ON THE USE OF ATTITUDINAL ACTIVITIES IN ECTS EXPERIENCES TO FOSTER STUDENT ENGAGEMENT IN THE COURSE: A CASE STUDY IN PROGRAMMING COURSES

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Abstract

We report the results obtained with the use of attitudinal activities in the context of an ECTS experience in sophomore programming courses in the last two years. These activities are intended to foster student engagement in the course and as such are evaluated according to the involvement of the student in them, rather than by pure performance indicators. The experience described here includes different types of activities, both individual and in group, which are shown to exert a positive influence in passing rates.

Keywords: Attitudinal Activities, Student Engagement, Programming, ECTS.

1 INTRODUCTION

Among the numerous criticisms that can be done to traditional teaching methodologies based on unidirectional lectures and a single final exam, one of the most salient ones is the difficulty of engaging the student into actively working on the subject at hand on a continuous basis. The use of additional grading activities during the semester can certainly help to this end. They do not constitute a panacea though, since mere performance tests are not necessarily motivating (and can actually discourage long term involvement on the subject if initial results do not fulfill the student's expectations). In this sense, the upcoming generalized implementation of the European Higher Education Area [1] (EHEA) is providing an excellent breeding ground for experimenting with other learning strategies oriented to foster active learning and student involvement.

One of the pillars of the EHEA is the adoption of the European Credit Transfer System (ECTS), a tool for collecting learning credits aimed to facilitate planning, delivery, evaluation, recognition and validation of qualifications [2]. ECTS credits are student-centric units that account not just the time the student spends in the classroom attending lectures, but also additional activities such as seminars, projects, etc. as well as self-study and evaluation. In this sense, the ECTS implies a change of paradigm with respect to more traditional teaching strategies gravitating around plenary lessons. The evaluation method should be consistent with this accounting strategy, taking into account the whole work carried out by the student during the semester. Continuous assessment practices adjust very well to this end.

During the last years Spanish universities have gradually attempted to adapt to the EHEA, both devising new degrees with adjusted curricula, and experimenting with teaching methodologies similar to those that will have to be implemented once the EHEA is fully functional. This work describes the experiences obtained in the application of an ECTS-based teaching model in two courses of computer science degrees in the Universidad de Málaga (UMA), in particular with regard to the use of attitudinal activities as a teaching strategy. We believe that these activities can play an important role in engaging the students into actively working on the subject, which ultimately plays a crucial role in achieving the learning goals of the course.

2 ACADEMIC CONTEXT

This work focuses on the experience obtained through the application of an ECTS methodology in two subjects taught in sophomore computer science (CS) courses in the UMA. These are Abstract Data Types (ADT) and Analysis and Design of Algorithms (ADA). These two subjects play a central role in the curriculum of the three CS degrees imparted in the UMA, namely a 5-year engineering degree and two 3-year technical engineering degrees. They actually constitute part of the backbone in

programming technology, and provide the means for putting at work the knowledge on basic programming and mathematical structures acquired during the first year.

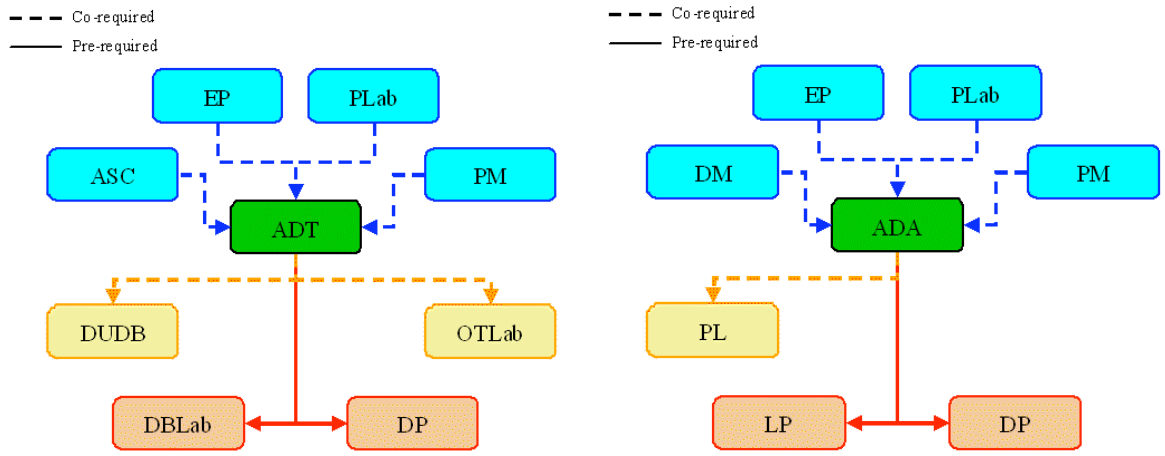

Fig. 1: Relationship of ADT (top) and ADA (bottom) with other courses in the CS degrees. Solid lines indicate pre-required courses (they must be successfully completed before enrolling in ADT or ADA), and dashed lines indicate co-required courses (previous completion or at least simultaneous enrolment is these courses is recommended). Course acronyms are: (1st year) **EP** = Elements of Programming, **PLab** = Programming Lab, **DM** = Discrete Mathematics, **PM** = Programming Methodology, **ASC** = Algebraic Structures of Computation; (2nd year) **DUDB** = Design and Utilization of Databases, **OTLab** = Object-Technology Lab; (3rd year) **PL** = Programming Languages; (4th year) **LP** = Language Processors; (optative) **DBLab** = Database Lab; (last year) **DP** = Degree Project.

As it can be seen in Fig. 1, these subjects assume the student is familiar not just with the essentials of programming but also with the basics of discrete mathematics and algebraic structures. These requirements respond to the contents of the syllabus of ADT and ADA. More precisely, ADT is a subject that focuses on the characterization and formal specification of abstract data types. The goal is having the students acquiring an adequate knowledge of the properties and specification of most usual ADTs (stack, queues, trees, etc.) as well as being capable of specifying new ADTs, either from scratch or by extending pre-existing ADTs. A formal approach to specification is done using Maude [3], an interpretable language for algebraic specification based on equational logic (hence the need for ASC). As to ADA, it focuses on the study of techniques for algorithmic design (e.g., divide and conquer, greedy techniques, dynamic programming, etc.), providing the students the means for reasoning about their applicability and suitability for specific problems, as well as for actually applying them. The student should be also capable of analyzing these algorithms in terms of their computational complexity in space and time, as well as ascertaining the intrinsic complexity of solving specific problems (hence the need for DM).

Both subjects have a workload of 6 LRU –*Ley de Reforma Universitaria*, the current legal framework for Spanish universities– credits (i.e., 60 classroom hours), and include theoretical, applied and lab components, hence requiring a combination of teaching methodologies including plenary lessons, problem-solving sessions, and hands-on computer sessions.

3 METHODOLOGY

The use of attitudinal activities advocated in this work falls within the context of an ongoing experience in the application of ECTS strategies in the UMA [4]. Thus, it is worth providing a little background on this experience, whose goal is providing a student-centric approach to teaching adapted to the ECTS framework in which the satisfactory completion of a subject amounts to successfully acquiring certain skills and competencies. This competence-based structure of subjects lends itself very well to a continuous assessment strategy. In this case, the continuous assessment is done by computing an accumulated grade from the outcome of numerous activities during the semester, namely five performance tests (both written and computer-based) focused on specific portions of the syllabus, each of them contributing 20% of the final qualification. The rationale behind these tests is obtaining successive snapshots of the learning achievements of the students, also introducing them into the

culture of continuous work. Indeed, there is a marked contrast with traditional approaches in which the assessment was done by a single final exam at the end of the semester. In this latter case it is much more easy for the student to forget about the subject during some parts of the semester, hence making his/her rentrée into the course –later in the semester, when the exam is perceived as a closer reality– more difficult. Obviously, this behaviour can be described as "myopic", lacking long-term foresight. Indeed, long term planning and self responsibility are valuable skills the students must develop, and the teacher must encourage. This said, it is unrealistic to assume these skills will emerge without reinforcement learning. Furthermore, a student that follows the course intermittently during his first year and ultimately fails to pass may learn a lesson about what he did wrong, but then his second year will be harder for him as he has to go again through the same material and lacks the stimulus of being exposed to new concepts and new activities.

Having several grading activities during the semester thus provides the student short term goal to be accomplished, and motivate him to work on the subject on a continuous basis. Of course the students must receive feedback on how well they performed on these activities (otherwise they might well stay in a state of delusion about their chances to pass the subject), so that they know what their current status is and have enough information to react. It is therefore essential to consider the effect that a non-positive result in some of the early tests may have on the student. Ideally, this should encourage the student to work harder and hint how to correct possible flaws in his approach to the subject. Then again, they may have a demotivating effect, just the least desired effect. It is precisely to correct this that we have introduced the usage of attitudinal activities as a complement to performance tests.

Attitudinal activities are intended to further stimulate the involvement of the student in the subject, as well as to promoting autonomous work (undoubtedly one of the pillars in our teaching strategy under the ECTS framework). These activities include:

- the public presentation of solutions to a list of problems specific to each course unit (this list actually includes those problems used as performance-tests in previous years). This presentation is done in specific sessions intended to work as a participative forum. The role of the teacher is kept to that of a conductor, overseeing the validity of solutions presented by the students, hinting potential issues in those solutions, stimulating discussion on alternative solutions to a certain problem or the adaptability of a solution to a slightly different version of the problem, and clarifying doubts. One of the objectives of these sessions is creating a bi-directional environment, in which participation is fluent and relaxed, and ideally more appropriate to engage students than traditional plenary sessions [5].

- the preparation of short papers stating the resolution to certain problems, posed weekly or biweekly via an e-learning platform, and typically involving computer experimentation. These problems are designed to appeal the students, avoiding purely academic formulations. For example, the students may be faced with finding an optimal schedule of pit stops for a Formula 1 car as an application of dynamic programming, or with a social network analysis as an application of some graphs algorithms. The goal is twofold: providing an attractive problem the students likes to tackle, and providing a proof of the real usefulness of the concepts taught in the course.

- a semester-long team-work, which in the last years has revolved around the edition of entries in the Spanish Wikipedia on the programming topics covered by the course syllabus [6]. This strategy was seminally proposed by M. Groom [7] in the context of environmental courses, who reported encouraging results in terms of student involvement on the subject. In our case, this activity has been approached within the context of the Spanish Wikipedia for several reasons:
    (1) Spanish sophomore students are in general not fluent enough in English to attempt a major revamping of an existing article in the English Wikipedia, let alone creating an article from scratch;
    (2) focusing on the Spanish Wikipedia boosts the legacy of the activity, resulting in a very valuable resource for future years' students who will be able to find updated information in Spanish on the topics treated in both ADT and ADA;
    (3) with some exceptions in which Spanish entries were non-existent, there was usually a base article (even if very incomplete) to start working with, so a straight translation of a non-Spanish article was not an option in general, thus requiring a more selective approach to detect missing information or relevant gaps in the Spanish article.

All these activities are attitudinal in the sense that they are evaluated not according to a performance scale, but to an involvement basis (a minimum quality standard must be obviously observed, but then again this base level corresponds to the minimal involvement expected from the student). The final grade is thus the sum of performance and attitudinal qualifications, the latter contributing up to an addition 20%. Notice that a minimum of 60% is needed to pass, and that the student can still achieve the maximal qualification (100%) even if they do not take part in any of these activities, i.e., there is a bonus for participating in them rather than a penalty for not doing so. This bonus is a short-term goal as perceived by the students, and one of the reasons they consider participating in them. Obviously, there is also an indirect benefit –which is highlighted to the students at the beginning of the semester– due to better preparation the student may have after having participated in these activities.

4 RESULTS

In order to analyze the impact of the strategies described before, we firstly take a look at the cross-distribution of grades in the last two years both in ADT and ADA. Fig.1 and Fig. 2 show these data. The higher density of points in the upper right quadrant indicates that the majority of students who obtain more than 50% of the attitudinal qualification also obtain an acceptable result in the performance tests and in the final grade. There is a very low density of points in the upper left quadrant, indicating that very few students were capable of passing the course without taking part in these activities. Finally, the relatively lower density of points in the left half vs. the right half indicates that a majority of students are engaged to take part in these activities.

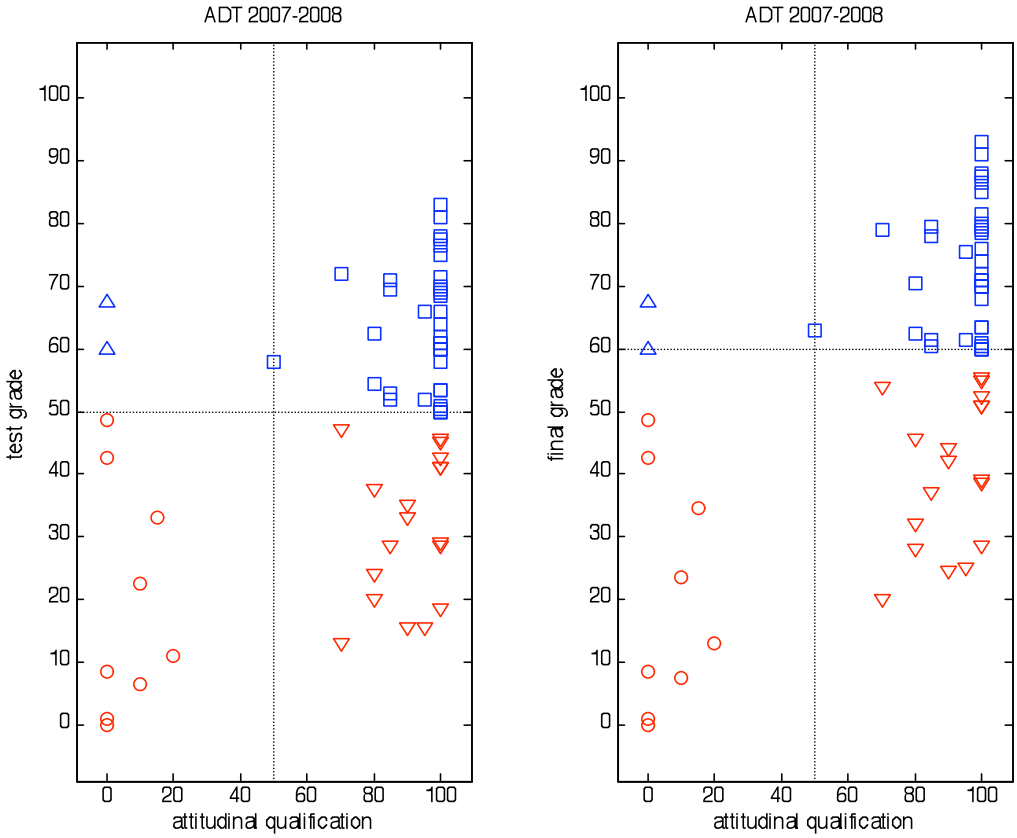

Fig. 2: Distribution of grades in ADT. The cross-distribution of attitudinal grades versus test grades is shown on the left. Blue squares indicate students that globally pass both the tests and the attitudinal activities, and red circles are students who fail both of them. Likewise, blue (resp. Red) triangles indicate students who pass on average performance tests (resp. attitudinal activities) but fail attitudinal activities (resp. performance tests). A similar plot on the right shows the cross-distribution of final grades and attitudinal qualifications. Note that in this case blue symbols indicate students who pass the subject.

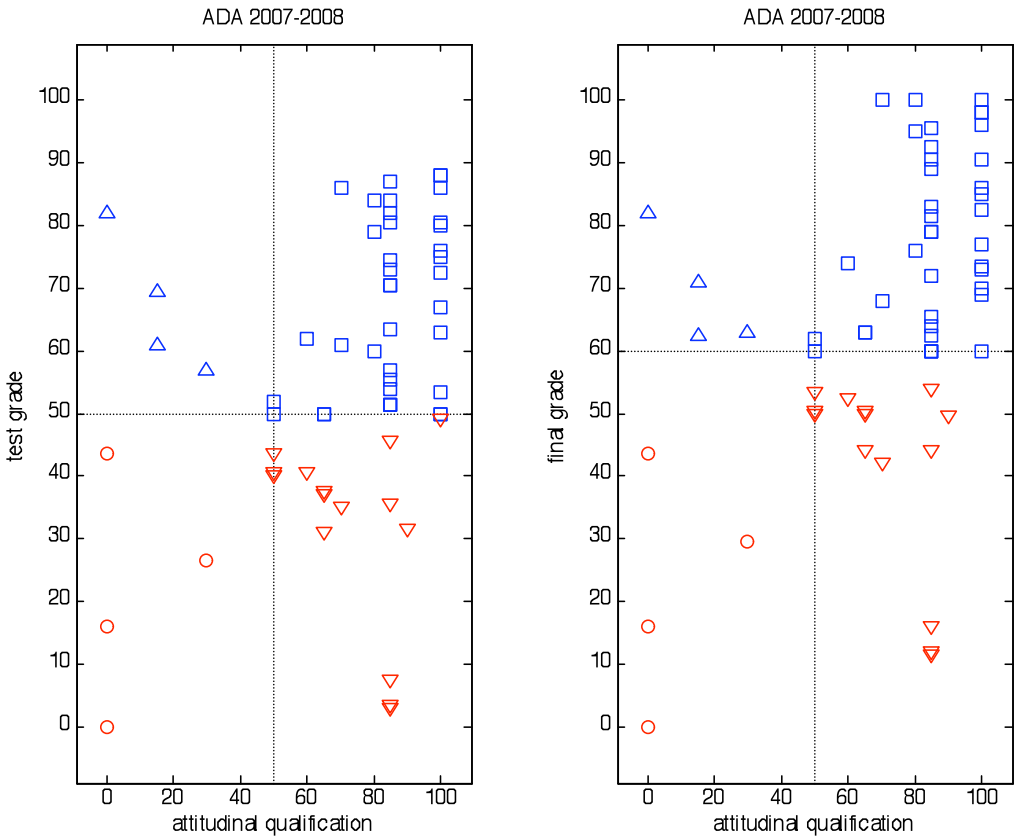

Fig. 2: Distribution of grades in ADA. The meaning of symbols is the same as in Fig. 1.

Looking closely at the numbers (i.e., check Table 1) we can see that students who complete attitudinal activities to a satisfactory degree mostly pass the course. The ratio is 2.16 : 1 in ADT and 2.79 : 1 in ADA, i.e., among those students who complete attitudinal activities, for each one who fails the course there are about 2.5 who pass it. Notice that the opposite is true among those students who do not complete these activities, with a global ratio around 1 : 2.17. As a remark, the global passing ratios are 1.46 : 1 and 2.39 : 1 in ADT and ADA respectively. The difference with respect to the subset of students who complete attitudinal activities is not is not large in the latter (although it is remarkable with respect to the subset of students not passing attitudinal activities), and marked in the former.

Table 1: Conditioned probability of passing/failing the course given that the attitudinal activities have been passed/failed in ADT (left) and ADA (right)

	ADT			ADA	
	pass attitudinal	fail attitudinal		pass attitudinal	fail attitudinal
pass course	68.4%	16.7%	pass course	73.6%	50.0%
fail course	31.6%	83.3%	fail course	26.4%	50.0%

A final question is whether the effect of including an attitudinal component in the final grade actually disturbs the purely academic results, providing a back door to pass the subject. This is disproved by Fig. 3 where the distribution of final grades as a function of test grades is shown. As it can be seen, the number of students not passing the performance test but finally passing the course is negligible, thus indicating that no reduction of the academic standards is attained.

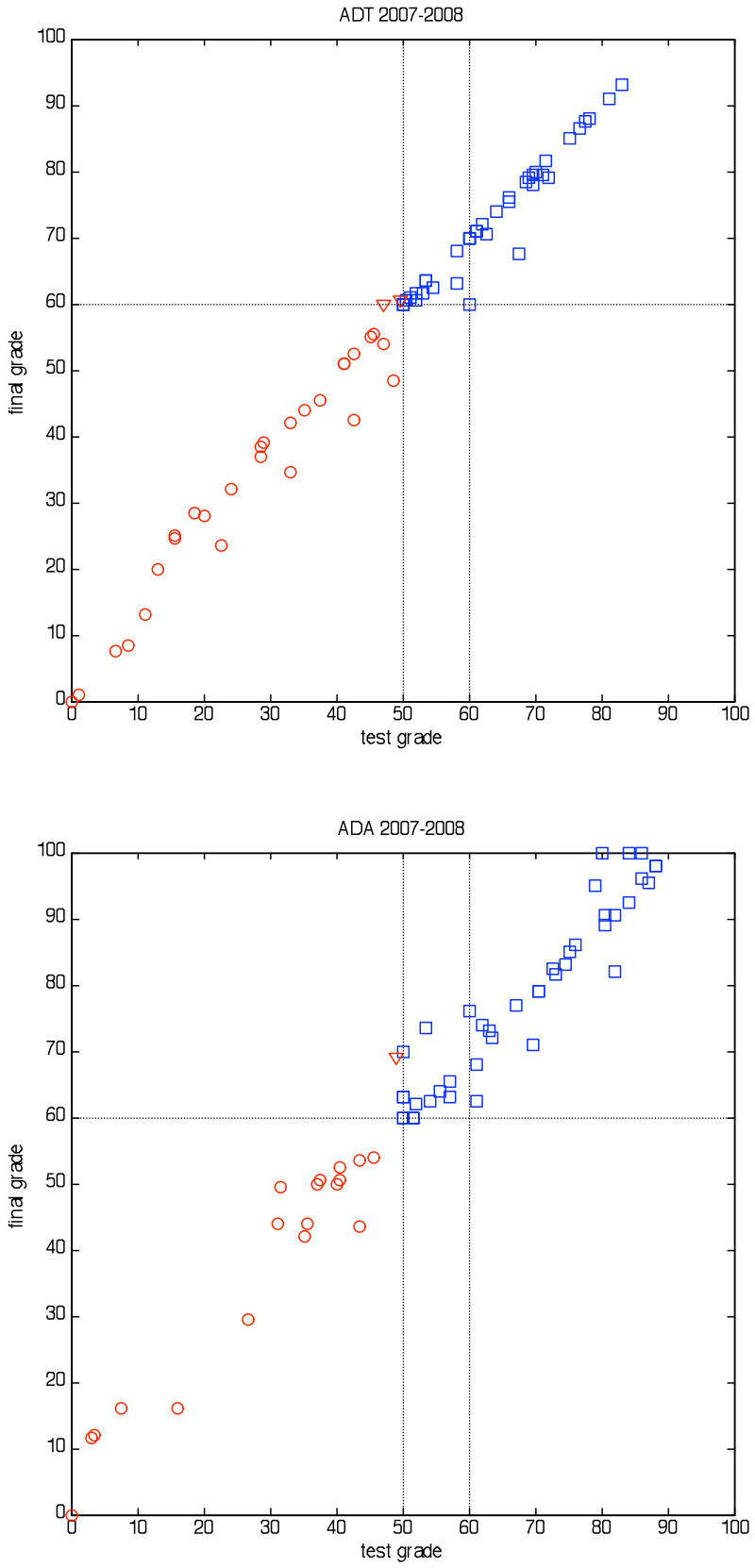

Fig. 3: Final grades in ADT (top) and ADA (bottom) as a function of test grades. Blue symbols indicate students who pass the performance tests. Red triangles are students who do not pass the latter but manage to pass the course.

5 CONCLUSIONS

We have presented an analysis of the impact that the inclusion of attitudinal activities in the teaching strategy of a sophomore programming course can have in the academic results. In general terms, we observe that the use of these activities does not have a negative effect in the objective performance of students who pass the courses (i.e., the quantifiable retribution the students receive for completing these does not help students with low performance to pass the subject, i.e., there is no backdoor for passing the course). On the other hand, these activities can have a positive effect in fostering student engagement in the course. In this sense, objective academic results indicate that successful participation in these activities correlates with above-average passing rates, particularly in the case of ADT (incidentally, a more self-contained –and possibly less appealing– subject than ADA). There are nevertheless other aspects that go beyond what is numerically quantifiable, such as the atmosphere in the lecture-room and the involvement of students in the subject. Even though the teacher's perception of these aspects does not tell the whole story, we can certainly state that according to the experience gathered in the last years, the use of these activities contribute to creating a much better learning environment or students.

6 ACKNOWLEDGEMENTS

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