Designing digital educational resources to facilitate learning for second language students

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Abstract: The number of students who struggle to execute reading comprehension tasks raises in Europe, questioning the relevance and effectiveness of the teaching methods implemented in regular classrooms. In Switzerland, students of French as a second language appear to be particularly at risk of encountering such difficulties. This motivates studies to investigate the specific difficulties in manipulating the language of schooling they may face. This study presents a discussion about teaching tools based on research findings in didactics, psycholinguistics and applied linguistics. This interdisciplinary approach leads us to propose a theoretical framework for 1) considering the specific needs of second language students and 2) developing digital tools to promote the literacy of these students in an inclusive teaching environment which may be in fact suitable for all students. We aim to develop a didactic ontology that will allow us to create customisable and automatically adaptable teaching-learning pathways.

Key words: French as the schooling language, second language students, reading comprehension, digitally assisted teaching and learning, didactic ontology, cognitive processes

1 Introduction

This article presents a discussion about students of French as a Second Language (L2 French) in an attempt to understand their specific needs in regular French-speaking classrooms. Based on these needs, we then aim to identify the ways in which digital technology may provide differentiating tools for dealing with heterogeneity in regular classrooms. Furthermore, our objective is to promote access to the language of schooling, thus providing all students with the opportunity to be successful. We will first expose the theoretical framework of this study to facilitate the reader's understanding of the terminology used. Second, in this framework, we will share our understanding of the L2 French students' difficulties. Our approach is interdisciplinary trying to bridge the gap between didactics and psycholinguistics.

Our discussion is set within the framework of the anthropological theory of didactics (ATD) (Chevallard, 1992), which states that any human activity (*e.g.* teaching practice or student activity) can be modelled using a four-pronged approach [type of task; technique; technology; theory]. This approach defines a *praxeology* which will enable us to model teaching-learning elements in a school setting.

Any *task* assigned to a student by a teacher, which is performed by a student, belongs to a *type of task*. This *type of task* is carried out using one (or more) *technique(s)*. A type of task and a technique makes the *practice block* of the praxeology. A corresponding *knowledge block* contains a *technology* (describing and explaining the practice block [1]) and a *theory* that allows systematic reasoning about the practice block [2]. Consequently, a praxeology is made up of these two blocks.

For example, in primary school, a typical type of task assigned to students is to conjugate a verb in a simple sentence so that it agrees with the sentence's subject. One possible technique would be to first identify the subject of the sentence, its person and number, then the conjugated verb and its tense in the sentence, before selecting the correct inflection. This technique and the associated technological discourse are based on the grammar of French – the reference theory in this case. The technique, therefore, consists of a set of knowledge-based types of task (subject-verb agreement), which can be verbalized (technology) and have to be carried out by the learners. A praxeology thus brings together the notions of knowledge, know-how and metacognition. From now on, we will use this vocabulary derived from the ATD (Geoffre, to be published).

Praxeologies and competencies can be linked to school curricula. At the European level, the definition adopted by the European Parliament on September 26, 2006, is as follows:

> " *A competency is a combination of knowledge, skills (abilities) and attitudes that are appropriate for a given situation. Key competences are those that underpin personal fulfilment, social inclusion, active citizenship and employment.* "

In ATD, a competency corresponds to the ability [3] to implement a body of knowledge and techniques in various types of task in order to achieve the desired objectives and to verbalise them. Competency mastery requires four kinds of acquisition: 1) the mastery of knowledge (elements of theory); 2) the mastery of techniques; 3) the mastery of the context in which a technique may be applied; 4) the mastery of the technological discourse on these techniques and on their usefulness/use. These different sub-levels of mastery are required to implement a competency successfully.

Performance objectives for a competency may or may not be met depending on the context. The learner's work setting (the learning environment as defined by

1. A technology is therefore a discourse on a practice block, and we will talk about *technology* or *technological discourse* in the following text.

2. Reasoning about the practice block is usually in relation to other practice blocks, this will lead to the concept of ontology, which we will discuss later in the article.

3. We adopt the definition proposed by Meirieu (1987: *153-154): "An ability is a stable and reproducible intellectual activity in various fields of knowledge".*

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Brousseau) and his or her psycho-cognitive state may hinder his or her ability to implement knowledge and techniques at a given time during a task. This phenomenon affects all learners – and, in particular, L2 learners, which we will endeavour to show in this article.

Having briefly outlined these considerations, we will now put forward an approach to the educational challenges faced in schools. The underlying notion of the article is that the aim of teaching and learning is to develop competencies, but that the use of these competencies depends on the didactic and cognitive context.

2 The educational context and project development

Switzerland is a federal state composed of twenty-six cantons. The language of schooling, the languages spoken by the inhabitants and the school curricula differ from canton to canton, although attempts are being made to harmonise the curricula. The official federal languages are, in decreasing order of frequency: standard German (63%), French (23%), Italian (8%) and Romansh (0.5%) (SFSO 2017). This study was conducted in the canton of Fribourg, a bilingual French-German canton.

Switzerland in general and the canton of Fribourg, in particular, have seen a substantial increase in immigration. In 2017, more than 37% of the permanent residents in Switzerland were foreigners (SFSO 2017). The immigrant population uses its languages of origin on a daily basis, and dedicated school structures ensure that these languages are maintained. Students who speak a language other than the language of schooling [4] at home account for 21% of the student body in the canton of Fribourg.

When second language students first arrive in Switzerland, they are given support with learning French as a second language. Schooling language support is provided from the first year of kindergarten (1H for 4-years-old) to the end of the mandatory school (11H for 15-years-old). This support is twofold. First, four units of instruction per week are devoted specifically to teaching French as the language of schooling. Students are supervised by a specialized teacher in 50-minutes lessons with several students from the school. They attend all lessons in regular classes that correspond to their age group other than those for the language of schooling. Second, as an additional support measure, the academic and evaluation objectives are adapted to the student's level of French. This system is implemented for four semesters.

After four semesters of support, students are considered to have overcome all the obstacles related to the language of schooling and can no longer benefit from teaching support or differentiated assessment. They are then expected to attend regular classes in the language of schooling. This study investigates newcomer L2 French students from the moment they leave the special support system and are considered to be regular students. It also includes the students who have been educated in French from the start of their education but who are bilingual or multilingual as French is their language of schooling but not the language they generally speak at home.

4. For simplification purposes in this text, we will refer to students as L2 French (French as a Second Language) students when the language used at home is not French, regardless of whether they were born in the country of schooling or arrived during their schooling.

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Although the level of French and linguistic background of these two categories of students differs, the students face similar academic difficulties.

The academic difficulties of L2 French students are greater than those of L1 French students; the PISA surveys of 2012 and 2018 showed a steady decline in their achievements in literacy. Analyses and modelling of the 2012 PISA results reveal that L2 French student status is a higher risk factor for academic failure than socio-economic status (p. 61, Roth & Soussi, 2014). Thus, in Switzerland, the difficulties of L2 French students appear to be more strongly associated with language difficulties than with socio-economic difficulties. Other statistical indicators seem to confirm that L2 French students have more difficulties in completing their school career path.

Statistical analyses of student orientation at the end of primary school show that L2 French students are not evenly distributed across the different levels of academic performance. A three-year orientation phase makes up the last stage of compulsory schooling in Switzerland. At the beginning of the orientation phase, all students are evaluated and assigned to four different class levels. The best primary school students are assigned to the so-called *pre-gymnasial classes* (PG) (the equivalent of grammar school in the British school system), and the average students to the *general classes* (G). Students with difficulties at the end of primary school join classes aimed at consolidating *basic requirements* (BR), while students with extensive difficulties are placed in *development classes* (Dv). L2 French students should be equally represented in each of these class levels in accordance with the proportion they represent in the student population (= 18%). However, they are over-represented in the very low-level classes (45% of the students in development classes are L2 French students) and low-level classes (30% in the basic academic requirements classes). Indeed, few L2 French students qualify for a place in the "pre-gymnasial" classes (9% of L2 French students) (p. 306, Annuaire statistique du canton de Fribourg 2019; see Figure 1).

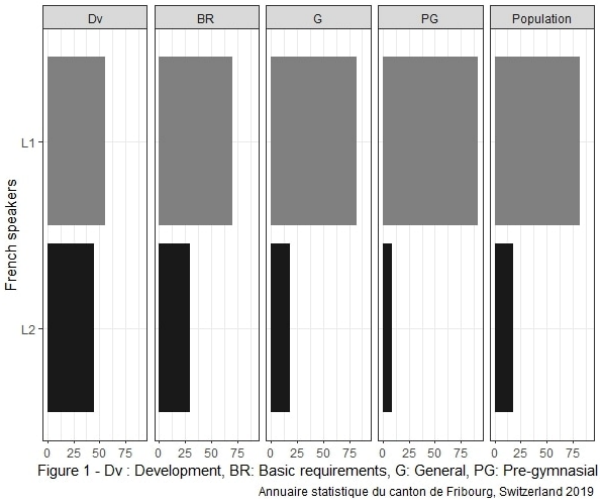

Figure 1 – L2 speaker percent per class level

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During the orientation phase, students can change class levels depending on their progress or difficulties. However, L2 French students remain over-represented in the lowest levels despite the support measures. As a result, we need to consider whether the specific language needs of these students are being adequately met by the current teaching approach.

At the same time, teachers report difficulties in dealing with the diversity of L2 French students. Their French language skills, mother tongue, previous educational background, social origins and migration history influence the way these students may be supported (Klein, 2014; Lecocq, 2018). This inherent diversity in the population of immigrant students poses very real teaching challenges which regular teachers face daily when working with these students. At present, in Switzerland, there is no pedagogical and didactic instrument that provides teachers with the necessary tools to differentiate their teaching and able to offer tailored assistance. Such tools are crucially missing, particularly when children start learning to read and write. Without dedicated measures or tools, most teachers cope by developing teaching solutions which are more or less adapted to the knowledge and profiles of the L2 French students. However, the teachers lack time, struggle to acquire the requisite knowledge in order to respond to the diversity of students, and do not have specific course materials for these learning situations or adapted diagnostic tools. Thus, they are often faced with the frustrating experience of having invested all their means into dealing with the diversity, but failing to achieve positive results, as shown for example by the PISA studies of 2000 and 2009 (Baye, 2015; Nidegger *et al.*, 2001).

The project we propose aims to assist teachers in their efforts to better mentor and support L2 French students in their classrooms. In order to adapt instruction, the nature of the specific needs of L2 French students have to be determined.

3 Specific needs of L2 students

Studies revealing the academic difficulties of L2 French students have often been based on the analysis of reading comprehension performance (*e.g.*, Berthelé & Lambelet, 2017; PISA; Roth & Soussi, 2014). Indeed, performance in reading comprehension correlates strongly with lifelong academic and career success (García-Madruga *et al.*, 2014; Heppt *et al.*, 2016). Therefore, this study focused on the acquisition of reading comprehension skills. A synthesis of research findings in applied linguistics allowed us to identify the specific needs of L2 French students.

Numerous studies in applied linguistics have sought to identify the nature of learners' difficulties in building competency in reading comprehension in their second language (=L2). A meta-analysis by Jeon and Yamashita (2014) reviewed 59 studies involving some 9500 participants. All the studies included in this meta-analysis focused on L2 speakers who had already spent more than one year immersed in the L2 at the time of the study. The ages and educational levels of the speakers varied from six years (*i.e.* 3H or preparatory course) to adulthood; some adults had completed higher education (Master's level and beyond). The objective of the meta-analysis was to identify factors that potentially restrict the achievement of L2 speakers in reading comprehension. Jeon and Yamashita (2014) identified three L2 factors highly cor-

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related with L2 reading comprehension performances: syntax (r= .85), vocabulary (r= .79) and decoding (r= .56).

In terms of L2 vocabulary, the breadth and depth of L2 students' vocabulary are known to be limited in comparison to the repertoire of monolingual students (*e.g.*, Berthelé & Lambelet 2017). Indeed, students' lexical fields are relatively developed by language, depending on the usage context and amount of input (*e.g.*, Cheung *et al.* 2018).

Concerning syntax, however, educational scholars know less about these difficulties. L2 reading comprehension is negatively impacted by the automatic activation of an individual's main language or mother tongue (= L1). Indeed, how a L2 speaker analyses and uses syntax is always influenced by his or her L1 grammar (Erdocia & Laka, 2018), regardless of the L2 level (Xue *et al.*, 2013; Zawiszewski *et al.*, 2011) or the age of acquisition (Díaz *et al.*, 2016). Jeon and Yamashita's meta-analysis reveals the importance of such interferences.

For decoding, it is surprising that this factor appears to be so important when the participants, for the most part, are not novice readers of alphabetic writing. Decoding competence is known to underpin successful reading comprehension processes. Gentaz *et al.* (2015) observed that reading comprehension performances of monolingual students in their first year of reading acquisition is mostly limited by decoding. According to Jeon and Yamashita, this difficulty also prevails among bilingual readers. However, although both monolingual and bilingual students struggle with decoding, partially different teaching approaches may be required for the two groups.

To be capable of decoding, monolingual and bilingual students need to acquire the same set of knowledge and techniques. The acquisition of knowledge about grapheme-phoneme correspondences, identification of words as a whole and techniques such as reading strategies are prerequisites for successfully developing reading competency (Cèbe & Goigoux, 2009; Coltheart *et al.*, 2001). Difficulties in decoding and, consequently, in reading may indicate a lack of knowledge or failure to apply these prerequisites (techniques).

When a L2 learner can't apply a prerequisite, it may be because he / she has not yet acquired the necessary knowledge (for example on grapheme-phoneme correspondences) or is struggling to apply the knowledge effectively. A diagnosis can thus be performed to determine whether the knowledge has been acquired or not. When knowledge has not been acquired, remedial action is required (see Section 4). When knowledge has been acquired, the student may not be able to apply this knowledge, or the knowledge he or she is applying may not be relevant for the context. Indeed, bilingual readers have to deal with the fact that linguistic representations pertaining to both languages are activated simultaneously, unconsciously and automatically when these representations are linked to the same structure. Such cross-linguistic interferences occur, for example, for grapheme-phoneme correspondences. A Spanish speaker may attribute the sound /j/ to the grapheme "ll", like in the verb *to cry* – *llorar* (= [jo'rar]), while in French this same grapheme is attributed the sound /l/, for example, in the feminine adjective *belle* (= [bɛl]). Alternatively, a German speaker

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may attribute the sound /kv/ to the grapheme "qu" as is the case for the verb *to squeeze – quetschen* (= ['kvɛtʃən]). In French, on the other hand, "qu" is attributed with the sound /k/, as is the case for the conjunction *qui* (=[ki]). The simultaneous activation of two phonemes corresponding to the same grapheme for two different languages is a cross-linguistic interference. These cross-linguistic interferences hinder the learner from applying knowledge, leading to a higher level of error (Dherbey-Chapuis & Berthelé 2020) or extending the time needed to identify the relevant knowledge.

Failure to deploy a technique might be because the learner is not familiar with it, in which case a diagnosis will allow the teacher to verify whether it has been acquired. On the other hand, the learner may be struggling to use the technique appropriately and effectively. Indeed, the learner has to be familiar with the techniques required for decoding and also to be able to use them appropriately depending on the language used. Furthermore, these decoding techniques have to be automated so that he or she can pay maximum attention to the comprehension processes (*e.g.* Klauda & Guthrie, 2008; Liberman *et al.*, 1989). As with knowledge, cross-linguistic interferences can arise for techniques when linguistic representations associated with the student's different languages are activated simultaneously, unconsciously and automatically. Indeed, a technique is the result of the application of knowledge to a context in order to perform a defined task. Consequently, the effectiveness of a particular technique depends on how well it is suited to the linguistic context.

The degree of transparency of the language being read influences the size of the orthographic unit that the reader automatically selects for interpretation (a sub-process). Numerous studies have shown that the degree of transparency of an alphabetic language determines the size of the reading span (*"Orthographic Depth Hypothesis"*, Katzt & Frost, 1992). When reading an opaque language, such as English, readers recognise words (*i.e.*, assign them a semantic meaning) using large orthographic units such as the first graphemes, rhymes or whole words. English speakers, therefore, prefer to use a lexical approach to decoding; once aware of this technique, readers automatically apply it. In contrast, when reading a transparent language such as German, Italian or Spanish, readers mainly draw on grapheme-phoneme correspondences for decoding (*e.g.*, Schmalz *et al.*, 2015; Sprenger-Charolles, 2016; Ziegler & Goswami, 2006). These differences in the choice of the technique used and, in turn, in the size and nature of the units of language that are cognitively processed persist even in adulthood and with advanced readers (Rau *et al.*, 2016). Decoding skills and the cognitive sub-processes they involve are therefore likely to be influenced by the linguistic background of the L2 French student.

The functioning of cognitive sub-processes is modified by the technique which is most used by the reader. The decoding technique that is most frequently used influences the size of the visual unit processed by a bilingual reader. Lallier *et al.* (2016) showed that young readers (4H in Switzerland, CE1 in France) who read in two languages engage in reading the same language (Basque) with techniques that vary depending on their other language (Spanish or French). Bilingual Spanish-Basque children mainly use grapheme-phoneme correspondences when reading in Basque, whereas bilingual

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French-Basque children use larger language units. Adapting cognitive sub-processes can confuse L2 readers and undermine their reading performance.

The effectiveness of a technique adapted to the L2 depends on the engaged sub-processes and can be compromised when these sub-processes are carried out following the rules of the L1 (*e.g.*, Bergmann *et al.*, 2016; N. C. Ellis, 2006). This competition between the rules of two languages (here synonymous with the "grammar" of the languages) is a source of cross-linguistic interferences at the sub-process level. Indeed, when different techniques are activated simultaneously, the student has to choose the most relevant technique for the context of the task at hand and devote part of his or her attention to smoothly processing the sub-processes involved. Chen and Siegler's model (2000) describes phases of development during which multiple techniques are activated and, therefore, compete against each other without the student having any control over the choice of the technique used or over the related sub-processes and how they proceed. This competition between techniques leads to errors in one language even though the technique would be effective in the other language. Hence, it is not the technique itself that should be called into question but its suitability for the context in which it is used or the suitability of its underlying representations or sub-processes. Cross-linguistic interference at the sub-process level is a source of confusion and, therefore, a potential obstacle to the acquisition, functioning and automation of techniques in L2.

The more a technique relies on automated sub-processes, the more efficient it becomes. Attention needs to be paid to how the sub-processes work before becoming automated. Likewise, available attention is required to efficiently combine techniques when performing a complex task. In addition, managing linguistic interferences also requires attention (*e.g.*, Segalowitz & Frenkiel-Fishman, 2005). In a meta-analysis of 197 studies, Peng *et al.* (2018) highlighted the importance of available attention for comprehension during reading, even after controlling for vocabulary level and performance in decoding and in identification of words as a whole. Simultaneously managing interferences and the complexity of a reading comprehension task is likely to result in an even greater cognitive overload for the L2 learner.

L2 students performing reading comprehension tasks can face cognitive overload if they are novice readers as many of the low-level processes are not automated (*e.g.*, Peng *et al.*, 2018). However, more advanced readers can also be affected by cognitive overload when hampered by linguistic interferences (*e.g.*, Cunnings, 2017). Dedicated teaching-learning methods could ease cognitive overload and thus be instrumental in fostering L2 students' reading comprehension competency.

4 Adapting teaching and learning to ease the cognitive load

We have seen that the difficulties of L2 students in acquiring or applying relevant knowledge and techniques may be the result of cross-linguistic interferences and/or a lack of automation of sub-processes (as with monolingual students). Attention is required to resolve cross-linguistic interferences (Kim *et al.*, 2016; Segalowitz & Frenkiel-Fishman, 2005) as does the functioning of non-automated sub-processes. However, the working memory has a limited amount of attentional resources. All

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available attention may be involved in applying knowledge and techniques and executing sub-processes and, therefore, be lacking for the advanced processes required to understand the text (see Part A, Figure 2).

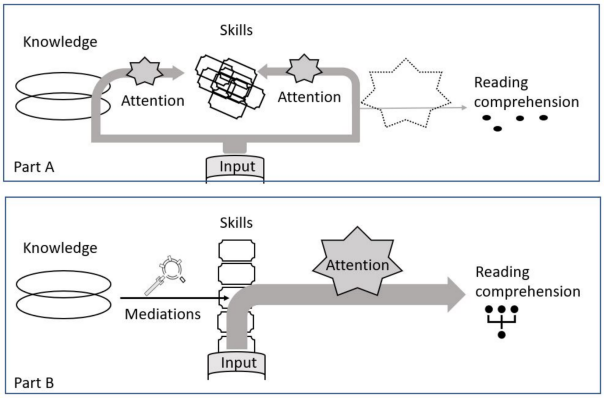

Figure 2 – Distribution of attention depending on the absence/presence of mediation for a reader with difficulties

Moreover, the high-level processes required for comprehension (*e.g.*, inferences, emotional empathy, overall construction) can only occur if the techniques in charge of the information processing are effective and efficient. Effective techniques produce abundant information, and efficient techniques produce relevant information without requiring an excessive amount of attention. When techniques are efficient, attentional resources remain available and can be devoted to the comprehension processes (See Section B, Figure 2). The efficiency of techniques depends in essence on how they are coordinated and organized.

The techniques need to be coordinated and organized so that they require the lowest amount of attention to be performed and can be effective and efficient (See Section B, Figure 2). Failure to coordinate the techniques (see Section A, Figure 2) may be caused by competition between them (Chen and Siegler 2000), by non-automation of their sub-processes and/or by cross-linguistic interference. For example, the non-coordination of techniques can deliver a phonological representation of a word without its semantic meaning. When the reader's decoding doesn't give him/her access to the word's meaning, he or she can't link it to the global text understanding. The techniques can only be successfully coordinated if attentional resources are available to do so or are freed up by a teaching intervention (see Section B, Figure 2).

Easing the cognitive load frees up attentional resources, which in turn allow the techniques to be executed in a coordinated and efficient manner, thus producing the information essential for comprehension processes. Didactic interventions can alleviate the cognitive load by means of different tools.

Didactic interventions can take the form of student's didactic tools and/or teacher's didactic tools, which Plane and Schneuwly define as follows: "for the teacher, the tools are those that allow him or her to create – in the terminology proposed by Brousseau

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(1988) – environments where the student can learn and which can be used to influence the student's mental processes to transform them – these transformed processes being the created object, having a utility [...]. For the students, these are didactic tools that enable them to transform their own mental processes and that they have to make their own for this purpose" (2000: 8).

Assistance in the form of mediation is a central student's didactic tool, which can help to reduce student's cognitive load during a complex task such as reading comprehension (see Section B, Figure 2). Established by Vygotsky (1978), the concept of mediation has more recently been operationalized by educators and techno-educators (*e.g.*, Hung *et al.*, 2018; Kozulin & Garb, 2001). Vygotsky (1978) defined a stage in the acquisition process named "zone of proximal development" where knowledge has been acquired but is still rather unstable, not very accessible and difficult to manipulate (Karimi & Ferreira, 2015). At this stage, mediation allows the learner to use unstable knowledge to succeed in a task which he or she would be unable to do without such assistance (Kozulin & Garb, 2001). For decoding, for example, mediation can provide aid in the form of visual or phonological support, facilitating reading comprehension. Mediation can also be vocabulary support or a preparatory exercise on grapheme-phoneme correspondences aiming to activate pre-existing knowledge. As a result of mediation, knowledge can be better applied, thus facilitating the implementation of the techniques related to this knowledge and their acquisition.

Two didactic tools are available to teachers in order to reduce the student's cognitive load: breaking down the teaching-learning objects and the competencies targeted in the lesson; and explicit teaching.

The teaching-learning objects are complex entities which can be broken down to show progressions which need to be considered. This will be further discussed in the last part of this article. The skill of reading comprehension can be viewed and broken down into simpler elements. According to Giasson (1995), the techniques of a reader who understands a text are organised into: "micro-processes, integration processes, macro-processes, elaboration processes and metacognitive processes". These "processes" are linked together by hierarchical relationships of dependence. For example, "integration processes" cannot be realized before "micro-processes". In other words, a large amount of basic and local information has to be produced using several techniques before the processes of understanding could be executed. Moreover, again according to Giasson, the more a "process" depends on others, the more it requires available attentional resources. "Metacognitive processes", which are implemented last of all, require a lot of available attention. However, attention can only be available if the techniques are coordinated and organized. Otherwise, all the attention is invested in executing the elementary techniques (or "micro-processes" and "integration processes" according to Giasson), and the comprehension processes cannot be executed (See Section A, Figure 2). The division of a complex task, such as reading comprehension, into simpler elements that require a more moderate cognitive load facilitates teaching and learning of the task.

The explicit teaching of the basic elements of the overall competency helps learners to integrate and use these elements during reading comprehension (Deum *et al.*, 2007;

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Giasson, 1995). Several studies have shown that targeted and explicit instruction is highly beneficial for L2 students to develop new competencies (N. C. Ellis, 2006; R. Ellis, 2015; Lantolf & Poehner, 2010; Rupley *et al.*, 2009).

We can, therefore, conclude that the cognitive load can be reduced by choosing suitable didactic tools for the student involving mediation, and tools for the teacher promoting progressive and explicit competence-building. Measures for assessing performance in the presence of mediation leads to more precise evaluation of whether a skill has not yet been acquired or is in the process of being acquired (Poehner *et al.*, 2015) and allows to identify which essential prerequisites are missing. Once a prerequisite has been identified as unearned, appropriate remedial actions can be taken. Such remediation involves explaining the reason for an error to a learner as well as placing the learner in a situation where he or she can learn the prerequisite and understand how to use it in order to improve his or her overall competence, for example as part of a problem-solving strategy (Rodi & Geoffre 2020; de Haan & Oppenhuizen, 1994).

To adapt teaching and learning, we therefore need student tools enriched with individualizable mediations, precise diagnoses integrating these mediations and available remediation. How can this adaptation be designed, taking into account the specific needs of L2 French students?

5 Adapting teaching and learning to the specific needs of L2 students: the digital route

If we return to the example of decoding, considered here in the broad sense, the automation of sub-processes involves rapidly and widely recognising words (Demont & Gombert, 2004) as well as automating the use of grapheme-phoneme correspondences (Wolf, 2018). In regular lessons, the teaching exercises aimed at automating these two processes are usually repeated reading activities (*e.g.* Therrien, 2004; Viriot-Goeldel, 2008 (for France, Quebec, Germany)). However, these exercises do not consider linguistic interference between the language of schooling and the mother tongue(s) of L2 students. It is unlikely that these repeated reading activities enable the L2 reader to control, address and overcome the difficulties caused by such interference. Indeed, the recurring presence of L1-induced interference makes it difficult for learners to perceive, identify and address L2 characteristics. On the contrary, targeted and explicit instruction is more likely to establish stable linguistic representations and can help establish routines that make these representations more accessible and easier to use (N. C. Ellis, 2006; R. Ellis, 2015; Rupley *et al.*, 2009). Such targeted and explicit instruction can be structured over the course of a learning pathway with the help of mediation, diagnostics and remediation.

Such learning pathways enable learners to make progress in reading comprehension, regardless of whether the mediation and remediation are provided by the teacher (Macrine & Sabbatino, 2008) or by a digital application (for a review, Jamshidifarsani *et al.*, 2019). Digitally assisted mediation has already been proposed to learners to promote L2 learning (*e.g.* Poehner *et al.*, 2015) or to dynamically measure learners' performance in reading comprehension (*e.g.* Pishghadam *et al.*, 2011).

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Pishghadam *et al.* (2011) developed a software program which was able to suggest mediation while students were doing reading comprehension tests. The participants in their study (n=77) were Iranian Master's students whose L1 was Persian, and level of English (L2) was homogeneous. The objective of the study was to measure the effectiveness of an application that provided clues to support the readers' understanding of the texts they were reading. Five available clues ranged from very implicit to very explicit could be provided to a participant when he or she gave an incorrect answer for a comprehension question. The results showed that all students improved their comprehension of the text, and that the weaker students made greater progress. These findings confirmed those of other studies indicating that mediation is more beneficial to weaker students, regardless of the cultural, socio-economic or academic reasons underlying the students' difficulty with reading comprehension (Skuy *et al.*, 2002).

Mediation can also enable the L2 reader to use techniques learned in L1. Such transfers of techniques between L1 and L2 are important for reading performance in L2 and involve metacognitive processes. In a meta-analysis of 47 studies, Melby-Lervåg & Lervåg (2011) investigated the correlations between phonological awareness, decoding ability and reading comprehension in L2 and L1. The participants in the selected studies were L2 speakers: children and adolescents (mean age under 18 years) whose languages were both alphabetic and idiographic, Indo-European for L1 and L2 or only for one of the participant's two languages. The results suggest that the ability to transfer the decoding techniques between two alphabetic languages is valuable when it is taught for each of the learner's two languages. The authors' interpretation is that similarities in techniques (the principle of phoneme-grapheme association, phonological awareness) benefit the development of reading in both languages, provided that a student is explicitly guided in this metacognitive transfer. A student can then develop specific techniques and automate certain sub-processes more easily. Digital tools thus appear to have the potential to address the specific needs of L2 students, not only because they can be programmed to add dynamic mediation, but also because they promote the individualization of teaching-learning pathways by allowing a close match between the needs of the learner and the mediations and remediation offered. This twofold promise is notably supported by digital teaching-learning platforms with adaptive learning.

6 Adaptive teaching and learning

Adaptive learning exploits the digital traces left by a learner during his or her activity on a digital teaching-learning platform by collecting them and analyzing them in order to adjust the learning process to the learner's individual needs. Adaptive learning thus makes it possible to offer targeted and customized instruction because one or more of the characteristics of the learning environment are adapted to the student. Three main elements can be adapted, depending on the student's profile:

— the mediation, *i.e.* the way in which learning activities are presented to the learner *via* the interface (the content, text, graphics, videos, the presence of lesson reminders or help bubbles, voice dictation, etc.);

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— the sequence in which the learning activities are presented and connected within the teaching-learning pathway (the equivalent of a didactic sequence);
— the level of difficulty (for the same objective) and the possibility of triggering remedial activities which, for example, support the learning of a prerequisite that has not yet been acquired.

Adaptive learning is therefore not only a support for student´s learning but also for teaching because it is difficult for the teacher to perfectly identify the profile of each student and to adapt/differentiate the programme accordingly. Either the system autonomously adapts the student's learning pathway, or it sends recommendations to the teacher who can then, for example, choose to validate a remedial activity (or not) or to activate access to additional mediation.

If adaptive learning makes it possible to identify the remedial measures necessary for each student, then, for example, in the case of an L2 French student who has decoding difficulties, the remedial measure may consist of specifically working on phonological awareness and assigning exercises on the phonemes identified as problematic for the student based on his/her L1 (*e.g.*, exercises on elision, segmentation, blending). Targeted teaching of phonological awareness has already been operationalized digitally. Hecht and Close (2002) trained children with a software program (*i.e.*, WERP-1) designed to improve phonological awareness in regular classrooms. Their participants (n=76) were monolingual kindergarten children (mean age 5 years 7 months) from disadvantaged neighbourhoods. For six months, the children carried out a daily 15-minute training session individually within the framework of teaching sequences based on more than 900 different activities. The authors found that the software enabled the children to improve their phonological awareness and their reading-writing skills of words, unlike the children in the control group who received traditional classroom instruction. These positive results suggest that identifying difficulties individually, followed by dedicated and personalized remediation might allow a large majority of students to progress. With adaptive learning, it is possible to precisely target a student's needs and provide necessary remedial measures by continuously measuring a student's performance during a teaching-learning session.

Analysing the specific needs of each student is possible on an ongoing basis by constructing 1) a framework that models the domain and connects up the different items of the teaching-learning pathway, and 2) an error repository to which the student's performance is compared throughout the learning pathway in order to identify the reason for the error and its eventual recurrence (Mandin *et al.*, 2015). When the frequency or type of error seems to indicate a specific problem (in our example, decoding difficulties), a task whose aim is to precisely diagnose the failing technique and/or knowledge (a prerequisite) is proposed within the student's learning pathway. Remaining with the same example, a non-word reading task could reveal a problem concerning the functioning of grapheme-phoneme correspondences and allow us to diagnose which specific grapheme-phoneme correspondence(s) pose(s) a problem. Based on this diagnosis, exercises would be assigned, for example, to improve phonological awareness or the reading of words as a whole. However, knowledge and techniques are not only prerequisites that need to be mastered; they have to be accessible and

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functional despite interference between languages (*e.g.*, Cunnings, 2017) and the cognitive overload they may induce. The coherence of all learning pathways and their effectiveness are therefore based on the mutual support and reciprocal potentiation of mediation, diagnoses and remediation.

A customized learning pathway, designed using adaptive learning, must be part of a teaching-learning framework that coordinates assessment, mediation and remedial actions, shaping the overall learning sequence according to the specific needs of each learner. The construction of a didactic ontology that models the domain is therefore indispensable 1) to ensure coherence between such a teaching-learning tool and the curriculum and 2) to facilitate its implementation by teachers. An ontology is an explicit specification of a conceptualisation (Gruber, 1993), *i.e.*, a description of the notions and concepts of a domain and the different levels of relationship that may exist between these objects. Such an ontology thus becomes a meta-model for representing the competencies of the domain and enables a computer to process them. Ontologies are also considered relevant for systematically organizing knowledge and planning teaching and learning in distance learning contexts (Bourdeau *et al.*, 2004).

7 Didactic ontology and adaptive learning

The anthropological theory of didactics (Chevallard, 1990) appears to be suitable for modelling the teaching and learning of French (Geoffre & Colombier, 2019), which is why we chose this theoretical framework. Within this framework, it is possible to construct *a praxeological organisation for a language*, which in our case forms the basis for creating an ontological representation of French as a domain of teaching and learning, independently of the educational institution concerned (Geoffre & Colombier, 2019). We divided the domain of *language* into three sub-domains: *word, sentence, text.* Each sub-domain contains the teaching-learning objects (from now on T-LOs) linked to it. These three sub-domains form the first level of the hierarchical framework of the T-LOs. A T-LO can then be linked to a level of schooling, depending on the programmes in question.

Each T-LO is broken down into types of task, based on the wording:

Type of task = [action verb; T-LO].

Thus, for example, phoneme-grapheme correspondences or lexical spelling constitute T-LOs from the sub-domain *word*; and "*identify the grapheme associated with the phoneme X (for example X=/k/) in a word* "is an example of a type of task using the action verb *to identify.* A type of task can be adapted to create different tasks by modifying the instruction and the words suggested (number of words, difficulty, etc.). Another example could be the subject-verb agreement classified as the type of tasks "*Conjugate the verb so that it agrees with the subject"* (thus differentiating *simple or complex cases*). The action verb is then linked to the idea of *connecting.* This type of tasks is involved in a branch of the hierarchical framework of T-LOs: the sentence > agreement in the sentence > subject-verb agreement.

To fully develop the framework of types of tasks, it is therefore necessary to determine all the different types of tasks that can potentially be assigned when teaching a given

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T-LO, that is, types of tasks that allow the T-LO to be practised in different ways. As a type of tasks is described using an action verb applied to the T-LO, we tried to simplify wording of the type of task. Based on preliminary work by Fabienne Vernet (unpublished, see Geoffre & Colombier, 2019), we used a limited list of eight verbs to define a set of types of tasks for a single T-LO: *to identify, to connect, to modify, to sort, to classify, to produce, to define and to justify.* When the eight action verbs can be applied to the same T-LO [5], it appears that the resulting eight types of tasks include all possible tasks that can be assigned to a student. For primary and secondary level 1, we did not find any tasks proposed in the textbooks that could not be linked to one of these eight types of tasks. Indeed, this framework of *types of tasks* reference is broader than that available in the teaching materials. At this stage, the *types of tasks reference framework* leads to create about 750 different tasks (Geoffre & Colombier, 2019).

All the types of tasks in the *types of tasks reference framework* can be performed using at least one technique that can be explained and modelled by means of relationships between subtypes of tasks. Indeed, the types of task in the framework are not independent of each other, rather interconnected with different levels of relationship, such as the relationships *isRequiredBy / requires* or *isComposedOf / composes.* When carrying out a precise type of tasks "TT_i", the learner is required to carry out TT_i task subtypes. All these TT_i task subtypes constitute the technique that allows the student to carry out TT_i; TT_i task subtypes are hence prerequisites for TT_i. For example, types of tasks concerning the T-LO *"subject-verb agreement"* require the learner to first identify the subject of the sentence (subtype of TT *to identify*) and the conjugated verb of the sentence (subtype of TT *to identify* with a different object). These task subtypes are an integral part of the technique required for the considered TT and are the basis of many school exercises. Other task subtypes complete the pool of subtypes that constitutes a technique which enables to perform a type of task on a given T-LO. The types of tasks are therefore linked within a praxeological organization of a given domain.

A linguistic praxeological organization allows to model the teaching-learning objects of a given language (word/sentence/text) and the types of tasks; based on these structures, relationships between prerequisites and their links within techniques can then be modelled. This aspect is essential for tailoring teaching-learning pathways. A student starts with a sequence of tasks related to defined types of tasks (the initial pathway); during this time, the system collects data on the student's activity and, in particular, identifies failures and errors which allow to automatically interpret the types of error. For example, it is able to identify a missing prerequisite which is causing a recurring error. We saw above that mediation can facilitate access to knowledge and make it easier for learners to use a specific technique adapted to a task. In such an environment, a recurring error can therefore be interpreted as reflecting a specific learner need which requires remediation. This, in turn, leads to a modification in the subsequent learning pathway, which is customized accordingly.

5. It is not always possible to word the different types of task using the eight action verbs for the same T-LO; thus, it seems that all the actions are not relevant or possible for some T-LOs.

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For reasons of space, we cannot present here all the types of tasks that make up reading comprehension competency, the subject of interest in this article. However, elements of our linguistic praxeological organization have been published (10.5281/zenodo.4001381). These types of tasks appear in the sub-domain *text*, with types of tasks that obviously involve other sub-domains (*e.g.* reading and understanding words and sentences). In this way, the hierarchical framework of the T-LOs linked to integration techniques is as follows:

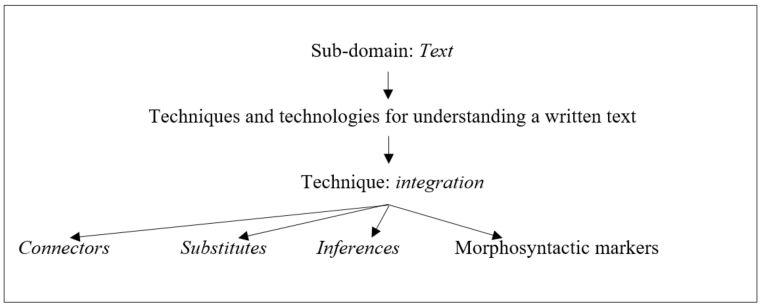

Figure 3 – Example of the hierarchical framework of a T-LO

Types of tasks linked to the teaching and learning of *Substitutes* as a means of improving understanding could be, for example:

— identifying all of the substitutes for a referent;
— changing a text using substitutes;
— sorting the substitutes depending on the referent;
— classifying the substitutes depending on the referent;
— defining a substitute;
— justifying why a word or group of words is a substitute.

In these examples, the *Substitutes* T-LO – an element involved in the *integration* technique – is addressed using both receptive tasks (type of task: *identify, sort, classify, justify*) and productive tasks (*change, justify*). These types of tasks make it possible to break down the overall competence (Reading comprehension) and to design specific tasks within a learning pathway. This results in specific exercises such as those provided by the teaching method *Je lis, je comprends* (Groupe Départemental Prévention de l'Illettrisme – 36) inspired by the work of Cèbe, Goigoux and Thomazet (2004). A difficulty related to a type of tasks within the learning pathway can thus be identified and then leads to potentially diagnose a prerequisite that has not yet been acquired (which could, for example, be related to grammar or grammar units). The student's further progress will then be supported by working on the prerequisite or by improving his or her knowledge of a particular type of tasks. Thus, adaptive learning can allow customization of learning pathways based on student needs. Adaptive learning needs to be based on the modelling of the domain and on the links between the knowledge components and the targeted techniques.

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8 Conclusion

We have sought to reflect on the interface between several domains in order to:

— address the specific needs of L2 French students enrolled in regular French-language classes by integrating didactic and psycholinguistic perspectives;

— explain how digital technology can make mediation more easily available in order to promote the learning of these students;

— explain how learning pathways incorporating adaptive learning can allow customization of learning;

— explain the theoretical framework that allows the development of a computerized ontology of the domain which serves as a framework of reference for adaptive learning.

Bringing together the concepts of tasks, techniques and skills makes it possible to integrate the psycholinguistic aspects of learning into the activity of the teacher, but also of the student, thus developing specific didactic tools for both teachers and students.

This study is the first step in an experimental and developmental phase which will begin in autumn 2020 and should enable us to create a platform with customized learning pathways for reading comprehension in French as the language of schooling. The platform will be designed to facilitate the activation (or not) of various types of mediation and will be developed with an interface specifically customized for primary school students, implementing universal design principles (Meyer, Rose & Gordon, 2014). The platform will thus feature the same interface for all students as well as mediation accessible to all. A tool will store the traces of each student's activity, enabling the platform to adapt and customize learning pathways by activating diagnostic and remediation. Such remedial measures will be activated in accordance with the teacher's choices and/or a student's specific needs, following the compilation of a student profile or based on assessment results.

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