A preliminary evaluation of the impact of using a visual tool in a compilers course

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Abstract

During the last academic year (2007-2008), theoretical lectures on the Compilers module were complemented with a visual tool to reinforce some of the more difficult concepts in the module. JFlap, a visual tool aimed at visualizing automata models which can also be used in a compiler course to trace, visualize and in-depth study the parsing methods taught in the course, was the tool of choice. This paper reports on the experience we carried out at the University of Alcalá where students were shown how to use JFlap, although its use was not compulsory. At the end of the term, a survey was conducted around students to discover its use while learning the subject and compared with their marks in the exam. The results show that students using JFlap frequently achieved better results than both students that do not use JFlap at all and those that make only sporadic use of it. Based on both qualitative and quantitative results, JFlap can be used as a help in a course like this, the user satisfaction using this kind of tools from an student's perspective being fairly positive.

Keywords. Compilers, computing education, survey, experimental study.

Introduction

Compilers is one of the compulsory subjects in the third year of the Computer Science degree at the University of Alcalá. It is composed of theoretical lectures (2 thirds of the time is dedicated to this) and laboratory work (one third of the time is spent in the lab). Per week, students have to attend to two classes of two hours of duration with a break of approximately 10 minutes in the middle, and one laboratory of two hours. The work in the laboratory is composed of 3 assignments to be completed during the term. We used JLex/JFlex [3] and CUP [1], the Java version of the popular Lex [4] and YACC [2]. While the first assignment is mainly related to grammars using only JLex, the second

one is about joining JLex and CUP with a very simple grammar. The last assignment usually extends the previous one with a more complex grammar. Last year around 100 students were enrolled in the course, divided into two groups.

During the academic year 2007/2008, theoretical lectures were complemented with a visual tools to reinforce some of the difficult concepts in the compilers module. Students were encouraged to learn the theoretical subject with the help of JFlap [5], a graphical software which was used as a demonstration tool during the lecturers. However, its use was not compulsory. At the end of the course, we surveyed the use of JFlap and compared the marks of those students who used it against the marks of those who did not.

Context, Subjects and Questionnaire

As stated previously, the compilers module is a compulsory subject composed of theoretical and practical classes. During a term lasting approximately 15 weeks, there are 2 classes of 2 hours of theory and one session in the laboratory per week. In the laboratory, students have to finish 3 assignments, using JLex and CUP. These assignments must be completed with some coursework at home. The syllabus is a standard first year compilers' course with some emphasis in the syntactic analysis from *LL*(1) to *LALR*(1). Although approximately 4 weeks are spent in this section of the module, a large number of errors were related to this part of the course (e.g., doubts in generating the *First* and *Following* sets, confusion with the different types of tables to use depending on the syntactical analysis, parsing of the inputs, etc.). As a result, lectures were complemented with JFlap to show students a tool able to help with lexical and syntactical analysis. Being the first year that the tool was introduced, it was not compulsory to use it for any assignment or practical work. Figure 1 represents a screenshoot of JFlap with the grammar, automaton, *First* and *Follow* sets and analysis tables. JFlap can also show how to step-by-step parse an input string that will be either accepted or rejected according to the grammar.

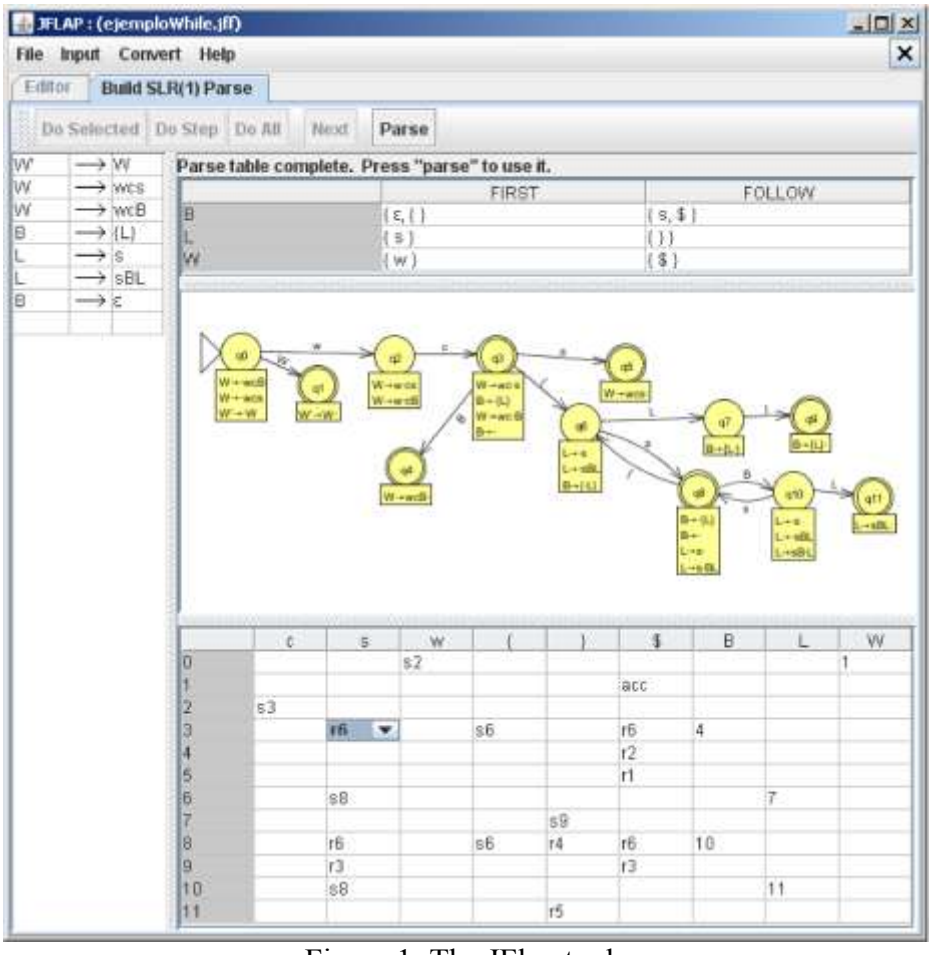

Figure 1: The JFlap tool.

At the end of the course, we surveyed its use between students to decide whether to adopt the use of such a tool more intensively next year. The survey was conducted using a questionnaire after the exam to gather the maximum number of responses. Out of 116 of students enrolled in the compilers module (in two different groups), 94 students took part in the survey. The questionnaire was not anonymous as wanted to correlate the use of the tool with the marks in the exam. Their final mark was, of course, not affected by their answers in the questionnaire. This was clearly explained to them at the beginning of the experience. There was no time limit to answer the questionnaire (shown in Appendix 2).

Hypothesis

Our initial hypothesis is that students using JFlap would understand better the subject in general, and the syntactical analysis in particular. Student's knowledge is measured by their marks in the exam. It is worth noting that although the final mark is composed of the mark of exam and the laboratory, in this study we only considered the mark in the exam as it is closer to the theoretical issues we want students to

master with the use of the tool. In the questionnaire, we also considered the number of exercises students did using the tool, *None*, *Sporadic* (between 1 and 3) and *frequent* (more than 4).

Therefore, we consider the null hypothesis (H_0) as there is no difference between the means for the different groups.

Results

We analysed the results taking into account the different groups depending on their use of JFlap (*None*, *Sporadic*, *Frequent*). Descriptive statistics (Table 1) show that different groups follow a normal distribution, existing some difference among the means but not statistical difference between the variance of the means (this was performed using the F-test two sample for variances).

Table 1: Descriptive Statistics for the Different Groups

Usage	#	*Avg*	*Var*	*Std.Dev*	*Min*	*Max*	*Rng*	*Std.Skw*	*Std. Kur*
None	56	6.14	4.22	2.05	1.21	9.47	8.26	-1.07	-0.47
Frequent	19	7.65	2.52	1.58	3.88	9.39	5.51	-1.80	0.354
Sporadic	19	6.08	3.53	1.87	3.67	9.64	5.97	0.96	-0.87
Total	94	6.43	4.05	2.01	1.21	9.64	8.43	-1.29	-1.07

Figures 2 and 3 show the scatter and box-and-whisker plots for the different groups.

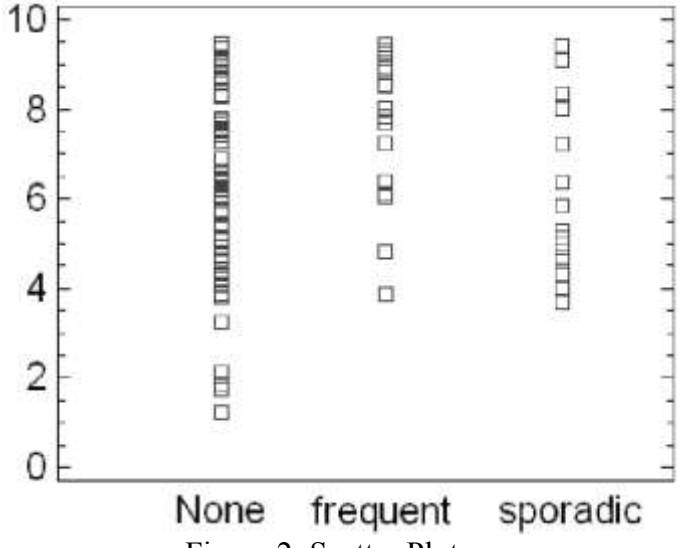

Figure 2: Scatter Plot

We considered the ANOVA (One-Way analysis of variance) to compare the means of the different groups to accept of reject the null hypothesis. As shown in Table 2 the ANOVA decomposes the variance of the marks into two components: a between-group component and a within-group component. The F-ratio, which in this case equals 4.73859, is a ratio of the between-group estimate to the within-group estimate. Since the P-value of the F-test is less than 0.05, there is a statistically significant difference between the mean mark from one level of use of JFlap to another at the 95.0% confidence level.

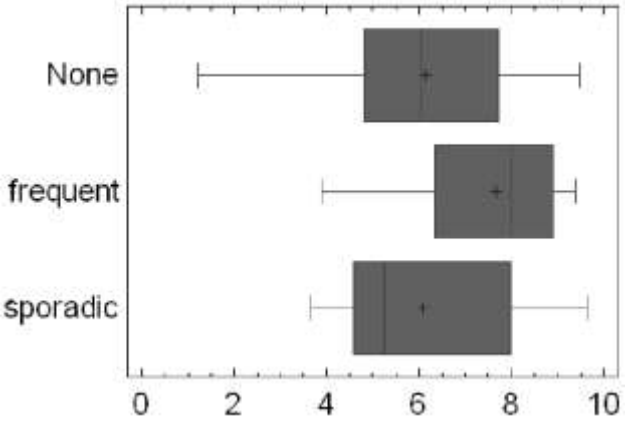

Figure 3: Box and Whisker Plot

Table 2: Analysis of Variance

Source	*SS*	*Df*	*Mean Sqr*	*F-Ratio*	*P-Value*
Between groups	35.57	2	17.78	4.74	0.01
Within groups	341.63	91	3.75		
Total (Corr.)	377.20	93			

To compare which means are significantly different from which others, a multiple comparison procedure was followed. This is represented in Table 3. The bottom half of the output shows the estimated difference between each pair of means. A diamond asterisk has been placed next to 2 pairs, indicating that these pairs show statistically significant differences at the 95.0confidence level. At the top of the figure, 2 homogeneous groups are identified using columns of X's. Within each column, the levels containing X's form a group of means within which there are no statistically significant differences. The method currently being used to discriminate among the means is Fisher's least significant difference procedure. With this method, there is a 5.0% risk of calling each pair of means significantly different when the actual difference equals 0.

Table 3: Multiple range tests for mark by use of JFlap

Usage	*Count*	*Mean*	*Groups*
None	56	6.14	A
Sporadic	19	6.08	A
Frequent	19	7.65	B
Contrast	Difference	+/- Limits	
None - Frequent	◊ -1.51	1.022	
None - Sporadic	0.058	1.02	
Frequent - Sporadic	◊ 1.57	1.24	

◊ denotes a statistically significant difference

Conclusions

Theoretical lectures in Compilers at the University of Alcala were complemented with JFlap, a visual tool targeted at reinforcing some of the difficult concepts in the module. We reported herein on an survey carried out during the last academic semester. During this period the use of JFlap was introduced to students, although its use was not compulsory. The main objective of this survey was to assess whether its use among students affected their performance comparing their marks in the final exam. The results show that students using JFlap achieved better results than students not using JFlap or using it sporadically, according to both qualitative and quantitative results.

As the main conclusion, it can be said that the use of JFlap is of help in a course like the one assessed. Student satisfaction is high at the same time, as it is reported in the free text comments section of the questionnaire, as the use of JFlap is linked to higher levels of confidence to facing final evaluation.

References

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2 Questionnaire about JFLAP — Survey

Name:

1. Have you used FLAP as a study tool for this subject?
   Yes □ No □
   If the answer to the above question is *yes*
   (a) According to the subjects studied during the course, JFLAP was used for
   Regular expressions: □ Grammars: □ Both: □
   (b) Estimate the number of exercises that you did using JFLAP
   1—3:□ **4—10**:□ **More than 10**: □
   (c) Taking into account the following scale
   1:"Not at all" **2**:"Low" **3**:"Average" **4**:"High" **5**:"Very High"
   Please, score to the following statements:
      i. JFLAP helped me to understand the creation of the *First* and *Following* sets:
      1: □ **2**:□ **3**:□ **4**:□ **5**:□
      ii. JFALP helped me to understand the differences between the ascendant and descendent analysis:
      1: □ **2**:□ **3**:□ **4**:□ **5**:□
      iii. JFLAP helped me to understand how to create analysis syntactic tables:
      1: □ **2**:□ **3**:□ **4**:□ **5**:□
      iv. JFLAP helped me to understand *conflicts*:
      1: □ **2**:□ **3**:□ **4**:□ **5**:□
      v. JFLAP helped me to understand how to generate *LR*(0):
      1: □ **2**:□ **3**:□ **4**:□ **5**:□
      vi. JFLAP helped me to understand how to analyse the inputs according to the different analysers:
      1: □ **2**:□ **3**:□ **4**:□ **5**:□
      vii. JFLAP helped me to understand how to construct syntactic trees
      1: □ **2**:□ **3**:□ **4**:□ **5**:□
   (d) JFLAP global evaluation. I consider the JFLAP tool quality as:
   1: □ **2**:□ **3**:□ **4**:□ **5**:□
   (e) I consider that lecturers of this module should use JFLAP in following year:
   1: □ **2**:□ **3**:□ **4**:□ **5**:□
   (f) Other comments: