Debt Environment in Computer Science Education

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ABSTRACT

Courses in computer science are often designed with a consideration of interesting topics and materials as well as with a significant amount of individual work. In order to encourage studies on complex exercises and projects, the aspects of competition and collaboration can be applied. Students are often motivated at the beginning of the course, but unfortunately their interest decreases as the semester continues. In this paper we suggest a debt environment approach that keeps students in a continuous pace to meet deadlines, which effectively distributes motivation throughout the course. A study implementing the approach with other methodological aspects is provided in a bachelor computer science course. Students work in teams and also as individuals and compete for their final grade. Applied methodological aspects are discussed regards to students' course evaluation. Evaluation of students' feedback shows positive effect of the approach regards students' motivation. As indicated in the feedback, our approach is significantly more motivating factor for students than competition. The approach can be applied as a complement to competitive and collaborative techniques to improve students' motivation.

Keywords: Competitive learning, Collaborative learning, Pace environment, Computer Science Education, Debt environment.

1. INTRODUCTION

Computer science experienced fast evolution in the last two decades. Many of it's disciplines are relatively young and with a close relation to mathematics. The difference is that the knowledge, which students gained 5 years ago, may not seem sufficient enough nowadays. Education in computer science should prepare experts in the field. They should learn to compete with each other in order to maintain and evolve their knowledge. The industry seeks for experts who, in addition to good technical knowledge, have the capability to build a team and compete with others. In addition, they need to manage pace environment, meet deadlines, handle stress, and use their time effectively.

This paper aims to improve education for computer scientists and prepare them in order to be become experts in their field. Debt environment approach is presented as a complement to competition and collaboration. Students experience the need to meet deadlines and effectively use their time to avoid short-time debt, which may result in lower final grade or failure from the class. A case study employing such environment is provided in this paper. Evaluation of the study is concluded from students' feedback. It is evident that students feel positive impact of the environment on their motivation.

This paper is organized as follows. Section Related Work describes related research, such as competitive and collaborative learning, programming Olympiads and research in the area. Proposed environment is described in section Debt environment. Case Study section employs the debt environment in our course. The Study Evaluation discusses the students' evaluation of the course. The last section concludes the paper.

2. RELATED WORK

Several researchers address improvements to education process. They focus mostly on students' interaction, competition, collaboration and teamwork, students' motivation and technological support. Their results and achievements are significant, but with the exception that the adoption of their results differs among various regions. For example, it is common for North American education system to have a strong competition among the students [7]. On the other hand in Central Europe the education focuses primarily on knowledge (content-driven) and on students as individuals [3].

The way students interact with others and with the materials can be seen as communication patterns [7]. Teacher-student interaction is commonly used in courses but student-student interaction is often ignored. In fact, there are 3 patterns of student-student interaction: competition, individual work and cooperation. Competition [4] is a social process that takes place when rewards are given to people on the basis of their performances when compared to the performances of others doing the same task or participating in the same event. Competition interaction pattern can be seen as the key factor among student-student interaction [7], although under certain circumstances collaboration might be seen more productive. In fact, competition is often applied together with collaboration where student teams compete with each other [2]. The benefit that competition gives is seen in increased motivation in order to do better than others, self-confidence, larger workloads for

students, or simply a good preparation for future employment. This technique increases motivation for some, but not necessarily for others [13]. Motivation often relates to winners rather than losers [12]. That could on the other hand affect the results among the peers.

Collaboration [4] is a social process through which performance is evaluated and rewarded in terms of the collective achievements of a group of people working together to reach a particular goal. Davis [5] states in his research that students who collaborate in a group seem to be more satisfied with their course as they feel more involved in their educational process. He suggests also that team collaboration should assign a role to each member. Cooperation with a large group may result in an inadequate separation of the assignments or imbalance in the workload among different members [13]. It is important that team members cooperate well, because it impacts the whole group. In order to indentify problems in cooperation, dysfunctional index (DFI) method can be used. This index is defined as the mean test score of the team divided by the standard deviation of team members' test scores [6]. A team with a small DFI is likely to be dysfunctional. This allows the teacher to identify such a team and locate the issue. Another way to avoid dysfunction [13] suggests that the teacher assign groups based on students' availability to meet outside the class schedule. On the other hand Oakley et al. [11] see self-selection of members more effective as it does not cause interpersonal conflicts. Different approach to mitigate dysfunction of the cooperation is to build small teams. A small team has positive impact on individual accountability [7]. To encourage cooperation the teacher should reward students for the participation in a team [10]. Recognition for both to the individual member and to the whole team should be evident [2]. Team cooperation in a competitive business-like environment prepares students for professional employment [2]. "The team cooperation encourage each other to do the assigned work, and learn to work together regardless of ethnic backgrounds or whether they are male or female, bright or struggling, disabled or not" [7]. Collaborative learning suits well for problem solving and solving techniques [9], which for example is computer science.

Both competition and collaboration techniques were successfully applied in the senior secondary school in the field of mathematics that was situated in Nigeria [8]. The results present the strategy of cooperative learning as more effective than competitive strategy. Furthermore, male students performed significantly better than female students in both learning strategies. Both techniques were also applied in bachelor class and the results were compared with the standard education [3]. From the research [3] students saw both competition and cooperation beneficial through motivation, concentration or increased attendance in voluntary lectures. Application of the techniques also supported active participation of students in the education process.

The motivation for students is brought by competition as well as by collaboration. As next, additional factors to increase motivation should be applied. Students should always be rewarded for their good work. Furthermore, they should feel that they contribute to the education process, so that they can share their knowledge with the entire class, influence the topics, discussion or peer review others. In addition, motivation grows in pace environments.

Another area besides educational institutions emerged impacting students' skills and capabilities. This area focuses on competitions among schools. In these competitions the students compete with each other or within groups and in the end, the best results are rewarded. In the area of computer science, multiple countries organize Programming Olympiads [1], [15], [16]. Among them, the most known is the ACM International Collegiate Programming Contest (ICPC) [14]. In these competitions, students build teams and compete with other teams when solving small algorithmic problems. The team that solves the most problems within the shortest possible time is the winner. These competitions are very popular among the students. For example in ICPC, tens of thousands of students from around 2000 universities compete each year. In fact, these contests employ multiple techniques such as competition, collaboration, pace environment or problem solving. Student attendance in such contests shows that the techniques applied are successful and should be employed in educational system due to the fact that the students often invest their personal time to train and prepare for the competition to do better than others. In addition, students learn to solve programming problems on their own as part of a game, although their primary focus is not the education, but preparation for the competition.

3. DEBT ENVIRONMENT

In the previous section we introduced competition and collaboration techniques. These techniques work greatly for programming competitions and in education bring forward multiple benefits. There are additional factors that may influence the success of these techniques such as well-selected materials, topics, examples and assignments. Another influence is the size of the class. It is easy to motivate a small class, but hard to motivate a large class. In addition, we can often experience that students' motivation decreases over time, mostly for large classes [13]. For example, students are greatly motivated the first month, but then they fall into a stereotype. Students who win competitions often keep up with motivation compared to the ones who are not doing well. As a result a certain subset of students loose their motivation and focus. Later in the course these students fail to deliver homework assignments and slow down the tempo of the rest. At the end of the course some of the students try to bring delayed work.

In order to address the above issues we present a debt environment that distributes motivation throughout the semester, motivates students to submit their assignments on time and introduces fair reduction of the grade for students who do not deliver their work on time. This environment complements competitive and collaborative approaches and is suits well for large classes.

The debt environment puts students or student groups into a role of profitable organization. This kind of an organization starts with no resources. Organization can gain capital by delivering assignments on time, passing the test, quizzes or submitting a project. The whole amount of the capital will be saved in a bank that holds the monopole and charges a large amount of capital for its services each month. The goal of every organization is to stay in positive balance and gain as much capital as necessary to survive the bank monthly charges. If an organization fails to pay charges, a loan is provided. A dept is placed on the organization, so that the loan doubles the forthcoming month. If the monthly loan is not covered the organization bankrupts.

Table 1. Imaginary dollars reward per assignment

Task ID	Task	iDollars per task	iDollars total	Applies to
a	Presentation of a SW design pattern	10	10	Team
b	Article on the SW design pattern	10	10	Team
c	Architectural programs	4x3	12	Team
d	Architectural program documentation	5	5	Team
e	A project applying SW patterns	10	10	Team
f	SW Challenges (first solved wins)	7x3	21	Team
g	Research paper discussion	5x1	5	Individual
h	Tests/Exams	2x20	40	Individual

The environment is complementing collaboration, as the organization can be a group of students. It also complements competition as the organization with the highest balance may gain the best grade. Each student (or a group) must properly manage his/her time and plan to deliver enough work in order to avoid debt. This also gives a student the benefit to make up poorly graded test or to plan his/her workload throughout the semester.

4. CASE STUDY

In order to evaluate our approach, we provide a study that employs competition, collaboration and other motivational techniques with debt environment. It is applied in a 6th semester eligible course of a bachelor degree. There were enrolled 36 students in the course and out of all 32 passed the class. Course syllabus is designed in a way that the students work both individually and within a team. They solve tasks, assignments, projects and tests, which rewards them imaginary dollars (iDollars) instead of points. The final grading supports competition, the final grade is based on the total amount of iDollars in comparison with other students. Furthermore, each student has to earn at least 15 iDollars each month throughout the semester in order to cover bank service charges; this amount is deduced from his/her account. At the beginning of the semester students are given tasks that they can submit throughout the semester based on their strategy. Course tasks are described in Table 1. The only dates that are fixed are Tests (h), which take place in the middle and at the end of the course. Small programming challenges (f) applying current topics are sent once in two weeks and the first correct solution is rewarded with 3 iDollars, second with 2 and the third with 1. Discussion on research paper (g) follows every other week. Other tasks (a-e) can be submitted at any time during the semester.

In this study teamwork supports both collaboration and competition. Teams consist only of two members, which apply a team student-to-student interaction. Teams compete with each other in order to reach the highest amount of iDollars and to solve the most of the SW challenges (f), these are similar to the problems assigned in ICPC contests. Furthermore, it is up to a team to split or cooperate on tasks (a-f), to divide the load.

Students take part of the education process as they present a design pattern (a) to the entire class and the others can influence their iDollars reward by direct feedback. This presentation broadens to student-to-many-student interaction with the feedback. Teams also learn to write a research article about the topic presented in the class (b) or to apply it in their project (e). A proceeding of submitted research papers (b) is published after the class that gives the students both reference and the first experience with publishing. The coursework contains a demonstration of architectural decisions with documentation (c-d), where teacher-student interaction plays the primary role. Individual student approach is applied to the tests and discussions of the research paper.

5. STUDY EVALUATION

After our study was applied and the grades distributed, we received students' feedback on given techniques and tasks. Students who passed the course, and received a grade (Figure 1), filled out a questionnaire, asking about their feelings toward specific techniques applied in the course, and particular tasks. Students could answer if a particular technique was useful, motivating for them or whether they liked a given task. Answers were in form of options and in form of short survey. Survey options were: "Certainly yes, rather yes, do not know, rather no, certainly no".

Figure 2 to Figure 6 show the response from the students on given aspects of the class. Graphs provide the amount of students divided by answer and grouped by the final grade. From responses can be seen that students rather like competition for the final grade, although they did not think that competition would increase their motivation level. Few students felt motivated by competition mostly because they were winners of SW challenges. Collaboration within a team was very well accepted, some students pointed out that it is better when the team is small rather than large, based on their experience from other classes. On the other hand, two students did not like team collaboration; the reason was an irresponsible team member. Students compared two motivation factors (Figure 5 and Figure 6). They felt that the monthly charge and the possible debt motivated them to work more intensely throughout the semester rather than the competition. Not all students liked debt environment; these were the students who experienced a loan. Students accepted well the imaginary dollars in comparison to regular points. In comparison with the results of the competition and collaboration, the collaboration was better accepted.

Particular tasks (a-h) from Table 1 are evaluated in Figure 7 to Figure 12. All tasks were well accepted. The most accepted was the contribution to student proceedings on SW design patterns. It could be understood that the students like to work on things that have a long-time value rather than shortly lived. There is almost no difference between a student attendance at practices and optional lectures, as shown in Figure 13 and Figure 14.

It can be seen from the attendance that there is no significant impact on the final grade. What is the difference in motivation and task evaluation among students with different grades? Better-graded students like competition, and some of the best students also felt motivated by the competition. Better-graded students also like the imaginary dollars more than the others. Regards the tasks; worse-graded students seemed to like SW projects. Better-graded students like to influence the education
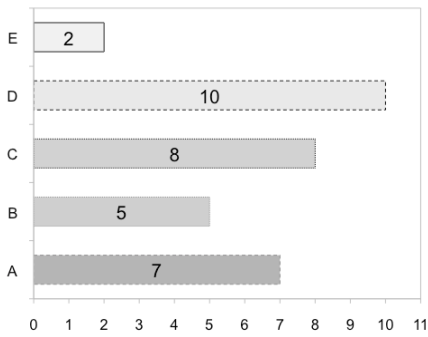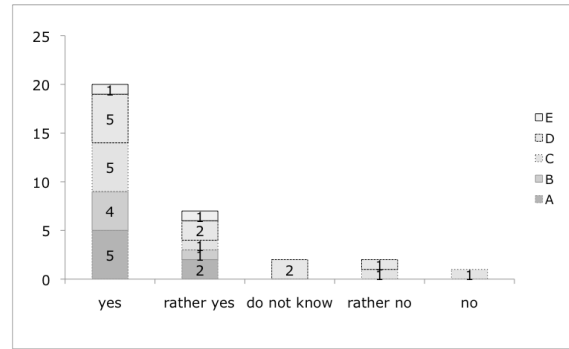
Figure 1. Final grades distributed in the course

Figure 5. Did debt and monthly charges increase your motivation throughout the semester?
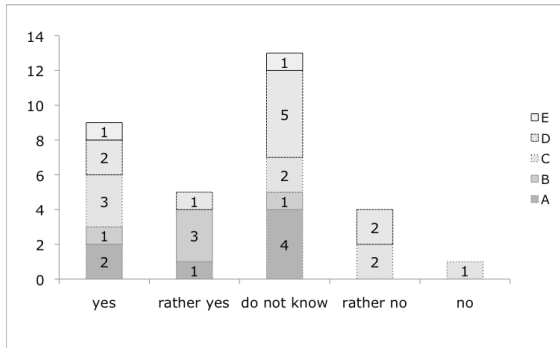

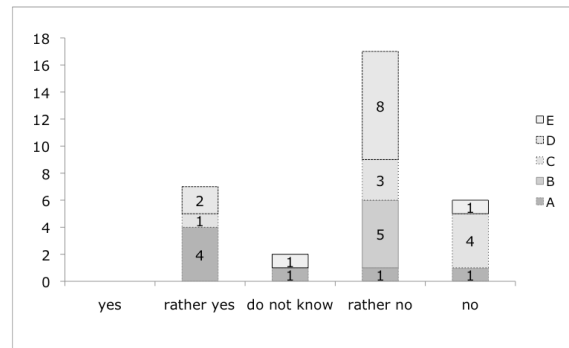**Figure 2. Do you think that iDollars are better than points?**

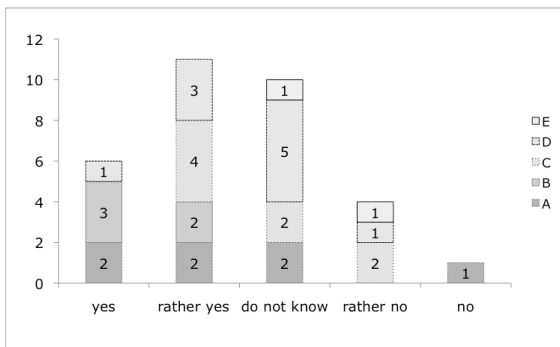**Figure 6. Did competition increase your motivation throughout the semester?**

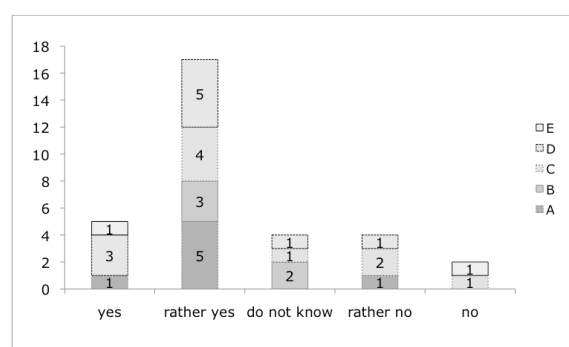**Figure 3. Did you like competition for the final grade?**

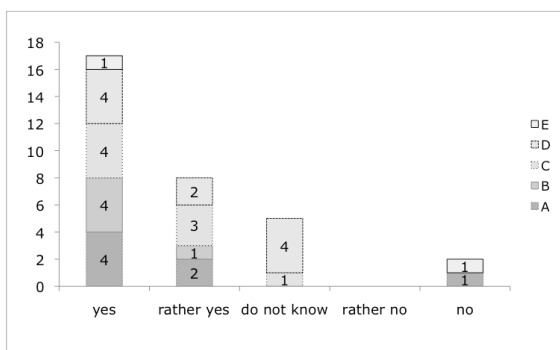**Figure 7. Did you like the option to influence education? (a)**
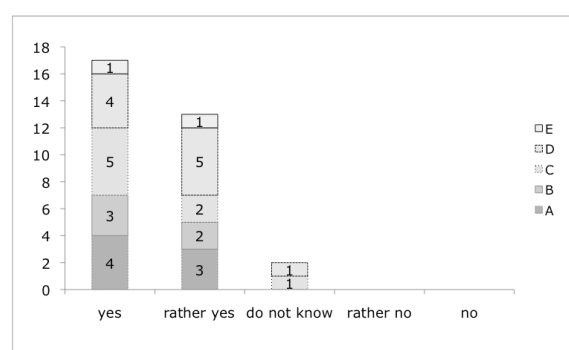

Figure 4. Did you like team collaboration?

Figure 8. Did you like to contribute to student proceedings? (b)
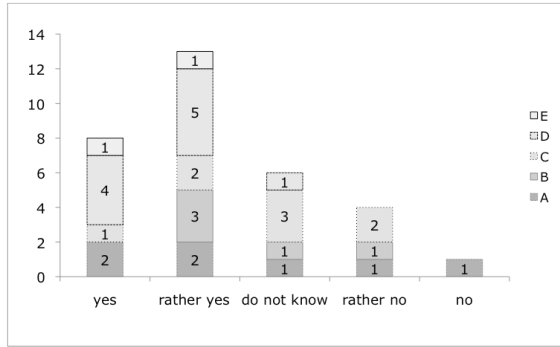
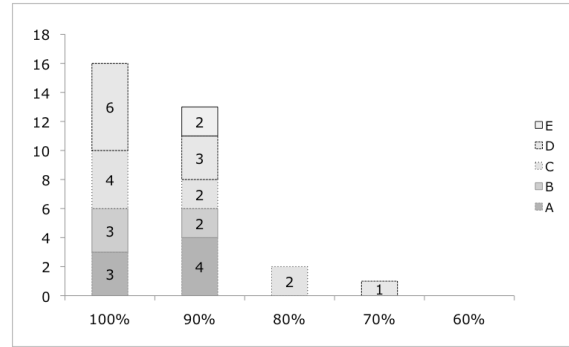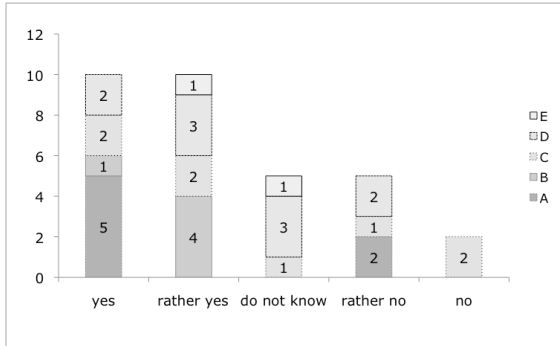**Figure 9. Did you like team SW projects? (c,d,e)**

Figure 10. Did you like small SW challenge competition? (f)

Figure 11. Did you like to read research papers? (g)

Figure 12. Did you like tests? (h)

Figure 13. Participation at practices

Figure 14. Participation at lectures
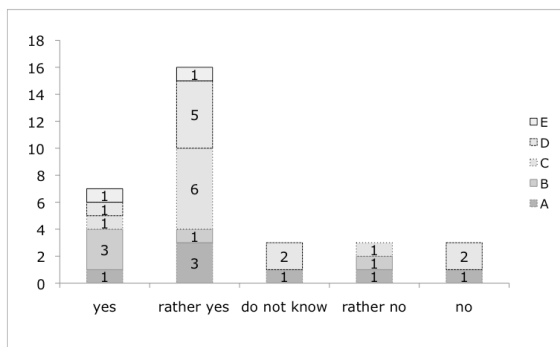
and contribute with a presentation; they also like research papers and SW challenges. Interesting is the feedback on tests, these are often not liked by students, but we must assume that a test in our environment is not understood as a verification of student knowledge, but as an opportunity to receive additional iDollars, which seems to be taken positively by students.

6. CONCLUSION

This paper suggests a new method to increase motivation for students throughout the semester. It can complement competitive and collaborative learning and other approaches. The method suggests the use of imaginary dollars instead of points. These dollars are deposited in a bank that monthly deduces service charges. It pushes students to deliver work in fixed time frames in order to prevent low-balance and possible debt causing increased bank charges the forthcoming month. The method was applied in a 6th semester course in a bachelor program. The results from the students' feedback show that this method motivates students more than competition. In our results competition seemed to be motivating small amount of students.

Our future work will focus on the comparison of other motivational techniques with debt environment. As next, we may reduce the time interval between bank charges. The method should also be applied in different disciplines in order to receive its impact on different fields. It is possible that the method may not be successful for some disciplines, other cultures and on different goals. From our results, we believe that the method fits well to the area of problem solving, which applies to computer science.

7. REFERENCES

[1] R. O. Anido, & R. M. Menderico, Brazilian Olympiad in Informatics. **Olympiads in Informatics**, Vol. 1, 2007. pp. 5-14.

[2] S. Attle, & B. Baker, Cooperative Learning in a Competitive Environment: Classroom, **International Journal of Teaching and Learning in Higher Education Applications**, Vol. 19, num 1, 2007, pp. 77-83

[3] T. Cerny, & B. Mannova, Competitive and Collaborative Approach Towards a More Effective Education in Computer Science, **Contemporary Education Technology**, Vol. 2, 2011, pp. 163-173.

[4] J. J. Coakley, **Sport in society: Issues and controversies** 6th ed., Irwin/McGraw-Hill, 1997.

[5] B. G. Davis, **Tools for Teaching**, San Francisco, Jossey-Bass, 1993.
http://teaching.berkeley.edu/bgd/collaborative.html

[6] C. M. Hsiung, Identification of dysfunctional cooperative learning teams based on students' academic achievement, **Journal of Engineering Education**, Vol. 89, 2010, pp. 45-53.

[7] D.W. Johnson, & R.T. Johnson, An Overview of Cooperative Learning. In: THOUSAND, J., VILLA, A., & NEVIN, A. (Eds) **Creativity and Collaborative Learning : A Practical Guide to Empowering Students and Teachers**, 1994, pp. 31-43, Baltimore, MD: Paul H. Brookes Publishing Co.

[8] E. B. Kolawole, Effects of competitive and cooperative learning strategies on academic Performance of Nigerian students in mathematics, **Educational Research and Review**, Vol. 3 (1), 2008, pp. 33-37.

[9] L. K. Michaelson, B. K. Arletta, & L. D. Fink (Eds.) **Team-based learning: A transformative use of small groups in college teaching**, Stylus publishing, 2004.

[10] B. Morgan, Cooperative learning in higher education: Undergraduate student reflections on group examinations for group grades, **College Student Journal**, 37(1), 2003, pp. 40-50.

[11] B.A. Oakley, D. M. Hanna, A. Kuzmyn, & R.M. Felder, Best Practices Involving Teamwork in the Classroom: Results From a Survey of 6435 Engineering Student Respondents, **IEEE Transactions on Education**, Vol. 50 (3), 2007, pp. 266-272.

[12] M. Vansteenkiste, & E. L. Deci, Competitively contingent rewards and intrinsic motivation: Can losers remain motivated?, **Motivation and Emotion**, Vol. 27, num 4, 2003, pp. 273-299.

[13] E. Verdu, & R.M. Lorenzo, Effective strategies for learning collaboration and competition, **A New Learning Paradigm: Competition Supported by Technology**, 2010, pp. 11-40.

[14] ACM International Collegiate Programming Contest Competition for computer scientists, 2011, http://cm.baylor.edu/

[15] Indian Computing Olympiad, 2011, http://www.iarcs.org.in/inoi

[16] The British Informatics Olympiad, 2011, http://www.olympiad.org.uk