Abstract - Intelligent tutoring systems (ITS) are able to provide a personalized approach to learning by assuming the role of a real teacher/expert who adapts and steers the learning process according to the specific needs of each learner. This is done by taking into account a number of learner features and deciding on the best action to follow at any point in the learning process. Within the field of computer assisted language learning (CALL), the “computer-as-a-tutor” modality has been widely accepted for some time now, although it has long been overshadowed by the “computer-as-a-tool” modality. This was mainly due to the observable lack of interactivity of language learning systems and the inability of technology to show “intelligence”. However, the development of artificial intelligence in general, and natural language processing, user modeling and ITSs in particular, gave impetus for the development of the field referred to as intelligent CALL (ICALL). The paper at hand outlines and briefly discusses the issues surrounding the development and use of ITSs for language learning, taking also into account the broader context of (ICALL), and gives an overview of such systems already in use.

I. INTRODUCTION

When considering any form of technology-enhanced or technology-based education regarding any subject matter, it is necessary to address the issue of learner variability. For some time now, it has been recognized that the educational paradigm “one size fits all” is not the right approach when dealing with a heterogeneous population of learners, as learners may differ in a number of characteristics and individual traits, which makes each learner’s approach to learning unique [1][2][3]. Taking care of learner differences is often a difficult task, especially in cases where these differences are rather prominent, and requires a great amount of planning time and effort from the teacher. A personalized approach to instruction is particularly important in educational contexts where the teacher is not immediately present (but rather distant), or is altogether absent. Such cases include, among others, online learning environments and web-based learning, the use of standalone tutorial software, and hybrid approaches to using technology. Leaving learners on their own in such environments, offering them no or loosely structured guidance through the learning process, might lead to poor attainment and subsequent failure of the teaching curriculum.

The field of computer assisted language learning (CALL) is not an exception. However, it needs to be pointed out that using computers (or other technologies such as mobile devices, CD players or TV) in the context of language learning is somewhat different than is the case with learning in other fields [4]: besides being one of the most complex undertakings, the process of learning natural languages is additionally complicated by the fact that it requires both knowledge-based and skill-based approach [5].

There is a general consensus and an abundance of research evidence that the use of technology, computers in particular, has positive effects in the language learning context (e.g. in [1] and [6]), and that technology could be used as the basis for an individualized approach to learning languages [7][8]. The main question thus is not whether to use computers for language learning/teaching, but how to employ them so that learner needs are met [9].

As suggested in [8], the main goal of CALL should be to simulate human teachers and their pedagogical competence whenever, wherever and to whomever necessary. It is possible to achieve individualization in both commonly accepted modalities within CALL, namely, computer-as-a-tool and computer-as-a-tutor. Within the computer-as-a-tool paradigm, computers are employed as mere teaching tools which increase the efficiency and/or efficacy of the language learning and teaching process [10]. Personalization in this context remains the responsibility of the teacher and should be addressed during the process of preparing and setting up learning tasks. This is achievable by, e.g., scaling the complexity of a task, suggesting the use of software packages which are likely to help learners in carrying out their tasks (such as online thesaurus or translation software), pairing or grouping learners appropriately or even choosing the right Web 2.0 tools that will be most beneficial for the development of a targeted skill. Conversely, the computer-as-a-tutor paradigm represents the situations in which the computer has temporarily taken over the role of a language teacher with the aim of addressing all learner needs as a human teacher would [10]. Moreover, the computer is responsible for tracking learner’s interaction with the designated software, storing that information for future reference, making pedagogical decisions, identifying learner errors and hypothesizing about the underlying cause(s), forming appropriate feedback meaningful for the learner, and, finally, adjusting its assumption about the overall level of learner’s knowledge of the subject matter. This however requires the usage of more sophisticated educational software that employs rather complex, intelligent and adaptive technologies - exemplified by user modeling (UM),

V. Slavuj*, B. Kovačić* and I. Jugo*  
* Department of Informatics, University of Rijeka, Rijeka, Croatia  
vslavuj@uniri.hr, bkovacic@uniri.hr, ijugo@uniri.hr
natural language processing (NLP), expert systems (ES), adaptive systems (AS) and intelligent tutoring systems (ITS) – and constitutes what is generally referred to as intelligent computer assisted language learning (ICALL) [11]. Our focus in this paper will primarily rest on ITSs as examples of systems taking over the role of real language teachers, but we will also touch upon other above stated technologies as they often appear as an integral part of ITSs.

The aim of this paper is to outline and discuss the issues surrounding the development and use of ITSs in the field of computer assisted language learning, taking also into consideration the broader context of (I)CALL. The paper also aims to give an overview of such systems developed for research purposes or successfully integrated into the language learning process.

The paper is structured as follows. Firstly, a theoretical framework for using ITSs in language learning is set. Secondly, the issues surrounding the development and use of ITSs for language learning are outlined and discussed. Thirdly, a variety of language-learning ITSs already in use are described as well as how they are employed to address different language learning skills. Finally, conclusions about using ITSs for language learning are reached.

II. INTELLIGENT TUTORING SYSTEMS IN LANGUAGE LEARNING

The field of ITS is usually referred to as the field of research which deals with the modes of design and developing adaptive and intelligent educational systems [12]. The term is further used to mark a range of computer-based instructional systems which keep up-to-date models containing information about what and how to teach, and use that knowledge for personalizing the access to learning [2].

Although ITSs are now generally accepted and seen as useful within the field of (I)CALL, we need to point out however that the situation was somewhat different a couple of decades ago, as practitioners mostly disregarded the tutor role of computers and only focused on the computer-as-a-tool modality [10]. The literature enumerates a number of possible reasons why language tutoring software was underappreciated and, consequently, marginalized, but we single out two reasons that in our opinion seem most plausible.

Firstly, the view that tutorial software is behavioral in nature and uses only "drill and kill" type of exercises deterred a number of teachers from using it, as it did not adhere to the dominant teaching methodology based on the notion of communicativeness [4][10].

Secondly, with the appearance of personal computers, too much was expected of CALL. Looking back at that period from our current standpoint we can clearly see that technology was not mature enough back then and software development lagged behind hardware development. As a consequence, there was a general disappointment with such software as it was rather rigid and lacked both interactivity and intelligence [5][10][13].

Notwithstanding, language tutoring systems are now widely acknowledged and are seen as being able to address more than just simple grammar and vocabulary teaching/learning, but they need to be designed keeping in mind learners’ and instructors’ needs [4][14].

General architecture of an ITS suggests that there are four functional components to every such system: domain or expert knowledge model, learner model, tutoring or instructional or adaptation model and user interface model [2][15]. In the section to follow we describe each of the ITS architecture components in more detail with a special emphasis on how they are applied in the language learning context. Our account will include an additional module frequently used in language learning oriented ITSs, namely the feedback module.

A. The Domain Model

The domain model contains all the expert knowledge of a particular domain that needs to be taught by the system [2][11]. It details different concepts of the learning domain, their hierarchy, mutual interconnection, and how they relate to educational resources to be delivered [16][17]. Broadly speaking, there are three main ways how domain models are conceptualized [16]: the set/vector model, the hierarchy model and the network model. The most popular and widely used type of domain model is the network model. In this model, the concepts are arranged into a network and are interconnected by different types of links. The most common type of links are, amongst others, prerequisite links, “is-a” or “part-of” links, and remedial links [16]. Links in both hierarchy and network models are very useful in for improving the accuracy of the learner model. For example, in case the learner does not possess knowledge related to a certain concept (e.g., formation of the Simple Past Tense), the links help in providing the most likely remedial concepts (e.g., irregular verb forms). Conversely, if the learner possesses knowledge related to a certain concept (e.g., formation of the first conditional), the links help in identifying other concepts that the learner is likely to know (e.g., the Simple Present Tense).

B. The Learner Model

In order to recognize individual learners’ needs successfully and take appropriate pedagogical action, a piece of software needs to be able to track what learners do with it while learning a language, i.e., how they behave during usage [18][19]. Such monitoring entails the creation and constant updating of a student model which gathers all the necessary data from the learner, be it the learning path, correctness of answers to questions, time taken to offer a solution, or the overall success in solving a task [2][14][19][20]. Learner models may contain other relevant information about the learner as well, such as their previous level of linguistic knowledge, learning style preference, cognitive style, strategic competence, goals or interests, to name just a few [2][21]. Typically, the information in the model should be enough to differentiate between learners who are using the system on the basis of their knowledge, task performance, overall proficiency, goals or background, and take appropriate action to personalize their learning experience [16][22]. Hence, the main goal of a learner model is to support the process of making assumptions about the learner and to support
pedagogical decision-making concerning, e.g., the feedback to be delivered back to the learner or the choice of appropriate follow-up activities, as defined in the instructional model [23]. The two broadly recognized and used approaches to student modeling are stereotype modeling and feature-based modeling [16].

However, we should be aware that monitoring is not an end in itself [20][23][24]: in addition to carefully deciding what and when to monitor, the tracking process is further complicated by the issue of appropriate interpretation of the gathered data and correctness of inferences made from that data. Erroneous assumptions about the learner’s input, his language knowledge and skills, may cause wrong action by the system, consequently leading to an inefficient learning process and poor language attainment [14].

C. The Tutoring Model

The tutoring model is made up of rules that define how a system should act during runtime, taken into consideration the data from the learner model [17]. It specifies which pedagogical action should be taken following each user activity. Therefore, this model defines what, when and how to adapt within the system [25]. In order for the adaptive action of a language learning-oriented ITS to be effective, the knowledge from language learning theory (usually First language acquisition (FLA) or Second language acquisition (SLA)) and pedagogical practice should be included as part of this model.

D. The User Interface Model

The interface model was only recently added to the above three, and is concerned with the graphical environment through which educational content is delivered to the learner [2]. In particular, it deals with the representation of instructional material, mostly focusing on multimedia and its advantages for the learner.

E. The Feedback Module

Another important and frequently included element of an ITS for language learning is the feedback module. Language teachers are often engaged in giving feedback to learners concerning their progress, success on a particular task, language areas they need to work on, etc. Similarly, tutoring systems should also be able to adequately respond to a learner activity.

Giving feedback may consist in a straightforward declaration of errors (e.g., The answer you provided is not correct.), request for additional clarification (e.g., What do you mean by...) or restating something in a correct manner [18]. In many ways this entails the usage of NLP techniques so that the computer is able to make sense of the learner’s written or spoken input.

From the point of view of technology, there are three possible approaches to appropriate feedback formation: pattern matching-based approach, statistical-based approach and rule-based approach [26].

III. Issues Surrounding the Development of ITSs

Designing each of the components of an ITS for language learning requires a careful consideration of the needs of both learners and teachers. In the light of that and based on available reports from literature on specific language-learning ITSs, we point out some of the issues that may arise during the development process, briefly explain them, and, where appropriate, offer some suggestions as to possible solutions.

One of the frequently noticed issues in language-learning ITSs is over-restricting the learning domain, both horizontally and vertically. Horizontal domain restriction refers to a system’s tendency to focus on a single linguistic skill (listening, reading, speaking and writing) or form (grammar, vocabulary) rather than a combination of them. Including a whole range of skills/forms or even all of them into the ITS would be more in line with the nature of language learning, which emphasizes the integration of both productive and receptive skills, visual and auditory input, written and spoken output, form and communicative competence, etc [27]. Conversely, vertical domain restriction refers to the inability of an ITS to cater for learners with different levels of language proficiency (e.g., CEFR proficiency levels A1 – C2), which decreases the number of potential system users and, consequently, system’s (potential) financial value. We maintain that a possible solution and a more sensible approach would be to offer learning content designed for a wide range of skills, forms and ability levels, and use the knowledge about the learner, kept by the ITS, to detect which skills/forms are needed by each learner. Moreover, learner data should be used to identify the learner’s current level of proficiency, offer learning materials that are appropriate for the identified level, and decide when the new level of proficiency has been reached.

The issue of user input evaluation is also a significant one. Whereas evaluation of certain linguistic skills and forms can be automated and independently done by the system (e.g., reading, listening and grammar), some skills are notoriously difficult for the computer to evaluate on its own. This particularly holds for productive skills, namely speaking and writing, which involve unrestricted user output. Even though natural language processing and speech recognition techniques have come a long way in terms of accurately evaluating user output, they maintain to exhibit certain flaws [13]. At present, a computer is still unable to fully replace a human being when it comes to evaluating unrestricted oral or written output. However, restricting user output to a particular domain with specific vocabulary (e.g., describe a room or a person, explain a shopping list) might make a significant difference in rising the accuracy of evaluating output.

Another issue, related to vertical domain restriction, is standardization and comparability between systems. Most of the ITSs reported in the literature do not use some generalized framework of ability reference (such as CEFR or ILR scale) to define the level of learner proficiency for which the learning content of the ITS is intended, but specify such a level in terms of school grade or educational level only (e.g., college freshmen course). This significantly affects learner mobility between different ITSs, mostly because learners are unable to
Designing learning materials that will be presented to a learner during the educational process involve several issues that need to be acknowledged. The most notable among those is the issue of interactivity of learning materials. When using languages for communication, learners are engaged in an interactive process of sending and receiving messages through a number of communication channels. In certain cases, the meaning of messages cannot be fully grasped simply on the basis of the sum of words and their meanings, but other elements, such as tone of voice, gestures and body language, and contextual information, need to be taken into consideration. Hence, learning materials should reflect real world communicative situations, which is possible to achieve through the use of multimedia. Another issue related to learning materials is how to keep learners motivated during the learning process, and how to actively involve them to work with materials at hand. One possible way is to give small-scale task to the learner, such as “click on the right word” or “translate a particular word”, which can also serve as indicators of learner knowledge and progression through the learning domain.

Feedback module design should deal with the issue of selecting or generating appropriate feedback once the learners have finished interacting with the system and the computer has evaluated their response. The feedback message in language-learning environments needs to be beyond a simple correct-incorrect statement: it needs to be able to point out the source of the linguistic problem and offer appropriate scaffolding towards obtaining correct knowledge. Additionally, the degree of feedback explicitness should depend on the already discussed level of language proficiency: more explicit feedback for lower-ability learners, and less explicit for higher-ability ones.

The final issue we point out here is how to model language teacher competences and their teaching strategies. For some time now, there seems to exist a strong tendency towards socio-cultural and socio-cognitive approaches to language learning, where the communicative function of language is strongly emphasized. As explained in [27], such an approach underlines two key concepts, namely tasks and interaction: language users and learners are seen as “social agents” who use their “communicative language competences” in numerous “language activities” to exchange meaningful messages as they try to accomplish a particular “task” at hand. The role of the language teacher in such a model seems to be the one of support, providing the learners with tasks appropriate to their level of knowledge and skill, observing their performance during the communicative act, and offering appropriate feedback. Additionally, based on the existing evidence (usually in the form of previous performance results), the teacher decides upon the best action to follow, be it a remedial task or a task involving the acquisition of new knowledge. ITSs can be considered a technology capable of successfully taking over the responsibilities of the language teacher. In order to do so, an ITS needs to be designed specifically for language learning purposes: sound pedagogy and language teaching methodology, supported by what is known from FLA or SLA theory, represents the basis on which to design an intelligent computer assisted language learning system.

The issues reflected upon above do not make up a definitive list of all the possible issues that may arise during language-learning ITS design, but they represent situations often encountered in practice. Moreover, these issues contribute to the discussion on the complexity of the process of conceptualizing an intelligent system for language learning which is one of the topics addresses in this paper.

### IV. Examples of ICALL Systems in Use

There have been numerous reports on the development of ICALL systems over the years; however, it seems that most of the systems have remained in the prototype phase or have been developed purely for research purposes. Literature review has revealed three systems in particular that are confirmedly used in the language classroom, integrated into the foreign language learning curriculum, and continuously updated and improved [14]: E-Tutor for learning German as a second language, TAGARELA system for learning Portuguese at the university level, and Robo-Sensei for Japanese.

E-Tutor system is a comprehensive Web-based learning environment for university level learners of German. It employs AI and NLP techniques in order to achieve individualized learning experience. The system is mainly focused on vocabulary and NLP techniques for which it offers several types of exercises, namely translation, dictation, sentence formation and providing the missing word. Evaluation of these activities is supported by NLP and feedback is generated based on learner performance. In addition, each section has activities for listening and reading comprehension, culture and writing. Writing assessment, however, is not automated, and is done by the teacher [19][23].

TAGARELA is an ICALL system for learning Portuguese at university level. It has been intended to complement the existing pedagogical materials. It serves the purpose of an electronic workbook, and offers feedback on spelling, morphology, syntax and semantics to each individual learner. There are six activity types in total: reading and listening comprehension, picture description, rephrasing, fill-in-the-blanks and vocabulary exercises. Creators of the system point out four main tasks the system can perform: detect errors in the student input, diagnose knowledge level and skills of the learner, adapt the system accordingly, and generate feedback [14][21].

Robo-Sensei is used for teaching and learning Japanese in 24 lessons, and focuses mainly on translation tasks. It receives input from the learner, performs itemization and morphological analysis, and parses the sentence syntactically. However, the sequence of
activities is the same for all learners, as is the feedback. Thus, the system does not adapt to student level of proficiency or knowledge about particular language items, but only offers NLP services [28].

Additional examples of ICALL systems address a variety of language skills. Thus, in Ref. [24] and [29] reports on WUFUN are found. WUFUN is a system for Chinese university students learning English, based on a regularly updated learner model. The system is special as it features both aural and visual input, which contributes to saliency, and, possibly, better attainment.

In [30], an ICALL system called Your Verbal Zone (YZV) is described, which is used to support Turkish students’ English vocabulary learning. YZV contains a morphological analyzer which is able to find the root of a morphologically complex word and return its base form together with affixes. It, of course, uses NLP in order to achieve that. In order to further support students, the system contains a built-in, bilingual dictionary, a number of examples related to word use and details of function and meaning of particular affixes.

In [13], the case for WordBricks is argued, an intelligent system supporting the process of writing grammatically correct sentences. The system features a grammar checker and allows students to produce free utterances. This also permits learners to experiment with language and test their own hypotheses on language structures. Feedback generation system is also implemented.

In [31], a program called C-DA, used for improving learners’ metacognitive reading strategies is described. The standalone program, also available in the Web browser, keeps track of learner answers to questions, and for each incorrect answer, it initiates the “mediation” mechanism which helps the learner solve the task. The mediation mechanism is designed to offer more implicit help at first, and if the error persists and the learner is unable to provide the correct answer, help gradually becomes more explicit.

An ICALL system called CASTLE is described in [32]. It provides an opportunity for language learners to practice their communicative skills, namely writing, through a number of predetermined role-play scenarios. Upon wrong input and depending on how the error is classified by the diagnosis module, CASTLE takes remedial action in the form of additional grammar exercises to stress certain formal language structures. In the same time, the system keeps an up-to-date student model which holds data concerning student proficiency for a particular topic, data about errors and proneness to commit them, and the estimates of the likely cause, so the system is able to adapt its behavior towards each learner.

A description of a Web Passive Voice Tutor is given in [33]. The system uses stereotype modeling to initialize the student model, applies NLP techniques for intelligent analysis of student solutions to tasks and tailors feedback and advice to each student separately. In addition, it uses the so called link annotation technique to guide the learner through the learning domain by suggesting the most appropriate activity to follow.

I-PETER, as described in [34], is an intelligent system for language learning that allows for three distinct ways of learning: identifying and mending holes in the existing knowledge of the subject matter; improving on the current level of knowledge of a selected part of the domain; selecting and practicing only selected concepts and/or subconcepts of the domain. In each case, the learner needs to give an answer to a particular question, and once it is evaluated by the system, the learner may request detailed theoretical explanation regarding the error. In addition, there is a possibility for the system to fully take charge of the learning process.

A personalized English article recommending system is presented in [35]. This system holds information about the linguistic ability of a learner and selects the most appropriate article to be read next. After reading it, learners are given a vocabulary test consisting of newly-encountered words from the article. Based on their performance on the test, the learner model is updated, linguistic ability recalculated, and a new article is chosen for delivery.

Lastly, we mention a computerized adaptive testing system for Chinese (reading and listening) proficiency [36]. This system offers each learner an individualized test in which the selection of the next test item is done “on-the-fly”, and depends on the (correctness of) answers to previously generated test items. After evaluating each answer, the system updates its estimate of learner proficiency. Thus, the system needs to keep a log of the estimated level of proficiency together with all the answers to all the test items previously administered. Test items are generated until a predetermined termination rule is reached (e.g., a sufficient number of items have been given, a certain amount of time has elapsed, etc.).

The examples of software given above clearly reveal that ICALL constitutes a broad field of both research and practice. Systems differ in their focus on skill, level of complexity, degree and manner of employing AI and ITS technologies, way of generating feedback, even learner modeling. One thing they have in common however is that they are usually restricted to a single problem area instead of addressing a variety of issues. Regardless of their differences and possible shortcomings, we should evaluate a piece of software not by what it is capable of doing, but by how well it does what it is intended to do.

V. CONCLUSION

Individualizing language learning experience is certainly facilitated by the maturation of technologies from computer science, in particular AI. These technologies offer new possibilities for developing better and more efficient software that will be available even at a distance and without the presence of a teacher.

In this paper, we have given an overview of ITSs as an example of technology often used within the field of ICALL to individualize the process of language learning and teaching. Development and implementation of language-specific ITSs is not without issues which need particular attention from the development team. Addressing such issues in a systematic way should
improve the overall quality and usability of an ITS, and contribute to a better learning/teaching experience. Some of the ITSs included in our overview have successfully managed to solve certain issues raised in our paper, while others continue to persist.

Given the current state of technology, we maintain that software is not yet capable of fully replacing the language teacher, but is able to do so only to a (significant) degree. Only further developments in AI and related natural language processing technologies will see the goal of full replacement be reached.

REFERENCES