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ABSTRACT

In this chapter, we introduce in this chapter *Apex 2.1* (i.e., Assistant for Preparing EXams), a prototype system that provides automated feedback to e-learning students on the summaries they wrote about the courses they attended. At first we present some theoretical underpinnings on how the system has been designed then we detail *Apex 2.1* architecture. Eventually, the first results of a validation study involving three groups of stakeholders (students, teacher, administrator) are presented. The utility, acceptability and usability of the system are examined.

KEYWORDS

Latent Semantic Analysis, Self-regulated Learning, Computer-based Feedback

1 INTRODUCTION

This chapter is devoted to the presentation of *Apex 2.1* (an Assistant for Preparing EXams), a prototype system that delivers automated pieces of feedback to e-learning students on the summaries they wrote about the courses they attended. *Apex 2.1* first enables students to choose a subject content they want to study, from a query composed of one or more key-word(s). Then the system delivers a set of documents semantically close to this query. At any time the students can write out a summary of the document they have read and understood and can get an automated feedback on this summary. If they do so, students can revise their summaries and enter in a self-regulated workflow: reading-writing-feedback-revision, which could lead to a better understanding of the chosen subject content.

The remainder of this chapter is as follows. We first introduce the theoretical underpinnings on which this system is based, as well as its architecture and the semantic analysis method (Latent Semantic Analysis) on top of which it is built. We eventually detail its first usability evaluation study upon three different categories of users.

2 WRITING TO LEARN

In a nutshell, the design of *Apex 2.1* starts with the assumption that students should write to learn and that the better their self-reflection (and self-assessment) on their learning is, the better their learning will be. Elaborating more on this assumption will lead to a better explanation on the possible use of *Apex 2.1* in an e-learning situation. According to the so-called "writing-to-learn" approach, the activity of writing yields to learning, in exploring and emphasizing the relations between ideas ("strong text" view, Emig, 1977), due to very close similarities between writing and thinking. Further research (Klein, 1999) showed that the writing-to-learn approach actually shares four different views and hypotheses:

- the *spontaneous writing hypothesis*, in which writers generate knowledge de facto, without any planning or revision processes (close to the knowledge telling process, Bereiter & Scardamalia, 1987);

- the *forward search hypothesis*, in which ideas are externalized in texts and new ones are then inferred through re-reading;

- the *backward search hypothesis*, claiming that writers first have rhetorical goals from which ideas and arguments derive, and thereby writers learn;

- *the genre writing hypothesis*, suggesting that writers use their knowledge of genre structure to create and analyse relationships between elements of texts, which in turn leads to learning.

These different hypotheses highlight the idea that writing is a self-regulated activity with multiple goals, whose account cannot be constrained, and that e-learning settings make this assumption more crucial. In such settings, feedback to students' learning cannot be as frequent as in presence, and students have to cope with their isolation from each other and to engage in self-regulated activities. Research has been developed on self-regulation of learning in a distance learning context, and Vovides et al. (2007) devised a model on this activity. First, students work on the *object level*, in preparing their activity according to the ongoing task. They can also apply some cognitive strategies for carrying out these activities. Then, students perform a first draft assessment of their production (its adequacy, its relation to their knowledge, etc.). Thirdly, a reflection on a meta level allows them to perform a comparison between the latter comparison and the object level, often offered by artifacts (computer-based services, prompts, etc.), so as to compare their perceived level of learning with proposed one by the artifacts. Eventually, the students can perform some adaptations to their work, which in turn fuels the possible update of the object level and can be re-acted in a further loop.
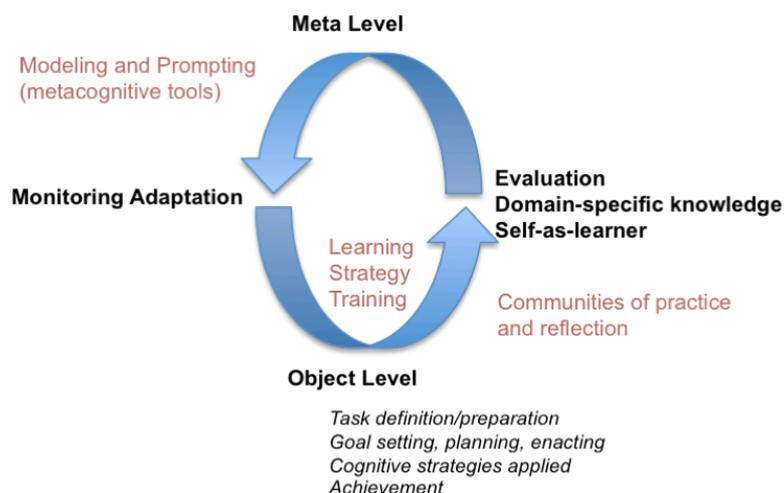
Figure 1 — A Model of Self-Regulated Learning in e-learning (after Vovides, et al., 2007, p. 68).

We claim that *Apex 2.1* enables students to have a deep understanding of the course they learn without (at least immediate) support from their teachers or tutors. This software belongs to a new line of e-learning services allowing their users to be freely engaged in workflows from which they can easily move to another one and which fosters their self-regulation. It is worth noting that both teachers and tutors benefit from *Apex*'s use as well, by providing an overall view of students' activity and understanding. Thus they can focus on higher-level or more individualized student support. Since the use of this kind of services is new, our aim is to collect fine-grained evidence of their usage, and views on the way students get acquainted with them.

3   SYSTEM DESCRIPTION

Apex 2.1 has already been subject to a first implementation (Dessus & Lemaire, 2002), but no evaluation in real-world settings has been undertaken so far. *Apex 2.1* is written in PHP and C, and built on top of Latent Semantic Analysis (Landauer & Dumais, 1997), a statistical method introduced in the next section. A running version of this service is available at http://augur.wu-wien.ac.at/apex2/Recovery/progPhp/Apex2.php.

3.1 SYSTEM ARCHITECTURE

The way *Apex 2.1* works is depicted in Figure 2. Two main loops (in yellow or grey) are successively carried out: the first one is a *reading loop*, allowing students to read a set of texts semantically related to a query, the second one is a *writing loop*, in which

students write out a summary from the source texts previously meant as understood, and can get feedback on this understanding.
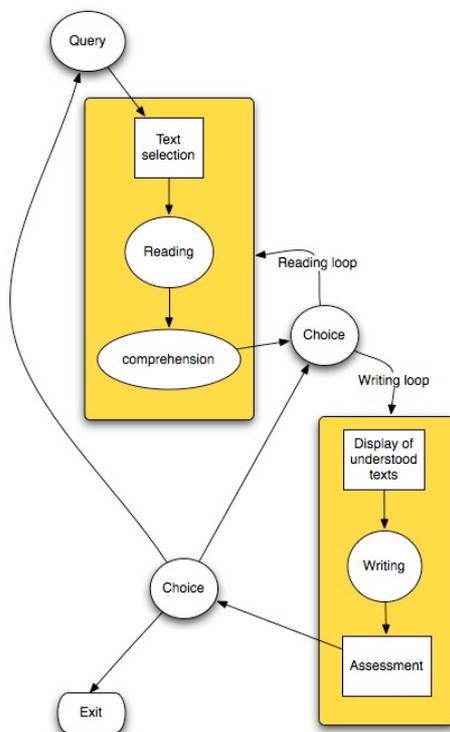
Figure 2 — The way Apex 2.1 functions. User-machine interactions.

Let us explicate the *reading loop.* A session typically starts when a student types a query, i.e., some key-words related to the subject domain or the theme he or she wants to be acquainted to (see Figure 3). Then *Apex 2.1* displays the student a first text to read, which is the closest text to the query. All the texts are presented to the student successively and are the closest to the query possible, as indicated by LSA. The learner model is updated accordingly, indicating that a given text has been actually presented and read.

Figure 3 — A message starting the reading loop, asking the student to type some key-words: "What is the course topic you want to read?"

Once the text has been read, the student indicates whether it is understood or not, and whether he or she is able to summarize it (see Figure 4). During this step, the learner model is updated, indicating whether the text is summarizable. *Apex 2.1* gives texts to read as long as there is no summarizable text yet *and* texts sufficiently close to the query but not delivered yet. On the contrary, *Apex 2.1* suggests the student to perform a new query.

Figure 4 — The interface for reading course texts. Once the text has been read, the student can assess his or her own comprehension: "I can summarize the text" or "I cannot summarize the text".

Once the student has understood at least one text, he or she can either read more texts on the given topic or start a *writing loop*. In the latter case, a table with the list of all the summarizable texts is displayed (Figure 5). The first column indicates the reading order of each text, the second column its ID number. The third column displays the first lines of each text read so far, which can be displayed as a whole by clicking on the + button. The "summarize" (*résumer*) button of the fourth column gives access to the writing zone (displaying the latest version of the summary, if it exists, or an empty field if not). Eventually, the last two columns respectively display the semantic proximity between the summary and the corresponding course text, as computed by LSA, and the comparison of this value and the student's opinion about his or her own comprehension of the text (i.e., "You said you understood the course text and your summary shows it is actually the case", « *Vous pensez avoir compris le texte et votre résumé le prouve* »).

Vous avez indiqué que vous pouviez résumer les textes suivants :

Rang d'apparition	Num texte	Texte		Evaluation	Commentaires
3	20	L'outil NEDERLEX génère un texte qui ... +	Résumer	0.91	Vous pensez avoir compris ce texte et votre résumé le prouve
1	29	Norme de saisie Il n'existe pas à l'heure ... +	Résumer		
2	30	Lemmatisation La plupart des mots sont susceptibl ... +	Résumer		

Figure 5 — Overall view of the texts read so far, displayed at the beginning of the writing loop.

Apex 2.1 currently works for a learner connected individually and updates a simplified learner model, as mentioned above. This model is coded in a text file, each line representing a course text to read and four columns representing respectively: the text ID, the "already-presented" identifier (0 or 1), the "understood" identifier (0 or 1), the proximity value (i.e., the LSA-based semantic comparison between the source-text and the corresponding student's summary). This text file is updated for every student's move and is re-initialized for every new query.

The student, after any feedback request, can perform one of the following actions:

- revise the summary and ask for a new feedback, since it is available for modification;

- go back to the table with so far read texts (see figure 5) and start with a new summary, or modify one already existing;

- read a new course text;

- perform a new query;

- quit *Apex 2.1*.

3.2   LATENT SEMANTIC ANALYSIS

Latent Semantic Analysis (LSA, Landauer & Dumais, 1997) is a well-known technique that captures semantic information in texts by uncovering word usage regularities. Extensive research has proven its efficiency in the domain of natural language processing, and more specifically for computer-based instruction—tutoring systems, interactive learning environments (Dessus, 2009). LSA represents the pieces of text to

be analysed (e.g., text courses, students' writings) in a multidimensional space. The processing steps are the following. LSA takes as input a large set of texts and a word-paragraph matrix of co-occurences is firstly built, then its dimension is reduced (to about 300 dimensions) by means of a statistical procedure. This reduction enables the emergence of semantic relations between words, paragraphs or texts. Thanks to this method two words can be considered as semantically close to each other, if they appear in *similar* contexts (i.e., sentences, paragraphs, texts), even if hey actually never appeared in the same one. However, this method works best only if a sufficiently large corpus of words is processed (i.e., multi-million word large corpus).

Apex 2.1 is built on top of LSA, which is used for providing the most adequate texts to the students (*reading loop*), and also to assess to what extent students' summaries are semantically close to the course texts they refer to (*writing loop*). Initially, we determined an arbitrary threshold value (0.6), above which the selected texts are sufficiently close to the query (*reading loop*). With regard to the *writing loop*, the same threshold has been used, and the following prompts can be displayed: "*You said you understood this text and obviously you did*" when the semantic proximity between the source text and its summary is above the threshold, and "*You said you understood this text, but obviously you didn't*" on the contrary.

4 SYSTEM VALIDATION

The validation of *Apex 2.1* is based on a corpus of sixty-six course texts (i.e. course notes or research articles) on natural language processing (NLP) and/or computer assisted language learning (CALL). These texts are homogenous regarding their length in words (an average of 650 words each). The texts provided in the reading loop were taken from this corpus. We added a larger and more general corpus to this base, so as to integrate general knowledge about language as well. This "general" corpus contains 101,123 different forms. It is formed from various texts representing several types, styles and vocabularies (articles from the daily newspaper *Le Monde*, texts written by children, texts written for children) and has been subject to validations (Denhière, Lemaire, Bellissens, & Jhean-Larose, 2007).

In order to test *Apex 2.1* in conditions as close as possible to e-learning settings, we defined three groups of participants.

- *a "user" group*, consisting of 11 masters degree or PhD students in NLP and/or CALL at our university. This group used *Apex 2.1* within the same conditions as e-learning students.

- *a "demo" group*, consisting of 28 bachelor degree students in educational sciences at our university. This group was given a demonstration of a standard learning session using *Apex 2.1* and answered a questionnaire afterwards.

- *a "teacher/administrator" group*, consisting of two persons: the manager of the pedagogical ICT department at the IUFM (i.e., "Institut universitaire de formation des maîtres", or Teacher Training Institute) of Grenoble university, and the manager of digital workspaces in the same institution. This group followed the same tasks as the previous one (demo).

The reason why the last two groups have been enrolled (those not testing *Apex 2.1* practically) was to evaluate the degree to which such a tool is acceptable to potential groups of users and prescribers. In brief, the participants of the first two groups, as learners, performed an empirical "evaluation" task whereas the participants of the latest group performed an "inspection" task, i.e., a prescriptive analysis of the possible uses of the system.

4.1 PARTICIPANTS TASK DESCRIPTION

The "user" group participants were of an average age of 24.6 years old (standard deviation 4.26) and were distributed as follows: five first year master students, two second year master students and four PhD students. Before starting the experiment, they were asked to acknowledge the protocol and to sign it, and then they had to fill in a questionnaire about their course revision methods. Afterwards, they used the software by entering keywords of their own choice. They had to summarize five texts of their choice (that they had read and that they considered they understood), without any time limit. Their usage trace on the software was recorded (e.g., chosen keywords, number of searches, texts read, time taken to read each text, texts understood or not, duration of each loop, etc.). At the end of this task, they were asked to fill in a second questionnaire regarding their opinion on the software. The whole set of documents given to this group is available at http://augur.wu-wien.ac.at/apex2/Expe/groupe-utilisateur.pdf.

The "demo" group participants (average age: 23.4 years old, SD: 4.5) had to fill in the same questionnaire as the user group regarding their revision methods. Then they were shown a screencast demonstration of *Apex 2.1* and answered a second questionnaire stating their opinion about *Apex 2.1*. The questionnaire is available at

http://augur.wu-wien.ac.at/apex2/Expe/groupe-demo.pdf.

The "teacher/administrator" group consisted of two persons, one aged 42, the other one aged 60. They followed a demonstration of *Apex 2.1* and answered a questionnaire available at http://augur.wu-wien.ac.at/apex2/Expe/groupe-admin.pdf.

4.2 HYPOTHESES

We defined the following hypotheses, based on criteria of utility, usability and acceptability for CALL (Bétrancourt, 2007; Tricot, et al., 2003):

a) *The utility hypothesis* assumes that the use of the system induces a benefit for the user (time-wise, interest-wise, etc.). It can be split in two sub-hypotheses:

- *Query-reading hypothesis: Apex 2.1* can be used as a search engine to find texts relevant to the theme chosen by the user. The texts have been provided by teachers; they are thus appropriate and from reliable sources. Hence the system allows students to read texts both relevant and understandable to them.

- *Self-regulation/evaluation hypothesis*: Students can freely enter each loop (query-reading and writing-evaluation), which allows them to regulate their learning better; furthermore, *Apex 2.1* provides them with feedback on their validated summaries.

b) *The usability hypothesis,* which corresponds to *Apex 2.1*'s handiness, refers to browsing and the interface. The aim is to evaluate, from an ergonomic point of view, the ease with which the system can be used and with which it can help the users achieve the goals they have determined.

c) *The acceptability hypothesis* corresponds to the "value of the intellectual representation (attitudes, opinions, etc. whether positive or not) of a system, its utility

and its usability[1]" (Tricot, et al., 2003, p. 396). This corresponds to a general point of view about usage demands induced by the system itself; in our case, this corresponds to knowing whether students find *Apex 2.1* easy to use and whether they would use it for their own work if they were given the opportunity.

4.3   RESULTS

In this chapter we present the results for all three participant groups. The previous hypotheses have only been studied in depth for the "users" group.

4.3.1 THE "USERS" GROUP

As noted previously, we gathered two types of data from the "users" group: their traces (users' behaviour in terms of queries, readings and writings) and their answers to the questionnaires. The analysis of the traces has shown the following points.

Utility/Query-reading hypothesis. 7 users out of 11 only carried out only one query (see Table 1), and thus worked on the same theme for all texts, two carried out two queries, one carried out three and the last one four (average number of queries: 1.64, SD 1,03). Regarding reading, all 11 participants read between 5 and 13 texts (average 8, SD 3.46). However, we should note that most texts judged as "not understood" and thus not summarized were only skimmed through. Out of 33 texts, 5 were read in more than 2 minutes and the average reading time for the 28 others is 30 seconds. It also seems that, when participants indicate whether they have understood the text and are capable of summarizing it, they give an appreciation of interest rather than an evaluation of their understanding. If the text is of some interest to them, they read it and summarize it, otherwise they skim through the text and turn to the next one. *Apex 2.1* would then be used to select texts corresponding to the user's expectations, which validates our first hypothesis.

Utility/Self-regulation-evaluation hypothesis. The following data only refer to read and summarized texts. On average, the inter-participant time taken to read a text varies between 3'24" and 14'19" (average 8'2"; SD 2'50"). This inter-participant variation is

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[1] Free translation of « la valeur de la représentation mentale (attitudes, opinions, etc. plus ou moins positives) à propos d'un système, de son utilité et de son utilisabilité » (Tricot, et al., 2003, p. p. 396)

thus very high. Regarding the intra-participant variation, the standard deviation on reading time ranges from 41" to 5'52", with an average of 2'40". All participants followed the instructions and wrote at least five summaries, taking from 1'49" to 27'40 to write them down (average writing time for each text, 7'5", SD 4'16"). The average summaries evaluation was 0.73; only 6 out of the 55 summaries had a grade below the threshold (0.6) and 3 out of the 6 corresponded to a single participant. Only one summary was rewritten. The students thus did not modify their summary after obtaining their evaluation. They did not take the feedback into account and did not try to improve them. This can probably be attributed to the fact that most feedback indicated that the summaries were correct, which was enough for them. More detailed feedback, rather than simply a correct/incorrect evaluation, would have certainly had more impact.

Table 1 — General data on reading activities using Apex 2.1

Student ID	Nb queries	Nb texts read and judged as understood	Nb texts read and judged not understood	Total Nb texts read
1	1	5	0	5
2	1	5	0	5
3	1	5	0	5
4	1	5	0	5
5	1	5	0	5
6	1	5	4	9
7	3	5	7	12
8	1	5	5	10
9	4	5	1	6
10	2	5	8	13
11	2	5	8	13

Regarding the analysis of both questionnaires, *the first questionnaire* referred mainly to using computers for course revision. Most participants mentioned they supplemented their courses with documents found on the Internet (7 out of 11 on a "weekly" or

"nearly daily" basis). Furthermore, they simultaneously used pen-and-paper and computer to revise (8 out of 11 distributed between "nearly every day" and "several times a day"). Hence, the "users" participants are used to revising with their computer. This first questionnaire allowed us to verify that they are used to working on a computer and thus any problems of usability would be directly attributable to *Apex 2.1* and not to lack of expertise in browsing, note taking or computer searches. The *second questionnaire* referred to *Apex 2.1* usability and was divided in two parts.

Usability hypothesis. In the first part, named "usage difficulties" and elaborated from the NASA-TLX test (Hart & Staveland, 1988), we note that for the majority of users, *Apex 2.1*:

- does not lead to any physical pressure,

- leads to a pressure related to the experiment itself,

- is easy to use.

In the second part, named "functions of *Apex 2.1*", we can note that, for the majority of the participants:

- the texts provided corresponded to the query,

- the texts provided were suitable, precise, etc.

This confirms our second hypothesis. Finally, most participants would use *Apex 2.1* from time to time if accessible, which confirms our acceptability hypothesis.

4.3.2 THE "DEMO" GROUP

The "demo" group answered a two-part questionnaire. Regarding their use of computers to revise courses, participants supplemented their course notes with documents found on the Internet less frequently (13 out of 28 "around once a week" and 9 out of 28 "around once a month") and used more the paper-and-pen method on its own to revise (15 out of 28 "nearly every day"). Their answers on computer and paper-and-pen simultaneous usage were: 1 "never", 9 "once a month", 10 "once a week", 6 "nearly every day", 2 "several times a day". Regarding *Apex 2.1's* functions, most participants think that *Apex 2.1* could help them acquire knowledge as easily as, or even more easily than, revision methods (19 answers, 11 "more easily", 8 "as easily"). Thus, the acquired knowledge is considered to be accurate (for 15 participants out of 28) and wide (14 out of 28) with

their usual method. Finally, if available, 20 out of them would use *Apex 2.1* from time to time for course revision purposes.

4.3.3 THE "TEACHER/ADMINISTRATOR" GROUP

Both participants in this group judged that using *Apex 2.1* could be an easier way to acquire new knowledge, compared to traditional methods (paper-pen), and furthermore that the new knowledge would be more precise. Both would suggest a frequent use of the tool to their students. They considered that *Apex 2.1* would provide students with better focus on the information required to learn course content. The administrator pointed out that the software gives students access to a wider range of information but remains easy to use.

4.3.4 SUMMARY OF RESULTS

Carrying out this study with three groups has given us a twofold evaluation: an "inspection evaluation" with the "teacher/administrator" group and a more "empirical" evaluation with the other two, with criteria of utility, usability and acceptability. Regarding the *inspection evaluation*, both teachers/administrators consider that *Apex 2.1* fulfils all three criteria. Regarding the *empirical evaluation*, the "demo" group validates all three criteria. On the other hand, concerning the "*users*" group, the utility hypothesis regarding texts evaluation is not completely validated. When summaries are judged correct, participants do not try to improve them, and when judged incorrect, participants did not reassess them. However, the second part of the hypothesis has been validated, as well as both other hypotheses.

5 CONCLUSION

The purpose of this chapter was to describe the underlying principles and a first validation of *Apex 2.1*. The software, dedicated to exam preparation, provides different uses to the learner. Firstly, *Apex 2.1* can be used as a text database with an integrated search engine. The advantage of this use, compared to an Internet search engine, lies in the fact that the text base has been built by the teacher and therefore only contains suitable texts (which avoids wasting time in Internet searches), and furthermore only contains reliable texts (which is not necessarily the case on the Internet). The search

engine, based on LSA, allows the partial reduction of problems related to polysemy, synonymy and inflections (Landauer & Dumais, 1997).

Apex 2.1 has been designed to help learners acquire knowledge through reading and writing (the "write-to-learn" approach). The advantage is to bring a flexible approach where the user evolves according to his or her wishes. Furthermore, he or she brings feedbacks to "real" contents, rather than answers to Multiple Choice Question papers or other closed exercises.

During the validation process, we have noticed that participants select the texts they wish to read and summarize. Most texts that they indicate that they are unable to summarize are texts that they have not read thoroughly. We also noticed that most participants indicate that *Apex 2.1* is easy to use and that they would use it from time to time if available. This therefore supports the continuing development of this software.

This version contains some limitations. The main one is the lack of feedback refinement after the evaluation. Indicating to the learners that they seem to have understood the text does not encourage them to try and improve their summaries. On the other hand, indicating that the text has not been understood without giving any suggestions is not constructive. For these reasons, in the next version currently under development, we aim at remedying these problems and allowing different kinds of feedback such as:

- coherence within the summary (so as to detect breaks in coherence);

- links between summary and source-text (so as to indicate the user sentences that might be off the point, or even those that can be reused in the summary).

This will then allow users to know on which points to work again in order to improve their summary or synthesis. The feedback would then improve both summary writing techniques (e.g., concentrating on inter-paragraph coherence), but also on the content (thanks to the emphasis on semantic links between source-texts and syntheses). Furthermore, in order to improve their appropriation of texts they have read, the learners will be able to highlight important sentences and take notes in the dedicated notepad. Finally, they will be able to keep a history of the different versions of their summaries and the associated notes and comments.

This article shows that it is possible to provide e-learning students with a tool that automatically assesses some semantic properties of their written production, and thus

their understanding. This tool, though imperfect yet, has been positively appreciated by three categories of potential users.

Note from the authors

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