Abstract: SigmaStar is a research project carried out in cooperation between the University of Applied Sciences Darmstadt and the department of Artificial Intelligence of the University Erlangen-Nuremberg. It aims at developing a role-based “Edugame” for mobile phones and focuses especially on the interlacement of learning and game experience as well as on the offer of open, flexible learning contents provided by natural language processing tools. Springing from the results of the master thesis “Mobiles Lernen mit dem Handy” [Ot04] and the master project “Audiovisueller Vokabeltrainer” [Ro05], our goal is teaching not only factual vocabulary knowledge, but also grammatical structures and their use in daily conversations and so providing more complex language skills. Inside a game scenario the process of language learning turns more attractive to the user. On the technological side, the integration of a morphological tool allows the checking of errors in exercises with random vocabulary content. Furthermore, with the inclusion of a German semantic dictionary, it will even be possible to correctly judge user input not implemented previously while developing the software. For this purpose, these tools need to be embedded in the constrained mobile phones we work on. Besides technological feasibility, SigmaStar group is also interested in usability and popularity of this type of learning application.
1 Introduction

“2047, somewhere in the Milky Way on a tiny, unknown planet each generation fights for the control of the planet. Now it is time for the fight for control of the following generation. The children of the two royal families have 250 days of the stars to find out everything about the Universe. The first destination on this journey throughout the galaxy is a planet called Earth. There, somewhere hidden in a dark forest is the only place where magical arts are still used and taught…”

This is the introduction to the game that guides the player through a learning process, that will lead him to level A2 of the German language [Gi02]. To achieve this objective – learning German as a foreign language within a game – the learning process must be embedded into a storyline, and the right balance between fun and learning must be found. This challenges us to find subtle ways of inserting the exercises and the tests into the course of the game. The player may and will learn, but this learning is all about a story, and this learning has to remain inside the boundaries of that story.

In this paper we will describe some generalities about game based e-learning and positive effects on learning. Then we present our motivations and expectations in creating this learning application for the mobile phone instead of for PC or game console. This provides us with special challenges that we will also detail. We shall explain the structures of our gaming/learning context and the way we intertwine them in this role-based game: the didactical design. An overview of natural language processing technologies we will use follows. We have at our disposal two powerful tools: GermaNet (a semantic dictionary) [LK02] and a morphological tool for the German language [Ha96]. Finally we discuss the costs of using this novel technology for learning.

2 Game-based E-Learning

2.1 The use of games for learning

The question of positive and negative effects of (digital) games on learning has been a subject full of controversy in literature for over 20 years [TSK04]. While Stoll [St99] argues that “learning isn’t about acquiring information, maximising efficiency, or enjoyment”, and that turning “learning into fun is to denigrate”, Heitkämper [He90] mentions findings on many positive effects on recall, motivation and group dynamics provided by games in conventional language courses.

In their review of literature Mitchell/Savill-Smith [MS04] come up with a similar contradictory result on the use of computer and video games for learning, but, with regard to current and future generations (see 2.2), recommend developing “educational games that are true games”. In fact we find several successful applications of games in different learning contexts, such as maths or reading support; or even positive results when applying games in clinical treatment (like attention deficit disorder or schizophrenia) [MS04].
When designing an edugame the question “Why do people play computer games?” becomes important. The answer has already been found: the prospect of power and success as well as the discovery of fantasy worlds stimulate people to play those games. The possibility to get control over the flow of events appears to be very attractive. People (especially children) like the chance to escape their environment. In games they get to play an active role, a possibility that does not exist in books or movies. Their self-esteem increases even if, thanks to individually chosen levels of performance, the success is nearly guaranteed [Fr03, Cr82].

Games may engage learning for different reasons. “They motivate via fun (…), via challenge and via instant, visual feedback within a complete, interactive virtual playing environment, whereby ambient information creates an immersive experience, sustaining interest in the game” [MS04].

Another advantage consists in learning through trial and error [MS04] but in contrast to real life situations no tragic consequences must be feared. The virtual experience allows users to retry tricky tasks until they are mastered [Fr03]. In that way games can provide a laboratory for problem-based learning, active learning and experimental learning [Ki03]. The learning process can be controlled by the learner’s individual progress [MS04]. Also post-game discussion should be taken into consideration as a positive experience for consolidation of learning [Ki03].

2.2 The digital generation

At this point we will have a look at our target group: pupils the age of 10 to 14. Today’s children grew up with digital technology all around their lives. That means that an average college graduate has already spent more than 10,000 hours of his life with computer and video games, 20,000 hours watching TV, but only less than 5,000 hours reading books. This has an impact on their thinking patterns and even brain structure. Instructors from the pre-digital age have now to teach a generation that prefers graphics to written texts, that is able to access information very fast, processes it in parallel, waits for immediate feedback and prefers gaming to serious work [Pr01].

We would like to point out some statistical data about mobile phone use among children and youth. According to JIM 2004 [JIM04] 90% of the Germans in the age segment from 12 to 19 years old possess (at least) one own mobile phone. Mobile games represent the third most important functionality after SMS and phone calls among children aged 12 to 13 years. This situation offers potential for new learning approaches.

3 The mobile phone

The physical consistency of this small and lightweight electronic gadget implies several strengths. As it has become a permanent companion, it offers the possibility to learn everywhere and at any moment, i.e. on the way home by bus, if the motivation is high or a sudden need of information occurs. Waiting times can be used meaningfully [LN03].
Today’s children and young people always carry their mobile phones with them. This means that the device our application will run on will always be as easily accessed. Besides the advantage of portability, mobile phones present some limitations which have to be taken into consideration. The small display and the constrained input methods require a thought-out interface design and navigation structure [Bu03]. While the problem of storage capacity can be solved by memory cards, the processing speed is still limited. Furthermore mobile use differs from stationery PC-applications in an increased need for immediate added value and shorter learning sessions [SM02].

In first tests with a mobile vocabulary trainer children liked the idea of learning wherever they want and the fact that the mobile phone combines the mobility of a book with the comfort of electronic support from the PC. Furthermore they claimed that because they carry the learning application always with them they would study more often. They even enjoyed the uncomfortable way of typing on the 12-keys-keypad [Ot04].

4 Didactical design

These findings encouraged us to find a complex learning application that is both an interesting game and a system for learning a foreign language.

4.1 Learning objectives

Starting from the very beginner level the learner will be guided to level A2 in German language. This means he will be able to communicate in a simple way in daily situations about familiar subjects [Gl02]. The selection of vocabulary and the grammar progression rely on the “Referenzrahmen” [Gl02], the German version of a compendium that standardises European wide language levels. Thereby our application stays independent from a certain textbook while following a similar path in instruction. This expands our target group and frees us from licence fees. The decision for novice level was made because in this stadium the audience is more homogeneous and we assume a greater interest in a playful, discovering approach on language learning than among experts with differentiated learning objectives.

4.2 Instructional game design

The instructional game design is going to be described in analogy with the five particular “Principles of mobile game learning” drawn up by Thomas, Schott and Kambouri [TSK04]: adaptation, challenge and mastery, goals, community and collaboration as well as context.

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1 The statement of Buchanan et al. can be generalized from WAP-pages to interfaces of mobile applications.
4.2.1 Challenge and mastery

Successful games rely on a smooth increase in difficulty and complexity as well as user-friendly tutorial elements [Fr03]. In consequence the introduction to the game with the general goal can optionally be read (and listened to) in the respective mother tongue. The game should be challenging at every level of mastery and produce at the same time an “illusion of winnability” [Cr82]. This will be achieved starting with small tasks and less details so that the player can get familiar with the rules and modalities of the game before more complex situations with tricky elements are to be mastered.

In terms of didactics this increase is going to be achieved – along with improvements in vocabulary and grammar – with exercises at different cognitive levels. Following the noted taxonomy of learning objectives by Bloom [Bl76] they reach from simple knowledge and understanding tasks (like assigning the right article or picking up the required object) to transformation (e.g. translating a situation into the future) and construction (e.g. unsupported input of synonyms).

4.2.2 Adaptation

The adaptation to the learner’s needs and performance is often seen as one of the advantages of e-Learning [EW03] and in the same time considered as important for games [TSK04]. On the one hand this requirement is met by the increase of difficulty described above, on the other hand we distinguish between four kinds of exercises which have to be performed only partly and offer in this way a bigger choice on how to master the game.

- **Story-inherent exercises** influence the course of the story and provide hints to find solutions to certain problems. If the learner seems to struggle, the dialogues can change and provide more explicit help. The learner has to solve most of them on his way through the virtual world in order to finish the game.

- As the game should really train the user, there will be **key-exercises** at the end of episodes to check if the user is up to a certain level. For assessing the student’s level so called “C-tests” have proofed themselves in language learning contexts [Si05] and will consequently be used in the game. If the learner fails, the application adapts itself in generating a loop with similar situations until the learner is able to get the key into the next setting.

- **Quality of life-exercises** (QoLs) are short, optional exercises with fun factor. They provide different contents and different cognitive levels. They can be accessed several times. Sometimes the permitted amount of time is limited. In those “games of chance” the user has to gamble some money. If he wins, he earns money or fitness points; otherwise he looses his stake. If the amount of successful attempts grows, the benefit when winning may be reduced or the exercise type may be changed: the “Future Shop” (where of the user can take exercises related with verb forms in future tense) closes and a “Past Market” opens instead. Therefore the program traces the learning path in order to
exclude topics that have been managed correctly two or three times, and brings them back some time later, to weaken the forgetting curve discovered by Ebbinghaus [in Hu75]. These drill & practice parts allow for the use of the game in even very short time slots which is an important point for the mobile environment [SM02]. In order to motivate the learner to participate in those exercises the earned money or fitness points ease the life on Earth.

- As to the authors’ best knowledge idioms are rarely taught in basic textbooks but are nevertheless nice to know in daily communication. That is why optional reward quizzes are offered as well. This last type of exercise has absolutely no influence on the course of the game. It presents an idiom with a picture of a funny situation, and the learner can guess its meaning.

Taking into count different learning types mentioned first by Vester [Ve78] learning material that appeals to different senses should be integrated. As pronunciation and differentiation of fine nuances while hearing spoken language are considered as the biggest difficulty in language learning [Ge04], there must be some audio exercises, where the user should e.g. try to distinguish the pronunciation of different vowels. Visual elements (e.g. well-considered use of colours for distinguishing the gender of words) should help the player to remember later on. Because of the game scenario the user needs to participate actively. This approach can support people that learn best in doing or applying the learning content, while tricky tasks might motivate especially cognitive learners.

4.2.3 Goals

Games, as well as learning processes, need goals, which are composed by several sub-goals. Learning goals and gaming goals shouldn’t be distinguishable for the players [TSK04]. This means, for our role-based game a scenario must be found where the use of language is implied per se and that contains real-life situations the learner might be confronted with every day – developed within an interesting adventure. Thus, a virtual world in which the character is somehow forced to learn a new language to achieve his goal seems suitable.

A too realistic approach provides two risks: it could reduce the fun factor and it could conflict with some cultural boundaries – reducing this way the number of potential users. That’s why we decided to shift to a world with witches and wizards. In order to find his/her way in this fantastical-real world the user has to come up with magic spells and secret formulas that are German. This way language and learning play a central role inside the story.

Dialogues as the ones found in adventure games like “Monkey Island” or “Zelda” represent a fundamental element, that gives both examples on how to use grammar and a guide through the storyline. While the overall long-term goal is presented in the introduction, the user will be confronted with sub-goals, as freeing his brother from an evil wizard. Lots of sub-sub-goals (like looking for a blue flower) split this still complex sub-task into many smaller ones, that provide short-term objectives [TSK04].
4.2.4 Community and collaboration

Thomas, Schott and Kambouri [TSK04] quote several positive effects on multiplayer games, and we have some interesting ideas on how interaction with other people could increase the motivation of learning and support collaborative learning. However, this feature will not be implemented – at least for the moment, for two reasons. On the one hand, the anonymity of individual learning frees from the fear of failure [EW03] and the danger of disgracing oneself, because learning is considered as not cool. On the other hand, the design of multiplayer games is much more complex and would exceed the boundaries of our small-scale project.

4.2.5 Context

It is context what makes content relevant and alive, and encourages learners to keep on learning [Le04]. As our intention is to teach communication skills for daily conversations, the situations in our fantasy world will be similar to the children's environment. Those situations will fit at the same time into our storyline (e.g. shopping is an essential part of language learning courses, but instead of buying a newspaper the character is interested in a youth magazine).

There won’t be an integration of the current (real) environment of the user.

5 Technology

The second big challenge of our project represents the integration of artificial intelligence into the learning application. We have at our disposal two powerful tools (a morphological tool and a semantic dictionary), but they need to be adapted to the use in a mobile device. This technology will turn the application much more flexible, as the exercises shall not be hard-coded: the correction will happen at runtime.

5.1 The game engine

The story line, the current situation of a game, and the exercise data and verification procedures are all represented in a specialized programming language ALGO (A Language for Game cOntrol). The ALGO interpreter is implemented in Java. Abstract data types are provided for morphological features, data from the GermaNet dictionary, and the objects found all along the game. ALGO allows the definition of (arbitrarily nested) procedures and local variables. Each situation is represented as a procedure. While-loops and conditional execution of statements are used to control the development of the story line in a game. ALGO also provides statements for interaction with the morphological tool and GermaNet, for feature unification (used to verify whether the user did an exercise correctly), and for communication with the graphics renderer.
The fact that the story line is stored as an ALGO program to be interpreted during runtime of the game allows for its easy adaptation and extension. For example, new levels can be added just loading new situations (this is, procedures). As all the exercises are kept as data in ALGO, one could even imagine to allow successful players to modify them for players later on.

5.2 Morphological tool

The morphological tool is used for two purposes: text analysis and text generation. Those features are very helpful when implementing Quality-of-life exercises. After each episode some new words and grammar get the flag “known”, and are, thereby, possible practising content. A second “mastery” flag stores the success rate, so random exercises adapted to the player's level may be generated. Using the tool afterwards we are able to check the user input without pre hard-coded pattern matching. The comparison of different linguistic features (person, tense, gender) can be trained as well. And as the tool knows nearly all German words, it can also be used to compose word puzzles or matching words in words tasks.

5.3 Semantic dictionary (GermaNet)

Any learning application which points an error where there is no one, but where the authors have not foreseen every possibility of user input, will annoy the user. That is where GermaNet [LK02] becomes important. GermaNet contains the German vocabulary ordered hierarchically by meaning. For instance, armchair and sofa have the same parent node: seats. Seats again has furniture as parent node together with table and cupboard. This provides, on the one hand, the possibility of checking a totally flexible user input correctly. On the other hand this tool can be used for generating random synonyms or antonyms exercises, or the typical “odd-one-out” exercises, where one word does not fit in the group.

6. Cost estimation

One decisive factor on the success of mobile learning games will be the costs from the learners point of view. As the application is thought for individual learning independently from any traditional or blended learning course, there are no additional teaching costs. To run the application the user needs a mobile phone with about 40 MB of available storage and unlimited size for added Java applications. As the application will be implemented with the Java technology the user mustn’t possess a smartphone. For the moment, a suitable device can be bought at about 300 Euro without contract. Which is still out of question for many children and youth but we wait prices to fall as usually. As our game doesn’t require communication via mobile networks, usage costs amount to zero.
Assuming that kids at the age of 11 to 14 give already realistic approximations about what they are willing to pay for a mobile learning application, such a program could cost up to an average of 7.37 Euro. Regarding only those who could imagine to learn on a mobile phone, they claimed a willingness to spend even 9.43 Euro. Those statistical data are based on a survey among 71 pupils after testing a mobile vocabulary trainer [Ot04].

7. State of the implementation and outlook

Most of the control mechanism for playing games as well as the morphological tool and the access to the semantic dictionary are already implemented. We have completely developed the storyline and the game for vocabulary training for the A1 level [Gl02] and are currently working on the integration of different exercises. Designing the graphics for the game is underway, as well as several performance tests on the mobile phone.

Based on the experiences in previous projects and on feedback from experts in language teaching, we think that a prototype of an interesting learning game is attainable. From the technological point of view, the approach is pretty innovative, as it incorporates advanced natural language processing technology to obtain an automated language learning tool. This technological progress increases, on the one hand, the amount of exercise types; and allows, on the other hand, to verify or reject any unforeseen answers. So we avoid the drawback of other learning software to reject user answers that are actually correct, but cannot be validated due to missing data in the software. In the long run, this positive effect should lead to an increased acceptance and effectiveness of language learning software.

References

[St05] Personal Communication of Sieben-Shimada, A., language department of the university of Erlangen, 2005-05-25