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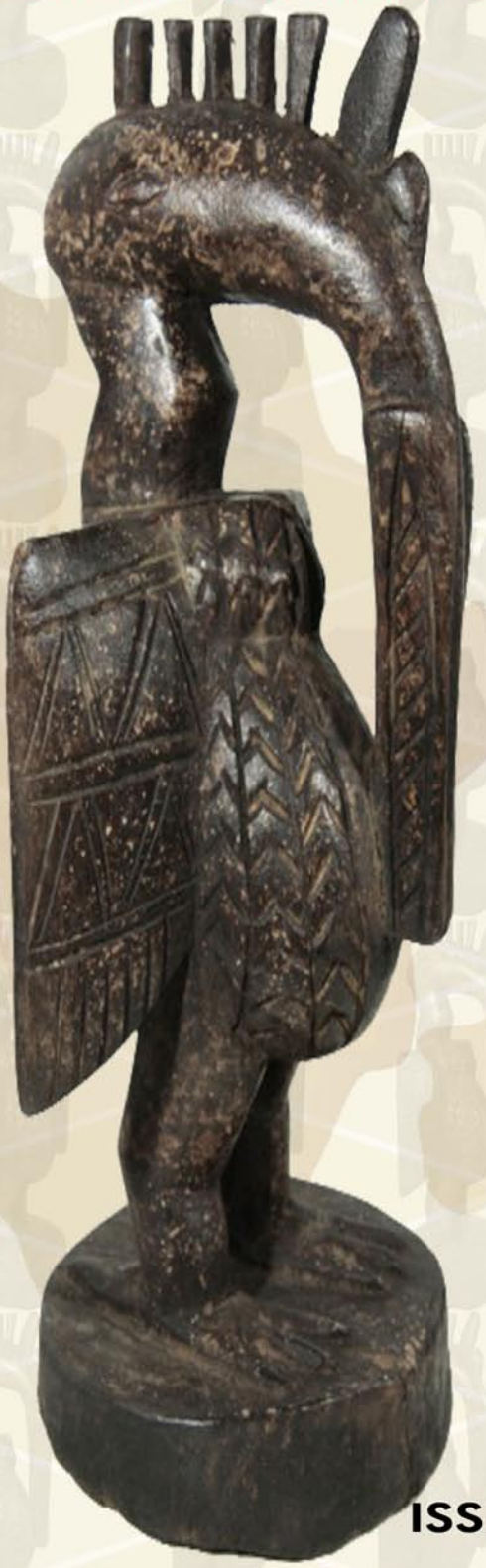

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Problem-Solving and Foreign Language Learner's Cognitive Growth

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Abstract

This study aims at examining the impact of problem-solving on foreign language learners' cognitive growth. The findings of this paper have two folds. Firstly, problem-solving activities have proved to have positive effects on learners' cognitive development with regard to the acquisition of enhanced foreign language proficiency and higher-order cognitive and metacognitive skills. Secondly, the positive effects observed on learners' cognitive growth are related to the use of top-down language activities, the recourse to problem-solving strategies and the use of the target language as a tool for thinking and interactions. Therefore, I suggest that foreign language curriculum and instruction should provide learners with more opportunities to experience top-down problem-solving activities.

Key-words: Problem-solving, foreign language learning, leaners, cognitive growth, cognitive strategies, metacognitive strategies.

Résumé

Cette étude a pour but d'examiner l'impact du processus de résolution des problèmes sur le développement cognitif des apprenants en langues étrangères. Le résultat de l'etude comprend deux points. Premièrement, le processus de résolution des problèmes s'est avéré bénéfique pour le développement cognitif des apprenants. Il favorise notamment une meilleure maîtrise des langues étrangères et l'acquisition de compétences cognitives et métacognitives de stade supérieur. Deuxièmement, les effets positifs observés sur le développement cognitif des apprenants sont dus au recours à des activités visant une résolution de problèmes du haut vers le bas, à des stratégies de résolution de problèmes et à l'utilisation de la langue cible comme outil de réflexion et d'interactions. Par conséquent, nous suggérons que les programmes et l'enseignement des langues étrangères offrent davantage de possibilités aux apprenants afin de faire l'expérience d'activités visant une résolution de problèmes du haut vers le bas.

Mots-clés: Résolution de problèmes, apprentissage des langues étrangères, apprenants, développement cognitif, stratégies cognitives, stratégies métacognitives.

Introduction

In recent years, problem-solving approaches have been encouraged in the foreign language classrooms. The aim is to focus on learning processes that prepare learners to be able to use language in order to cope with common situations and problems in a world which is becoming more and more complex. This change of paradigm requires exposing leaners to activities which allow them to acquire language while ensuring their cognitive growth. Though some studies provide evidence for the mutual influence of language and cognition on the use of native languages in childhood (Johnston, 1988; Byrnes and Gelman, 1991), little is known about the link between problem-solving activities and language learners' cognitive growth. In order to have more insights into this issue this paper intends to answer the following main question: What is the impact of problem-solving activities on foreign language learners' cognitive growth? This question calls for three subsidiary questions: What does cognitive growth refer to? How do problem-solving activities influence foreign language learners' cognitive growth? What problem-solving activities are more conducive to language learners' cognitive growth? The study is based on theories and empirical classroom-based work in the field. The article consists of three parts: The first part outlines some theories of cognitive growth. The second part describes problem-solving in foreign language learning by highlighting its relevance to learning, its impact on foreign language learners' cognitive growth and classroom problem-solving activities that are more conducive to that growth. The last part is devoted to our concluding remarks and suggestions.

1. Theories of Cognitive Growth

1.1. Piaget's view

According to the related literature, various mechanisms are responsible for cognitive growth. For Piaget, cognitive growth results from individuals' personal efforts to construct schemata or mental representations based on their experience with objects. These efforts, which consist in manipulating objects and reflecting on incoming information, result in the creation of schemata or representations in individuals' minds (Piaget, 1971, 1978a, 1980 cited in De Lisi & Golbeck, 1999, p.12).

Actually, Piaget holds that the experience in manipulating objects and reflecting on them gives rise to two interactive mental growth processes: assimilation and accommodation. Assimilation occurs when individuals' pre-established representations or knowledge allow them to understand the characteristics of new objects or events. The ability to assimilate something means that the individuals possess an appropriate level of existing knowledge which enables them to make sense of incoming information. The accommodation process "involves changing mental representations to explain new experiences" (Van Blerkom 2009, p.224). Accommodation usually occurs with experiences that challenge individuals' established knowledge leading to what Piaget calls 'disequilibrium'. It is a mismatch between pre-established knowledge and incoming information from experience with new objects. As Saracho (2012) posits, when individuals face such problems, they seek to modify what they already know "for an appropriate match to their new reality" (p.118). Thus, cognitive growth occurs through the interaction of thinking processes of assimilation and accommodation whereby a subject elaborates his/her existing knowledge and creates new knowledge.

1.2. Vygotsky's view

For Vygotsky, many cognitive aspects often thought to grow naturally from individuals' personal actions and thinking do not thrive from natural processes. He explains that higher-order mental processes and abilities such as selective retrieval of information from memory, conceptual thinking, and problem-solving rather depend on social interactions and the use of social tools. Vygotsky uses the terms 'intermental' and 'intramental' to highlight the existence of two main processes of growth. The 'intermental' process, the one he values most, describes the interactions between individuals and their peers or more knowledgeable people over an activity. The process is marked on the one hand by individuals gathering data (different ways of thinking and information) and asking and answering questions. On the other hand, peers and experts offer 'scaffolding' or support in accordance with recipients' existing level of understanding. The product of the 'intermental' interactions will serve as a basis for personal thinking and actions at the 'intramental' level (Vygotsky cited in Hubbard & Levy, 2016). Hence, Vygotsky assumes that cognitive growth results from the interplay between the two processes and not solely from the individualistic 'intramental' process.

1.3. Bloom's lower and higher levels of cognitive knowledge and abilities

Bloom's taxonomy (1956, 2005) provides six levels of increasing cognitive growth and processes: the cognitive skills of knowledge (or memory), understanding, application, analysis, synthesis and evaluation. Knowledge or memory skill refers to the ability to recall information, describe or define an object. Understanding skill has to do with summarizing, comparing, predicting or explaining. Application skill enables individuals to transfer pre-established knowledge to new situations. Analysis skill involves individuals in identifying problems, consequences and solutions. Synthesis skill corresponds to the ability to put ideas together in original new ways. Activities at this level are likely to foster creative thinking. Evaluation skill requires that individuals think critically to make decisions about the value of something.

Bloom's cognitive taxonomy is usually divided into lower and higher levels of cognitive skills. The first level processes result in knowledge and understanding while the second level processes lead to the acquisition of application, analysis, synthesis and evaluation cognitive skills. Both levels are not sequential, they are rather interdependent insomuch as more complex possesses rely on lower-level process to thrive and vice versa.

1.4. From lower to higher levels of cognitive growth

Based on Piaget and Vygotsky's theories of cognitive growth and taking into account Bloom's taxonomy, it can be argued that individuals' cognitive skills may improve from lower levels to higher ones. This change results mainly from the use of tasks and individuals' efforts to construct and co-construct mental knowledge schemas based on the task at hand. At a higher level specifically, knowledge schemas and understanding concepts that are previously gained serve as tools for more complex interactive and reflective actions and more significant cognitive growth. Piaget and Vygotsky expose two complementary explanations of how cognitive growth occurs whereas Bloom's taxonomy is used to measure cognitive processes and growth.

2. Problem-Solving In Foreign Language Learning

2.1. Problem-solving and its relevance to learning

Since it was first adopted by medical universities of McMaster in Canada and Maastricht in The Neverlands from 1969 onwards, problem-solving approach to education has gained attention as one instructional or curricular means. Problem-solving, as a learner-centered approach, focuses on the use a given problem-based task not for its own sake but rather for the sake of learning. Getzels (1982), cited in Pretz, Naples & Sternberg (2003), proposes three main types of problems: problems that are presented directly to learners by a teacher, problems that are discovered while dealing with a learning task and problems that are created by problem solvers in order to provide an innovative solution. However, for all the three types, learners do not possess all the required knowledge in advance but do construct and co-construct it to attain the set goals or solutions. Any educational activity which rests on a mere retrieval of information from memory is therefore not a sufficient condition.

According to Barrows & Tamblyn (1980: VIII), "learning through problems is much more effective for creating in students' minds a body of knowledge usable in the future than traditional memory-based learning". The researchers add that because problem-solving activities require higher order operations such as critical and creative processes, they are more relevant to ensure enduring outcomes. Indeed, incoming information related to the problem solution is not taken for granted. It is rather analyzed, evaluated before acceptance or rejection and organized in new ways depending on individual learners' pre-established abilities.

Demetriou & Kyriakides (2006) group those processes into three categories: general potentials, domain-specific processes and problem-solving-specific processes. The first category comprises general mental abilities such as attention, memory, speed of processing and so forth. General potentials, which are normally common to all humans, are applied to the processing of contents no matter their nature (mathematics, geography, language). The second is dependent on disciplines' specificities, different inputs requiring specialized processing operations. The third category includes cognitive and metacognitive thinking strategies. These strategies correspond to thinking actions and steps learners use in order to plan, monitor, execute and evaluate their problem-solving activity. O'Mallet & Chamot (1990) differentiate between cognitive and metacognitive strategies. They define cognitive strategies as actions that learners apply "directly on the incoming information, manipulating it in ways that enhance learning" and consider metacognitive strategies as "higher order executive skills that may entail planning, monitoring/evaluating the success of a learning activity" and self-regulation (O'Mallet & Chamot, 1990 in Brantmeier & Dragiski, 2009, p.55). Albeit the importance of mental actions to problem-solving, Pretz, Naples and Sternberg (2003) argue that, learners must possess a certain level of pre-established knowledge to succeed in problem-solving:

> When we approach a new situation, our knowledge based on prior experience will influence our ability to define and represent a problem correctly. In fact, we may fail to notice the existence of a problem if it runs counter to our strongly held expectations. To the extent that an individual has misleading expectations or schemas about a problem, due (…) to crystalized expertise (…) that person may have difficulty thinking flexibly about how to approach the dilemma (p. 26).

The terms collaboration and scaffolding have often been tied to problem-solving based learning. According to Mazorodze and Reiss (2019), problems are usually situated within students' zone of proximal development; they are the kind of "problems learners cannot solve on their own but can solve when they work with one or more able individuals" (p.19).

Learners have to work with peers and tutors to identify or understand the problem and elaborate on their existing knowledge. In other terms, they are scaffolded where they encounter more complex difficulties. In a study that involved medical students, De Grave, Boshuizen and Schmidt (1996) found that collaborative problem analysis allowed individual students to activate and evaluate existing knowledge thanks to the operations of "co-elaboration and co-construction" in their attempt to comprehend a problem. They explained that:

> In the problem analysis students generate explanations for the problems. Based on this exercise they identify what they know and what they do not know of the issue at hand and make decisions about individual study. As a next step, this individual study is carried out and the results are reported to the group, after which re-evaluation of the problem takes place (p.322).

The collaborative activity allowed the students to deploy certain mental strategies: activation and evaluation of existing knowledge during group work, self-guided study and decision-making, executing/reporting and re-evaluation.

2.2. Problem-solving and foreign language learners' cognitive growth

During speaking, listening, reading and writing activities, learners have to solve problems in their attempt to comprehend and use the target language (Hayes & Flowers, 1986; Bereiter and Scardamalia, 1987 and Heine, 2010). Writing involves texts creators in finding ideas and appropriate language. They either retrieve them from memory or construct them. This calls for a number of overlapping stages along which they resort to various cognitive and metacognitive strategies. At the prewriting stage, learners have to think about the topic, their purpose in writing, their audience and text content. What is more, they have to continually activate, elaborate on and organize the ideas in their minds. This involves intensive thinking (corresponding to Bloom's higher level of cognitive skills) which allows them to have a deeper understanding of the topic and discover more efficient ways of analyzing problems and generating solutions. At drafting stage, writers need to make connections between the intended meaning and the target language. They have to create the language that best translates their ideas through construction and reconstruction till a satisfactory point is reached. Revising and rewriting imply evaluating thoughts-language relationship, identifying and compensating for related weaknesses in the written product. Specifically, learners attend to the rhetorical aspects of their draft and monitor ideas and text structure to ensure cohesion and coherence within and across paragraphs. This corroborates Vygotsky's claim that language is one of the systems individuals use to mediate (that is, support and transform) the learning of higher-level cognitive skill of meaning or concepts 'externalization'.

Speaking in foreign language involves ongoing and deferred conversations. It entails two main communication problems. Firstly, speakers have to convert their ideas into linguistic forms (meaning-form connection). This requires retrieving their intended ideas and language on the one hand and constructing new meaning and language, on the other hand. Secondly, they have to comprehend their interlocutors' messages. This difficulty is specifically perceived in cases of ongoing conversations where most speakers have to overcome time pressure and lack of required communication strategies to achieve their automatic comprehension and production goals. In both situations, speakers call on "alternative speech plan when the original plan proved to be unencoded" (Kormos, 2006, p.138) by revising ideas or language and negotiating meaning during the course of communication.

Listening is meant to give practice in decoding sounds, vocabulary and grammar at lower levels and construct understanding of content at higher levels. Along this process, learners face various problems. In interactive listening, the primary challenge is to make sense of interlocutors' meanings through a flow of sounds, vocabulary and grammar forms uttered. As mentioned earlier, learners can use interactive communication strategies (that is, meaning negotiation and other such types of interactive strategies) to achieve their comprehension goal. In contrast, non-interactive listening (such as lectures, online non-synchronic courses, spoken texts and audio/video-recorded materials) lacks such scaffolding condition. Learners constantly try to understand what they hear with no or little support. As meaning is carried by linguistic elements, mishearing them can cause the misinterpretation of meaning and construction of faulty language and meaning concepts. Seen from this angle, non-interactive listening could prove even more challenging when learners lack sufficient experience in listening and background knowledge (metacognitive and foreign language cognitive skills). Listeners therefore have to deploy problem-solving strategies in order to cope with comprehension problems.

Reading confronts readers with the major problem of constructing an authors' intended meaning from the linguistic patterns used in a text. To solve this problem, they perform diverse interdependent 'bottom-up' and 'top-down' activities situated at different layers of comprehension. At the 'bottom-up' layer, they rely on the text to identify meanings that are explicitly stated in the passage. Asking and answering 'WH' questions allow readers to understand literal meaning in a passage. This corresponds to Bloom's most basic cognitive skill of knowledge about the passage. The 'top-down' layer is generally meant to allow them to make sense of authors' implicit meaning(s) and construct their own meaning. Hence, by making use of their prior experience and through additional useful mental strategies at this layer of comprehension, readers construct the message expressed in the text. They construct deeper understanding of a passage, summarize the main ideas in the passage, make inferences or predictions about the author's message and connect information internal and external to the passage. Comprehending a text in foreign language involves interplay between cognitive (actions on the text) and metacognitive (actions on the process and oneself) strategies.

2.3. Top-down problem-solving: An approach that is more conducive to foreign language learners' cognitive development

Although both bottom-up and top-down problem-solving is to be encouraged in foreign language classrooms, top-down solving is arguably more conducive to learners' cognitive development. As stated earlier, top-down activities emphasize learners' verbal thinking and interactions in finding a common solution to a problem.

2.3.1. Listening to lectures and tutorials in the foreign language as top-down problem-solving activities

The top-down dimension of listening in lecture and tutorial courses involves constructing the representation of the course content rather than that of isolated linguistic items. Learners use a series of strategies to compensate for gaps in making sense of the information presented by lecturers, tutors and classmates. With the application of their prior experience in attending such listening tasks, their existing knowledge (i.e., language proficiency and knowledge of the topic being presented) and the use of cognitive and metacognitive strategies learners can achieve greater comprehension of the course content and improve their participation in related tutorial courses. Piaget holds that cognitive development stems from experience that provides more opportunities for accommodation activities. Hence, lack of such experience means that

individual learners could not progress beyond lower levels of cognitive and metacognitive skills. A condition which is directly linked to the positive impact of such top-down tasks is the quality of the strategies it triggers in learners. Illustration of this idea is found in expert and novice learners' use problem-solving strategies. Thus, expert learners are said to resort to a given type of strategy according to the task at hand. By the same token, a large number of strategies novice learners tend to use focus on superficial formal aspects of the task missing by this, the central message of the courses. This suggests that the quality not quantity of strategies matters most in increasing learners' cognitive and metacognitive skills.

2.3.2. Collaborative writing as a top-down problem-solving activity

The notion of collaborative writing rests on the premise that cognitive growth is a collaborative process. An example is dictogloss activity. Dictogloss is a collaborative writing activity based on a heard passage. In this sense, it involves both listening and writing. Learners reconstruct a passage by working in collaboration. The task can be considered as a problem that teachers present to learners and the passage to be reconstructed, the solution. Learners follow some steps and carry out a number of actions in order to achieve their goal. First, individual learners listen to the teacher, take down notes and reflect to attend to problems in their notes regarding meaning and forms relying on their memory and background knowledge. Then comes, the co-construction of the text. At this phase, while discussing more complex vocabulary and grammar, learners focus more on meaning offering, accepting and criticizing peers' ideas. Finally, the co-constructed texts from different small groups are compared among themselves, then to the original passage and finally commented upon by teachers. A follow-up task may consist in learners producing their own texts they can present orally or in a written form. Clearly, the task comprises three levels of cognitive and metacognitive operations: identification or decoding (by individual learners of spoken words and sentences for initial and personal interpretation of the passage), collaborative elaboration of meaningful solutions, evaluation of solutions found when learners compare them to the original text. Dictogloss thus becomes a problem-solving activity where learners solve the problem of reconstructing the meaning of a spoken text thanks to peers' and teachers' language input.

Collaborative top-down problem-solving writing is said to be most effective when learners have the opportunities for discussions with peers and teachers. For many leaners, more complex language-based problem-solving becomes out of reach particularly when they lack appropriate foreign langue abilities and are unaided. According to Vygotsky, verbal interactions over a given social activity provide the needed scaffolding and are therefore fundamental to significant positive change in cognitive skills. More importantly, it is suggested that interactions prove profitable when they are carried out in the target language. Indeed, large proportions of learners do not progress because they are found to use primarily their mother tongue during the course of the activities. But Heine' study has shown that:

> When we use [foreign language] lexical items and syntactic constructions in order to express a thought, we automatically feature the conceptual structure that the lexicon and grammar of that encodes; by this, certain aspects are put in the background, while others are pushed into the focus of attention (Heine, 2010, p.22).

In other terms, the use of the target language during problem-solving is more likely to transform existing knowledge than the use of learners' mother tongue. Verbal exchanges seem to be a valuable source of the required target language and content. Talking over a problem, receiving and offering feedbacks can lead to knowledge elaboration and critical-creative

thinking. A review of literature conducted by Lin (2015) illustrates that idea. The findings showed that learners engaged in peer problem-solving could succeed in completing the tasks, and acquiring some communicative, discourse and linguistic skills. More importantly, they subsequently applied the knowledge they had acquired during their verbal interactions to resolve more problems. Ransdell & Barbier (2002) examined a group of studies on writing problem-solving. They concluded that collaborative writing positively influenced problem identification, learners' prior knowledge consolidation, metalinguistic awareness of grammatical and lexical rules and text quality. However, the authors pointed out that even though talks over some aspects of problem-solving helped learners to improve the quality of topic-related material, they were distracting when learners attempted to attend to "textualization demand" in their argumentative writing (p. 8). This suggests that, whether self-directed or collaborative activities, cautions must be taken by teachers to select an approach accordingly in order to avoid the influence of distracting factors.

2.3.3. Top-down reading problem-solving activities

Top-down reading problem-solving activities are associated with deep understanding and acquisition of higher-order cognitive skills. The activities encompass inferential tasks, text global comprehension and creative questions. Inferential tasks are meant to relate explicitly and implicitly stated information and usually require critical thinking. Learners critically examine some linguistic clues from the text, which lead them to understand some aspects of the text meaning hidden in the clues. Placed at a higher level, global comprehension tasks such as text summary, connections with other texts or conclusions drawing, often enable learners to represent mentally the core meaning of the given text from pieces of explicit and implicit information.

At the creative phase, situated beyond the text but related to it, learners apply to new situations the knowledge they have acquired from the text literal and critical exploitation. Indeed, with the improved knowledge of the text-based meaning and the use of additional thinking strategies, learners are more likely to organize their elaborated ideas in order to use them in more personal ways (in writing or speaking activities, for example). Thus, without the use of metacognitive strategies such as the recourse to prior knowledge, external sources of information and thinking in addition to the cues provided in the reading text, the resolution of inferential tasks, text global comprehension and creative questions is nearly impossible. This shows that proficiency in the cognitive skill of reading is dependent on top-down activities and the deployment of learners' metacognitive strategies. As researchers agree, the more complex an activity, the deeper the processing and cognitive change. Obviously, this does not mean that bottom-up activities should be neglected. Their role resides in the fact that they prepare learners for more cognitively demanding top-down activities. In other words, top-down problem-solving tasks lead to more important impact on cognitive growth when bottom-up tasks are used at the service of top-down activity.

3. Concluding remarks and suggestions

Two main lessons derive from this reflection: the need for a structured integration of problem-solving approach to foreign language learning/teaching and the use of more blended approach to problem-solving.

3.1. For more structured problem-solving experiences

Acquiring a foreign language is a complex endeavor whereby learners encounter many problems. Therefore, teachers and educators should not take for granted the fact that their

learners will automatically be able to identify and solve problems while they engage in language learning activities within and outside classrooms. There is a need to integrate a concrete problem-solving experience to curriculum and pedagogy in structured way. At the curricular level, related materials including syllabi, textbooks and guidebooks that include problem-solving principles and activities are advisable. As for pedagogical intervention, an explicit instruction about strategy use may prove useful in providing learners with some experience in problem-solving. This supposes raising their awareness of potentially useful strategies and also providing assistance regarding their preferred strategies. More structured foreign problem-solving experiences are catalysts for foreign language learners' cognitive development.

3.2. For more implicit and blended problem-solving activities

One way to train learners for problem-solving is to select activities that combine top-down and bottom-up mental processes. Teachers avoid engaging into complex activities unprepared. Learners are offered the opportunity to perform learning tasks at various levels of complexity (lower and higher ones). In a composition task, for example, there is a need to train learners to generate meaning (top-down process) while helping them to construct the language they need to express meaning (bottom-up process). A coordination of pre-reading, literal and inferential comprehension activities allows learners to tackle the more complex phases of comprehension related critical and creative thinking. Another way is to blend self-directed and collaborative processes. While receiving assistance from teachers and their peers, learners are provided with opportunities to take responsibility of their cognitive growth. Some activities are carried out either individually or in collaboration and others require both conditions. In all cases, the selection of one approach or another is dependent on learners' background knowledge and the tasks at hand.

Conclusion

The aim of this article was to examine the link between problem-solving activities and language learners' cognitive growth. Firstly, the study provided evidence that problem-solving activities can have positive effects on learners' cognitive development with regard to the acquisition of enhanced foreign language proficiency and higher-order cognitive and metacognitive skills. Secondly, it showed that the positive effects observed on learners' cognitive growth are related to the use of top-down language activities, the recourse to problem-solving strategies and the use of the target language as a tool for thinking and interactions. Finally, it offered useful implications for allowing foreign language learners to have more structured problem-solving experiences. Despite its contribution to reflection in the field, the main limitation to this study lies in the fact that the study focused more on previous studies and literature. For further reflections, it would be advisable to investigate language classrooms in order to provide more insight into the relevant issue of the impact of problem-solving on learners' cognitive growth.

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