).

Therefore, this article offers an overview of existing research on technology-enhanced LLS, following Oxford's (2017) categorization of L2 learning strategies. The sixty-six research reviewed explore language learning strategies, including strategic self-regulation, in technology-enhanced language learning (TELL) contexts. We define TELL broadly as any language learning activity that uses technological means and/or tools for efficiency, motivation, and learning style flexibility. Oxford's categorization divides L2 learning strategies into a set of interlocking but flexible systems: (1) strategies for language skills area (i.e., reading, writing, listening, speaking, and related aspects) and (2) strategies for language subsystems (e.g., vocabulary and grammar). The strategies under review are arranged in a similar way. We first review strategies for L2 skills learning, then look at strategies for language subsystems, and finally we focus on self-regulated L2 learning. The article concludes with overarching issues in the field of language learning strategies in digital environments, provides recommendations that guide language instruction in technology-enhanced contexts, and highlights questions that still need to be answered (e.g., lack of research) regarding the role of technology in the application of LLS.

2. Strategies for language learning skill areas in TELL

LLS research in technology-enhanced contexts are abundant in three language learning skill areas: listening, reading, and writing. It, however, is scant in speaking.

Literature reviewed here illustrate the richness and/or scarcity of LLS research of listening, speaking, reading, and writing in the context of TELL.

2.1. Listening

Utilizing the *Strategy of Inventory for Language Learning* (SILL) (Oxford, 1990) to evaluate students' self-dictation activities with YouTube videos, Chang and Chang (2014) examined forty-eight Taiwanese college students' English listening comprehension strategies on YouTube's caption manager platform. SILL's metacognitive items assess the use of strategies such as planning, setting goals, organizing, noticing, paying attention, looking for opportunities to make learning effective, monitoring, and evaluating. In an Advertising English college course, Chang and Chang first spent 8 weeks presenting and having students practice top-down strategies (listening for main ideas, prediction, and drawing inferences) and bottom-up strategies (vocabulary, sound patterns, and syntactic patterns), then spent another 8 weeks implementing metacognitive strategies. In the second stage, students were required to recall and reflect upon (e.g., what I know, what I want to know, and what I learned) their metacognitive strategy development by answering questions related to: (1) strategies they used to understand the online video, and (2) reasons why they could not answer certain listening comprehension items and the problems they encountered. The results indicated that, after strategy instruction, students consciously incorporated metacognitive listening strategies (e.g., "I notice my English mistakes and use this information to help me do better"; "I pay attention by listening when someone is speaking English in the advertisement videos") to manage and adjust their English learning when listening YouTube videos. Students who reported using the metacognitive strategies in the SILL performed significantly better on listening comprehension tests. They reinforced their listening comprehension by creating dictation questions, recalling strategy uses, and reflecting on their listening problems.

Using the *Metacognitive Awareness Listening Questionnaire* to investigate metacognitive listening strategies awareness and podcast-use readiness of 141 Tehran college students, Rahimi and Katal (2012) found the importance of metacognitive listening strategies in technology-based learning environments. Strategies such as problem solving, planning-evaluation, directed attention, person knowledge, mental translation, and problem solving are important indicators in effectively using English podcasts. The researchers discovered that metacognitive listening strategy awareness predicts the readiness of using podcast in English language learning. Similarly, in a dissertation study investigating 27 adult Taiwanese English language learners' strategy in comprehending authentic short documentary-style news videos, Slimon (2012) found that learners with higher listening

proficiency used significantly more bottom-up (e.g., comprehension of phonemes and single words to build up meaning) and total strategies as well as recalling significantly more audio contents than those who used fewer strategies.

2.2. Reading

Reading strategies in the TELL context are mainly scaffolded by platform design or software programming. For example, Dalton, Proctor, Uccelli, Mo, and Snow (2011) developed a web-based reading prototype to improve reading achievement. The goal of scaffolding is reading digital texts with embedded prompts that ask students to apply reading strategies. The six strategies that pop up for students to consider are: predict, question, clarify, summarize, visualize, and feeling. Student participants were 75 monolingual English and 31 bilingual fifth-grade students in Boston area where the majority non-white student population was composed of Latinos. After the teacher introduced reading strategies offline, the students were assigned to one of the three conditions aimed at improving comprehension online (ICON) conditions of eight English folktales: reading comprehension strategies, vocabulary, or combined version of comprehension strategies and vocabulary. During the research, the students read eight multimedia folktales and informational texts within their respective ICON condition and completed embedded activities. The reading-comprehension instructional actions they utilized in their prototype design were: (1) support strategic learning through prompted reading comprehension strategies, text-specific and generic comprehension strategy hints, models, and think-alouds, (2) provide access to contents through multiple means of representation (e.g., bilingual pedagogical avatar, synchronized, real-time highlighted bilingual texts or vocabulary translation on screen), and (3) support affective learning through age-appropriate and appealing folktales with quality interface and leveled coaching and support. By design, all three conditions shared common set of features such as Spanish-English bilingual hints, Spanish translation of instructional supports, and text-to-speech read-aloud functionality in English and Spanish. As a result, the researchers found that the strategy and vocabulary combination group and vocabulary group outperformed the strategy alone group.

One distinctive technology feature of reading online is the interactivity between learners and texts. In their interactive *English Language Learning System* (i-ELLS), Nor, Hamat, Azman, Noor, and Bakar (2011) employed interactive tools such as *Annotation* and *My notes* to teach English reading comprehension to 81 Malaysian college students. By design, the system embedded reading strategies that students would not be aware of, thus encouraging them to comprehend. The embedded tool, *My notes*, encouraged students to reflect on what they read and to share with peers or to comment on peers' notes, write down questions and notes, get

notes organized, and list unknown words. The *Annotation* tool allowed students to process the reading materials by applying reading strategies such as highlighting important points or points that they do not understand and by writing comments into the texts. The *Annotation* tool provided the opportunity for students to process and internalize the text at their own pace, leading to development of reflective learning.

Regarding online reading strategies, Ramli, Darus, and Bakar (2011) found in their study carried out in a Malaysian university that 92 ESL (English as second language) adult learners preferred metacognitive strategies over taking notes or reading aloud in online reading tasks. Metacognitive strategies include advanced planning and comprehension monitoring, such as global reading strategies (e.g., having a purpose in mind when reading online, checking understanding, deciding what to read closely and what to ignore), problem-solving strategies (e.g., trying to visualize information), and support strategies (e.g., seeking tools to aid comprehension). Similarly, Roy and Crabbe's study (2014) with 75 graduate-level, advanced English learners in a Japanese technical university found that the students employed global strategies (e.g., "I have a purpose in mind when reading") through both online and offline resources to aid their online reading. The researchers recommended that online reading materials developers design structured and compartmentalized questions for broad design queries to make thinking easier and channelized. In a study with seven graduate students from China, South Korea, and Taiwan at a US university in the Midwest, Park, Yang, and Hsieh (2014) utilized pre-reading think aloud before reading online texts to elicit participants' prior knowledge about the reading passages. They found that prior knowledge in students' native language and disciplinary background (e.g., business, chemistry, biology, health science, and instructional systems technology) assists their online reading comprehension. As more matured students with higher level of proficiency, the graduate students demonstrated self-regulated reading strategies such as planning, predicting, monitoring, and evaluating.

On the basis of their technology-assisted research involving 137 sixth-grade learners of English in Western Cape South Africa, Klapwijk and Toit (2009) suggested enhancing reading comprehension strategy instruction through a blended approach. The instructional approach was composed of an interactive, multimedia lesson on CD-ROM, an online assessment version of the comprehension test, and a booklet to guide the learners through the lesson steps. The interactive multimedia lesson included basic sound, a short video clip and interactive exercises that addressed three reading strategies: activating prior knowledge, summarization, and lookback. According to the researchers, technological advantages such as immediate feedback, self-paced learning, and exposures to a variety of media (audio and video), on the one hand, relieved teacher's workload, and on the other hand, motivated students to read.

2.3. Writing

When four Korean college students performed error correction in writing with the help of a free online corpus, *Lextutor*, Yoon and Jo (2014) found that students utilized four categories of learning strategies: metacognitive (e.g., self-evaluation/monitoring), cognitive (e.g., making use of materials, association, grouping, and translation), affective (e.g., lowering anxiety and self-encouragement), and social (e.g., questioning for clarification). Among these, the category of cognitive strategies was used the most and significantly more often than the other three categories.

In a German/English tandem project of Open University, UK, Stickler and Lewis (2008) paired 25 English speaking German language students in a higher intermediate German course with native German speaker partners in an adult education institution in German. Their intention was to investigate students' collaborative language learning strategies in an email tandem exchange. They identified six online-specific strategies and seven tandem-specific strategies used by the language learners. The online strategies were: (1) copying the previous message to highlight mistakes or offer corrections, (2) using greetings and social niceties of email writing conventions, (3) planning for the next email by announcing the time, date, or content of next message, (4) signposting in the email to demonstrate that next part will contain correction or switch of language, (5) using symbols (highlight, underline, color-in words) for corrections, and (6) using attachments with a reminder in body of email. The seven tandem-specific strategies were: (1) offering or giving corrections, (2) evaluating partner's performance, (3) encouraging partner with positive feedback, (4) offering a fair deal exchange, (5) answering explicit questions by directly responding to partner's previous emails or referring directly back to partner's statements, (6) planning face-to-face meeting via email to negotiate time and place to meet, and (7) negotiating for error corrections. According to the authors, memory strategies and compensation originally listed in Oxford's (1990) strategy groups were either not found or were very rare in tandem collaborative learning strategies.

With the purpose of examining the role of mobile phone technology in language learning strategies, Bekleyen and Hayta (2015) conducted a study with 75 English language teaching majors in a state university in Turkey. They found that the participants used cognitive, memory, compensation, metacognitive, affective, and social strategies with affective strategies being the most frequently employed. Social strategies were the least common.

In a bilateral tandem *MOO* (multiuser domain, objected-oriented) project between Irish ($N = 29$) and German ($N = 22$) college students, Schwienbhorst (2002) investigated learners' intended discourse repair strategies in native/nonnative speaker email exchange. Discourse repair strategies arose when there was incomplete

understanding and students used strategies such as negotiation of meaning, compromise overt request for clarification, self- and other- repetitions (i.e., exact or paraphrasing), complete or partial repetition, code switching, etc. The findings indicate that active strategies or processes of meaning negotiation are prominent in repairing communication. In the case of misunderstandings caused by language barriers, the repair strategies the participants used the most often were asking partners to translate, paraphrase, clarify, guess, and negotiate meaning.

In a Chinese university, Tang, Xie, and Wang (2011) designed a Wiki-based collaborative writing environment for their e-Commerce Specialty English course. This environment was composed of four types of tools for students to use when completing writing assignments: (1) tag web resources, an online semantic annotator allowing learners to conceptually model semantic relations, (2) peer revision and feedback to assist group members in coordination of collaborative learning process, (3) semantic search that facilitated search and retrieval options, and (4) page histories that recorded every major review version. Three learning strategies were identified by the researchers, namely, collaboration and knowledge sharing, peer assessment, and monitoring the stages of the writing process. Evaluation results showed that Wiki-based collaborative writing can promote student engagement, group work, and audience awareness.

2.4. Speaking

Surprisingly, speaking strategies research in the TELL context is scant. This might be because of the constraints of technology available for interactive speaking and also speech recognition technologies. Taking advantage of video feedback, Hung (2016) conducted a project over the duration of a semester among 60 EFL learners in Taiwan. The project required students to post a 3-minute video presentation on Facebook for questions and discussions occurred in class, then two 2-minutes video-mediated oral feedback. The researcher investigated learners' strategic behaviors in the process of developing video-mediated peer feedback and explored the strategies employed by learners when giving video-mediated oral feedback. Hung's findings revealed that the most frequently used strategy was modifying language for accuracy and constant practices, along with watching others' oral comments, jotting down comments for future improvements, and discussing with classmates.

3. Strategies for language learning subsystems in TELL

Oxford (2011) categorizes LLS use into main areas such as the four language learning skill in learning the target language systems and subsystems (grammar

and vocabulary). Research focusing on LLS use with respect to the remaining L2 sub-areas in the TELL context (e.g., affective and pragmatics) could not be found in major linguistics databases. We, therefore, focus our review on vocabulary and grammar.

3.1. Vocabulary

Vocabulary learning strategies might be the most productive research area in TELL, though grammar learning strategies sometimes accompany vocabulary learning strategies. Li (2009) compared vocabulary learning strategies with or without technology support among Chinese speaking ESL students in Canada. 24 high school students were asked to read 10 short Aesop's fables, among which, five in paper format and five in *e-Lective* platform. The *e-Lective* features English-English and English-Chinese word definition, an unknown word bank for students to record what they have looked up, a partial and blank word bank for cloze test and comprehension exercise, and a grammar notebook for students to look up parts of speech when inferring meanings of words. The strategies used in the *e-Lective* condition included using online dictionaries, taking notes, guessing and inferring, summarizing and making connections, reading aloud, and discussing. According to the participants, compared to those in printed texts, *e-Lective* allowed them to utilize more strategies in ways summarized in Table 1. Li pointed out from the results that technology-enhanced scaffolding can effectively assist students in advancing their learning strategies, potentially optimizing their reading-based vocabulary acquisition. Overall, students in the *e-Lective* condition used higher levels of cognitive and social strategies (e.g., summarizing and discussing), whereas the in paper condition they employed fewer social strategies (e.g., consulting with the researcher and peers regarding meanings of words).

Table 1 Strategies used with *e-Lective* and associated reading activities (Li, 2009, pp. 131-133)

Strategies used with <i>e-Lective</i>	Associated reading strategies
Note taking	Taking more, well-organized notes with <i>e-Lective</i> to facilitate memorization and review
Guessing and inferring	Using contextual cue-oriented guessing strategies with higher accuracy than in the paper condition
Summarizing and making connections	Engaging in the use of higher levels of cognitive strategies that promoted deeper semantic processing and better vocabulary retention, such as summarizing, applying, and manipulating phrases and words
Reading aloud	Being able to use the built-in text-to-speech module to read aloud and practice the pronunciation in words, sentences, and whole texts; attention paid to syllables and stress patterns
Discussing	Using a wide range of cognitive strategies to process the reading and retain vocabulary (e.g., repeating, quoting, referencing the texts); switching languages to make communication as comprehensive as possible; translating to verify understanding; and reasoning – a higher level of semantic processing of information

Furthermore, gamification of learning so frequent in TELL makes it natural to learn vocabulary via computer games. Smith, Li, Drobisz, Park, & Kim (2013) designed a vocabulary learning game for intermediate level Chinese students enrolled in a College English course. Fifty-seven students used the interference-based computer games the researcher designed to learn new vocabulary words and make inferences about a text. The interactive game-like interface forced learners to create sentences through constrained choices. Smith et al.'s (2013) experimental study found that inference-based computer games enable students to process the vocabulary more deeply and have better recall. The strategies that the students needed to incorporate with the game-like constrained sentence-writing were making inferences, encoding more effectively, comparing the game to reading lists of words, and answering multiple-choice questions.

Gallo-Crail and Zerwekh (2002) researched how L2 learners used different strategies with different web-based tools as they studied new vocabulary and how this affected their success in learning and mastering such vocabulary. The participants in this study were 25 beginning level students of Tagalog at Northern Illinois University. The researchers identified five types of learning strategies supporting online vocabulary learning: memory strategy (e.g., association), cognitive strategy (e.g., translation), compensation (e.g., use of linguistic and other clues), affective (e.g., developing cultural understanding), and metacognitive (e.g., overview and lining with previous learning materials). The more diverse strategies students used to learn vocabulary, they performed in vocabulary tests.

Some researchers and instructional technologists design and investigate vocabulary learning strategy software or applications. For instance, Lan (2013) developed a co-sharing-based strategy learning system, *Mywordtools*, for 61 sixth-grade students in Taipei to learn English vocabulary. This application enables students to learn vocabulary by using the available language learning strategies embedded in the design. When an L2 word is chosen, the learner can look up the strategies that have been used by all of the other learners in *Mywordtools* or select one of the strategies that he or she wants to use to aid the process of learning and memorize the word. The choices are: note-taking, contextualization, grouping, imagery, recombination, deduction, analysis, translation, etc. The users have four options (i.e., audio, video, image, and note) to record their learning strategies. Once the learners have uploaded their learning strategies, the learning module allows them to look up the strategies used by other peers. The function of embedded strategies sharing is to raise the awareness of learners so that they can self-evaluate their own strategies, make them cognizant of gaps in their knowledge, and enable them to re-construct their strategies or increase their self-confidence. The results of this study indicated that students using *Mywordtools* to practice and share vocabulary learning strategies outperformed

both those who did not use *Mywordtools* and those who used the platform but without sharing. It was also found that strategy sharing helped L2 learners use more vocabulary learning strategies, and they consequently performed significantly better than those who did not engage in strategy sharing.

Ou Yang and Wu (2015) incorporated LLS instruction into their e-learning platform called *MyEVA*. *MyEVA* is a mixed-modality English vocabulary learning strategies system. In this system, they used Schmitt's (1997) division of strategies for learning L2 vocabulary into discovery (i.e., determination strategy and social strategy) and consolidation (i.e., social strategy, memory strategy, cognitive/metacognitive strategy, pictures/imagery, related/unrelated words, grouping, the word's orthographical and phonological forms). *MyEVA* was piloted with nine undergraduate students in northern Taiwan. The findings indicate that the vocabulary learning mode that allows learners to pre-determine a preferred learning strategy (e.g., word-card, flashcard, Chinese-asonance, synonym, antonym, imagery, grouping, and clipping) before actual learning resulted in greatest vocabulary acquisition and best retention.

3.2. Grammar

Research on the use of grammar strategies by learners has been scant (Cohen, Pinilla-Herrera, Thompson, & Witzig, 2011; Oxford & Lee, 2007; see the paper by Pawlak in this issue). Even more scant is technology-enhanced grammar strategies research. However, an exhaustive search of major databases allowed us to identify several attempts in this area.

To strategize the learning and using of Spanish grammar, Cohen et al. (2011) designed a website to track grammar strategy use by 15 students of Spanish. Unlike a collection of grammar rules, this website collected 72 strategies that were found to be effective for Spanish learners. It contained two sections. One section included strategies for a particular grammar form that students thought were necessary for them to learn. The other section contained strategies for enhancing learners' use of grammar strategies. In this section, learners can select strategies that match their learning style and their ideas about what they can put into practice. To examine the accessibility and navigation of the website, a small-scale user test was administrated. The research questions were related to strategies that the learners chose, the extent to which these strategies were helpful and the rationale for choosing specific strategies. The results indicated that the learners thought 73% of the grammar strategies were helpful and that found certain strategies helped them improve their Spanish grammar performance. In addition, the students reported improvement in class activities, on tests, and on writing assignments during the 6-8 weeks of practicing with the

grammar strategies website. Some participants even reported improvement in their ability and confidence to use grammar forms that they had struggled with before. Overall, the learners benefited from use of the grammar strategies website. It can thus be assumed that reliance on the strategies included in the website allowed them to enhance their mastery of grammar.

A study that examined the effects of the application of grammar strategies that aided learning of specific grammar forms was conducted by Hwu (2007). Hwu investigated how different students used a grammar application created by the researcher. The objective of the application was to teach the uses of two Spanish past tense forms. He asked learners to watch Spanish soap opera clips that contained various pragmatic meanings of the two forms in conversations. Each of the 19 clip lessons included in the application consisted of one component that explicitly asked the students to explain how a linguistic form was used in the clip, provide their own explanation of the form in terms of the speaker's intention, indicate the reference point of the intention, decide whether the other word is acceptable in that context and why/why not, and to explain of the use of the target verb form in the sense of pragmatics. The grammar strategies instruction provided by means of this application was integrated into the syllabus and a pre- and posttest was administered to determine whether the students' understanding had improved over the semester. The results indicated that the experiment group students spent a substantial amount of time with the grammar strategies application, which resulted in significant improvement from pretest to posttest while the control group students remained at the same level. Furthermore, Hwu (2007) analyzed the correspondence of the strategy preferences expressed in the SILL (Oxford, 1990) and predominant types of learning styles. The results indicated that intuitive students tended to use cognitive strategies and developed their own understanding of how target language pragmatics works. Sensing participants, on the other hand, tended to use memory strategies to memorize grammar explanations. The only cognitive strategies sensing students used were making summaries of the grammar explanations and reasoning grammar explanations deductively.

Another study focusing on grammar strategies in the context of TELL explored the effect of using self-explanation (e.g., infer and reflect) on a web-based Chinese sentence-learning system and was conducted by Chang, Lee, Su, and Wang (2016). They integrated a self-explanation strategy into a Chinese-learning system that included self-explanation prompts, instructional feedback, and remedial learning materials. The self-explanation strategy provoked the students to discover, analyze, and overcome their misconceptions about Chinese sentences. When the students were inspired to identify and self-explain their errors, they had to infer possible reasons for the errors and to discover what they had misunderstood and if they could revise or correct their mistakes. To

determine the effect of the use of the self-explanation grammar strategy web-based application, the researchers had the students complete pre- and post-tests, and sentence-structuring exercises. After comparing grammar test scores and cognitive loads of the experiment group and control group, the researchers found greater learning outcomes in the experimental group in terms of grammar and sentence structure, as indicated by the higher means on the posttest. Three rounds of comparisons for sentence-structuring exercises between the experiment and control groups indicated that, when in the first round, the numbers of errors made by the experiment and control groups were 67 vs. 86; the results in the second and third round were 29 vs. 49 and 11 vs. 27, respectively. There were, however, no significant differences between the experiment group and control group in terms of the cognitive loads involved in the performance of the grammar tasks. Although the self-explanation strategy was effective in learning Chinese grammar, the students complained that the process was time consuming and did not always enable them to eliminate their errors.

4. Strategic, self-regulated language learning with technology

Despite different purposes of using strategies to learn the language skills and subsystems of the target language, self-regulation is crucial in the success of language learning. Self-regulation is a process in which people organize and manage their learning, including control of their time, thoughts, emotions, behaviors, and environment (cf. Zimmerman, 1998). The richness of the technology design and applications available causes teachers to consider integrating technology in and out of language classrooms and makes self-regulated learning strategies a necessary skill set for L2 learners. It should be noted that all learning strategies are aimed at self-regulation, although self-regulation as a specific construct was not linked to language learning strategies until the late twentieth century (see Oxford, 1999).¹ If learners are motivated, they autonomously select a particular activity, decide how long they are willing to persist in it, and what effort they are going to invest (Dörnyei, 2001). In understanding the importance of self-regulated learning strategies for L2 proficiency, Oxford (2011) distinguishes three dimensions of strategic self-regulation. The three dimensions are:

- 1) *cognitive strategies* for remembering and processing language and *metacognitive strategies* for planning, organizing, monitoring, and evaluating in the cognitive area;

¹ Autonomy was first associated with language learning strategies several decades before that (Oxford, 1999).

- 2) *affective strategies* linked with emotions, beliefs, attitudes, and motivation and *meta-affective strategies* for planning, organizing, monitoring, and evaluating in the affective area;
- 3) *sociocultural-interactive strategies* for contexts, communication, and culture and *meta-social strategies* for planning, organizing, monitoring, and evaluating in the sociocultural-interactive area.

This section will follow Oxford's three dimensions to look into research findings of strategic, self-regulated language learning enhanced with technologies.

4.1. Cognitive/metacognitive dimension

Self-regulated learning strategies are crucially important in online learning environments. Chung's (2015) questionnaires administered to 441 Taiwanese college students taking a Massive Open Online Course (MOOC) revealed that high-level English learners utilize more self-regulated strategies in the process of learning, such as cognitive regulation strategies (e.g., rehearsal, elaboration, organization, critical thinking, comprehension, and correction), motivational regulation strategies (e.g., intrinsic, task value, success expectation, and positive affectivity), and resource management strategies (e.g., environment, adjustment, peer cooperation, and seeking assistance).

In technology-enhanced language learning classes, researchers found it is effective to include self-regulation strategies in task design. For instance, in an Australian university, An (2013) integrated self-regulated tasks into a Chinese language course built around the web-based podcasting platform, *ChinesePod*. In her design, pre-tasks exposed the 49 student participants to extensive authentic Chinese language use in context through online podcasts. This involved the students' self-study of the podcast lessons, which included listening to the podcasts and understanding the contents. The major tasks involved students' creating, writing, re-writing their own dialogues and plays. The report stage was when students acted out their self-created plays or videos in class and received feedback. An (2013) reported that the task design, where self-regulation strategies were embedded, yielded impressive learning outcomes in terms of vocabulary, grammar, and improvement from first to final writing drafts.

In another study exploring the effects of a self-monitoring strategy on students' academic performance and motivational beliefs in web-based instruction, Chang (2007) found that the strategy had a significant effect on students in these areas. The instructor required the 99 students in Freshman English class to keep a self-monitoring recording form each time they logged into the course site. The form functioned as a record and an alert of time logs, learning modules,

prediction and real test scores. Students who employed self-monitoring strategies outperformed students who did not on both academic performance and motivational beliefs. Within the higher-level English proficiency group, students who employed the self-monitoring strategy obtained higher scores than those who did not. Chang's research revealed that self-monitoring treatment in instructional design compensated for the lack of use of metacognitive strategies among the lower-level English proficiency group.

Self-instruction, self-regulation, and learning autonomy are crucial for distance language learners. In a study involving 37 students learning French ($N = 19$, of which 4 were in classroom mode) and Japanese ($N = 18$, of which 5 were classroom mode), White (1995) found that distance learners used strategies more often than classroom learners (e.g., 26.6 instances vs. 10.2 of strategy use in self-reports). With respect to metacognitive strategies, distance learners made greater use of the monitoring and evaluation dimensions of metacognition than did classroom learners. Distance language learners therefore need to develop an understanding of the nature of language learning as well as an appropriate repertoire of language learning strategies. Among the three strategies that distance learners use, the most influential self-regulation strategy is self-management as it fosters learner autonomy.

It is important that teachers facilitate or assist the development of learners' self-regulated strategies in strategic language learning in TELL environments. Hourigan and Murray (2010) pointed out the importance of developing learning strategies in digital times because students of the 21st century are not necessarily "digital natives" (p. 212). Similarly, it is necessary to provide opportunities for learners to develop metacognitive awareness and to guide them in improving and expanding their knowledge about learning and becoming autonomous language learners (Hauck, 2005). Without adequate training or guidance, technology-based language learning outcomes may not be ideal, for instance, for effective English listening learning (Zhang & Song, 2009). One good example of strategy instruction is what Saks and Leijen (2015) did in an attempt to find a more efficient way to support learners' use of cognitive and metacognitive learning strategies. They integrated strategy learning as scaffolding with strategy prompts to improve students' learning efficiency at various phrases of learning. In their blended Tourism English course, 28 Estonian students were encouraged to plan, monitor, and self-evaluate their learning activities with the help of learning journals. The evaluation of the course indicated that the most obvious improvement resulting from such scaffolded strategy prompts in course design are active use of language as well as compensation, and social strategies. Assignments prompting learners' use of cognitive and metacognitive LLS facilitate the development of content knowledge and language skills, and also support self-expression in English.

Similarly, in Spain, Pujola (2002) designed a web-based program called Im-PRESSions, consisting of multimedia news (newspaper, radio, and television) to facilitate the use of reading and listening comprehension strategies in the course of self-study. It was designed in response to Garrett's (1995) assumption that students lack awareness or strategies for help seeking. The design contained four modules: newspaper, radio, television, and expert (note: this module was designed to provide grammar practices for the learners). 22 adult English learners reported that inferring strategies in context was what they used the most in this program. The participants also engaged in analysis of parts of the words, similarities between the target language with their native language, and links to previous news item. Examples of prompts that facilitated participants' thinking about help seeking and learning strategies in the form of a pop-up button ASK-THE-EXPERTS included: What can I do when I do not know a word? What can I guess the meaning of a word? When can I use skimming? How can I improve my reading? What can I do when I cannot follow the speed of the speaker? What can I do when I hear too much unfamiliar information? (Pujola, 2002, p. 256). The most frequently consulted listening strategies question was what can be done when students cannot follow the speaker, whereas the most frequently consulted reading strategies question was when they can use skimming and scanning.

4.2. Affective/meta-affective dimension

Technology-enhanced self-regulated L2 learning is related to positive affective learning outcomes and language gains (Lai, Wang, Li, & Hu, 2016). Affective strategies are linked with emotions, beliefs, attitudes, and motivation, as well as sociocultural-interactive strategies for contexts, communication, and culture (Oxford, 2011). Self-regulatory strategies are influential in promoting motivation and autonomous learning (Kormos & Csizér, 2014).

Kondo, Ishikawa, Smith, Sakamoto, Shimomura, & Wada (2012) designed a MALL (mobile assisted language learning) self-regulated learning module to help improve students' scores on the TOEIC listening and reading tests. Their goal was to investigate whether certain MALL practices can foster an advanced form of self-study and self-regulated learning. Their module was composed of five-steps in order to foster, in the initial stage of self-study, and in the long run, to support students' gradual transition to self-regulated learning. 88 first-year students at Kyoto University, Japan, participated in this study. In this strategic language learning pedagogical design, students took responsibility for stimulating and sustaining their motivation so that they could formulate, carry out, and evaluate strategic learning plans. Results indicated that students in the MALL group improved self-study behaviors and spent more time on studying outside

of class. They increased their scores in both the listening and reading sections (e.g., an increase of 40.83 in the MALL group vs. 18.15 in the control group).

Lai and Gu's (2011) survey study with 279 Hong Kong college students learning foreign languages (i.e., Chinese, English, French, Japanese, Spanish, and Korean) investigated how technology enhanced students' self-regulated language learning outside the classroom. Data analyses indicated that students' motivations for using technology in self-regulated L2 learning included: regulating emotions and making learning appealing, planning, evaluating, and monitoring learning progress, enhancing social connections and seeking help, making commitment to learning goals, making use of learning resources, and having better cultural understanding. In addition, teachers were found to provide important emotional support in students' self-directed language learning with technologies outside of classroom. The strategies that students thought were effective in supporting self-regulated language learning with technology included encouraging students to use technological resources and using technology in class (Lai, 2015).

4.3. Sociocultural-interactive/meta-social dimension

Informed strategy use is particularly important in the context of online language learning, where learner interaction often takes place in environments that students are either less familiar with or more interested in communication with their peers rather than in educational purposes. In an internet-mediated intercultural foreign language exchange project, Hauck and Hampel (2008) created a telecollaborative exchange with students from three different countries, France ($N = 10$ learning English), the UK ($N = 5$ learning French), and United States ($N = 10$ learning French). Telecollaboration takes place when learners in internationally parallel language classes use internet communication tools such as email, synchronous chat, threaded discussion and so on to support sociocultural interaction. In Hauck and Hampel's project, the participants spent 10 weeks taking part in a structured exchange exploring the benefits of synchronous and asynchronous learning environments for partnership language learning. The analysis of the online interactions yielded the most examples of affective strategies (e.g., lowering anxiety, encouraging, and taking emotional temperature) and social strategies (e.g., asking questions, empathizing with others, getting to know others, and facilitating interaction) proposed by Oxford (1990). In addition, a new set of strategies, which the researchers termed *socio-environmental strategies* played a vital role in successful online learning of languages and cultures. The researchers claimed that interactions in online environments require different ways of making and maintaining contact, finding out about common interests, and developing an identify as a group. Compared to face-to-face communication,

affective and social skills cannot simply be transferred but need to be tailored to virtual learning environments. Due to the nature of online intercultural exchanges, strategy (especially metacognitive strategy) instruction, is an important step in facilitating language learning. The online language learners need continuous support from teachers in terms of LLS use.

5. Discussion

The arrival of the Digital Age has been a *white water change*, a metaphor describing the rapid, complex and all-encompassing nature of this technological wave (Oxford 2008, p. 191, cited in Oxford & Lin, 2011). The widespread availability of technology tools brought about new opportunities and challenges in language learning strategy pedagogical design and research, and, consequently, new considerations for instructed second language acquisition. As Chapelle (2009) writes, "Technology dramatically extends and changes the breadth and depth of exposure that learners can have with the target language and interactive events in which they have the opportunity for language focus" (p. 750). The increased use of technology in language classrooms makes it no longer appropriate to think of it as a supporting tool in face-to-face language classroom (Nunan, 2000). Technology is far more than this. Learners are now challenged to explore strategies for effective language learning in digital realms (Oxford & Lin, 2011). This new context of language learning calls for new pedagogical designs involving strategy instruction and new methodologies for research into LLS.

The overview undertaken in this article revealed that although 21st century L2 learners, especially those in technologically developed countries, are digital natives (Hourigan & Murray, 2010), they are not necessarily experts in learning with technologies. This is especially true in the case of language learning. Although a large portion of language learning extends to outside of the classroom due to the pervasive employment of multimodal technologies, learners might not be self-regulating or autonomous unless they have been explicitly taught to use learning strategies. Digital Age learners who benefit from proper language learning strategy instruction outperform their counterparts who have not received such training both in language learning efficiency and language skills. Strategies-based instruction which is enhanced by technology produces impressive outcomes in terms of developing strategic, self-regulated language learners in the Digital Age (Mutlu & Eroz-Tuga, 2013).

We strongly agree with Salaberry's (2001) proposal that the most important challenge posed by TELL is the identification of pedagogical objectives that technology-based teaching is to achieve. The diversity and universality of modern technologies available have challenged both language teachers and

learners. The teacher's role is crucial in identifying the best technology tools and guiding students to be strategic, self-regulated language learners when using technologies. A teacher without ample knowledge and skill in evaluating and utilizing effective technological tools may not be a good teacher in the Digital Age. Kern (2006) examined how the rapidly changing communication landscape of the 21st century affects the way we learn, use, and teach languages. While technological devices and easy access to them are powerfully transforming how human society communicates, researchers are becoming increasingly aware of the importance of strategy use with technology in the cognitive and affective dimensions of strategic, self-regulated learning. In contrast, research into the use of grammar strategies as well as the sociocultural-interactive dimension of strategic, self-regulated learning seems much less fertile, despite the availability of authentic, interactive materials online and on mobile apps. It is important for 21st century language teachers to have "new understandings of language and communication, critical awareness of the relationships among technology, language, culture, and society, and new trends in research methods" (Kern, 2006, p. 183). Although communication strategies were originally categorized by Oxford (1990) as "tools for active, self-directed involvement" (p. 1) for the development of communicative competence, at this point in history they are also crucial strategies in computer-mediated contexts and may be considered very important in pedagogical designs and research informing synchronous, virtual communication.

6. Conclusion and recommendations

In this paper, we reviewed existing research on language learning strategies in TELL environments, first in relation to specific language skills (i.e., listening, speaking, reading, and writing), then as associated with target language subsystems, such as vocabulary and grammar, and finally, as linked to strategic, self-regulated language learning. The technology-enhanced language learning strategies reviewed demonstrate the specifics of what learners and teachers do with technologies in the Digital Age, how they embed language learning strategies into games, online platforms, and/or apps, and how they cultivate self-strategically self-regulated learning. If the communicative approach has profoundly changed the components of language classroom, the rapid technological changes and pervasive presence of interactive Web 2.0 tools (e.g., voice interactive CALL, Kern & Warschauer, 2000) in the 21st century have extended language teaching and learning to any time, at any place, with any device. New thoughts, practices, and research protocols are needed to cope with the rapidly growing new technologies (e.g., smart phones, tablets, 3D glasses, real-time virtual interactive tools) and new learning environments (e.g., virtual reality, mixed reality, and immersive, intelligent

learning environment). Although the unprecedented human-computer interaction formats (e.g., emails, Facebook, Google hangout, Skype, Twitter, WeChat, QQ) have provided more authentic language learning venues, it does not necessarily mean that our learners of the 21st century are born to know how to learn a foreign language effectively with these technologies and how to self-regulate their learning outside the classroom. Instead, there is a need to equip learners with strategies for effective human-computer and sociocultural interaction. We therefore make the following recommendations in terms of language learning strategy theory and practice for more effective language learning.

First, with the embeddedness of technology in and out of language classrooms, in addition to traditional research protocols, we call for more research instruments to investigate technology-enhanced LLS (see e.g., Chai, Wong, & King, 2016 on learning strategies and strategy instruction in TELL contexts). Strategies which were not included in traditional frameworks of LLS need to be added, such as, for instance, socio-environmental strategies, proposed by Hauck and Hampel (2008), and human-computer interaction strategies with emerging technologies. In addition, social language learning strategies, which were seemingly less important in traditional schemes, are now known as collaborative language learning strategies and identified as one of the most important strategy sets in email tandem exchange tasks (Stickler & Lewis, 2008). Furthermore, normalization of technology in language classrooms and the multi-faceted aspects of language learning technologies have altered traditional language learning and teaching approaches. This change calls for new learning strategies, digitalized data collection, and data analysis. It also presents new challenges for research design and instrument-building and requires a new frontier of research methodologies (Stickler & Shi, 2016) in language learning strategies and self-regulated learning with TELL.

Second, due to specific and ungeneralizable technological infrastructures, most TELL-based strategy research has investigated the effectiveness of a technology and/or platform in a laboratory setting, often including only short-term treatments. Instruction in language learning strategies and self-regulated learning with TELL over longer periods of time (e.g., a semester), taking place in intact classes (e.g., Zhou, 2016) seems to be more suitable in digital realms. More research is needed to explore how 21st century L2 teachers and learners handle strategies and self-regulated learning in technology normalized day-to-day classroom operations.

Third, language learners are challenged by new forms of learning and seek new strategies for learning (Oxford & Lin, 2011). In addition, the availability of new technologies and language learning tools has grown much faster than the preparation of language teachers. Learning strategy instruction should be integrated into the curriculum of technology-enhanced language learning. Successful use of new language learning technology tools and new types of learning strategies

depends on language teachers' increased knowledge and dedication to help their students gain awareness of and skill in using optimal LLS. This calls for a change in the curricula for language teacher education. In addition to knowing about teaching methodologies and assessments of language learning in traditional ways, language teachers in digital realms also need to be equipped with knowledge and skills to: (1) identify technical attributes specific to the new technologies that can be feasibly integrated into and engaged with classroom instruction, and (2) design technology-enhanced pedagogy with LLS orientation for their students.

Finally, emerging technologies (e.g., Web 2.0, augmented reality, Google glasses) and learning environments (virtual reality, 3D, mixed reality, cognitive immersive), which have been designed in collaboration with artists, programmers, and language educators, have opened up a new era for L2 learning research, including strategy research. There are many unknowns in this new form of research. Investigations into language learning strategies and the effectiveness of strategies-based instruction need to be expanded and diversified taking into account new types of human-computer interactions and modes of learning.

In conclusion, technology has changed considerably since the incorporation of computers into language learning and teaching in the 1980s. It has shifted from being a tutorial tool to an ecological tool integral to language learning and language teaching. It has transformed from being a concept to a reality. New initiatives have begun to update theory, practices, and research in computer-assisted learning (Bush, 2008; Garrett, 2009). As for the field of language learning strategies, technology has offered, and continues to offer, research findings and practical insights concerning strategies that make L2 learning more effective (cf. Griffiths & Oxford, 2014). Rapidly growing new technologies and emerging, immersive learning environments call for a quick reaction from theory, research and practice of language learning strategies. It is time for researchers and practitioners to rethink the role of TELL and immersive, interactive, learning environments that require reliance on language learning strategies. Language learning strategies have to be reconsidered (Bekleyen & Hayta, 2015) since they must be adapted substantively to new technological devices and learning environments. New initiatives, then, must be brought into the field of language strategy instruction, assessment, and research.

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