The Role of Competitions in Education

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Abstract

I give an historic overview of education, competition, and competition within education, with an emphasis on computing science education. It appears that large-scale formalized competitions are a relatively recent phenomenon in the long history of education. I argue that in the future the role of competitions should be expanded, but that this requires more effort from all branches of society.

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1 Introduction

Education and competition are two universal ingredients of all human cultures, in fact, of almost all animal life. Humans have always considered education and competition important issues, both in the past and in the present. Of course, there have been fluctuations in emphasis and much has changed throughout the centuries.

In this paper, I investigate the role of competitions in education, especially in modern education. I begin with a brief, historically inclined, overview of education and competition separately. Then I trace some developments in the role of competitions within education, in particular computing science education. I conclude with some recommendations.

2 Education

All life forms somehow possess knowledge and skills for survival and propagation. Such knowledge and skills are transmitted from generation to generation in various ways. On one hand, there is the direct path via inheritance. Properly

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expressed genes provide the offspring that carries them with built-in knowledge and skills, sometimes referred to as instincts and reflexes. On the other hand, there is the indirect path via education, where education is meant in a broad sense. The offspring learns by observing and imitating mature members of the species. The knowledge and skills transmitted by education are collectively known as the culture of a species.

For most species, inheritance is the dominant mode of transmission. The human species, however, relies very much on education, because for certain types of knowledge and skills, humans inherit only the ability to learn them. For example, the ability to learn language is inherited, but subsequent development of this ability through education is needed to learn any particular language. It is often not clear whether something, such as for example a desire to compete, is inherited or acquired (resulting in the nature-nurture controversies).

To summarize, a child is born without culture, and education can be viewed as the process of transmitting culture. Cultural knowledge and skills concern all aspects of human life. Long ago the list began to include such items as hunting, fighting, caring, healing, worshiping, farming, building, governing, judging, accounting, pleasing, competing, and educating.

The presence of education in human cultures can be inferred from the oldest historical records, dating back to about 3000 BC. These records indicate that education was at that time already formalized to some extent. That is, our early predecessors were aware of the educational process, which itself was a part of their culture, and certain members were specialized in dealing with educational matters. The knowledge and skills of formal teaching are, thus, in turn transmitted culturally. We do not know when education first appeared in this formalized way, but it is generally assumed that it is much older than the first references that have been preserved.

Formal education in more complex societies gave rise to teachers, schools, and out-of-context learning in classes, because this specialization allows a more efficient transmission of culture. Over the centuries entire school systems have been developed with their own educational philosophies. Today, the partition into primary, secondary, and optional tertiary (university or vocational) education is predominant, and the educational duties of schools are clearly prescribed by law. Note, however, that informal education, such as happens within the family, still plays an important role. Oscar Wilde once said: “Education is an admirable thing, but it is well to remember from time to time that nothing that is worth knowing can be taught.”

As the demands on a society change, its culture changes, and consequently also its educational practices must change. Though difficult to understand in detail, this process of change appears to be a never-ending, self-propelling cycle. In order for a system with feedback to be stable, the response to change must be delayed. Education, therefore, always seems too late in its adjustment. Currently, the knowledge and skills to survive in what has become known as the information society are being incorporated.

3 Competition

The roots of education lie hidden in an unknown past; those of competition are even less traceable. Children spontaneously seek competition with their peers.

They seem to have an innate desire to compare themselves with others in every way, for example, by running and wrestling. Such play is obviously beneficial to a child's development. From play it is a small step to physical and intellectual contests, generally known as sports, which adults indulge in for their own sake.

Just as with education, also some forms of competition became formalized long ago in human history. That is, competition is bound by rules and becomes organized by specialists. However, early historical records are much less explicit about this than in the case of education. At first, formal competition was restricted to sports. The role of formal competition in other areas is a much more recent phenomenon. Again, it should be noted that informal competition still plays an important role as well.

Large-scale sporting events involving athletics or ball games took place perhaps as early as 2000 BC. From the earliest records of champions it is known that the Greeks have held their Olympic Games at least since 776 BC. However, it is believed that by that time, games had been organized in Greece for already over 500 years. The Olympic Games were the most famous of four classical Greek sporting events organized regularly as part of religious festivals. In conjunction with these games there were often also music competitions. At first only token prizes could be won (a wreath or garland), but eventually substantial prizes were awarded at a luxurious closing ceremony. That the Olympic Games played an important role in Greek life is evidenced by the fact that the Greek unit of time was the *Olympiad*, the period of four years between two issues of the Olympic Games. The classical Olympic Games were put to an end by the ruling Romans in AD 393.

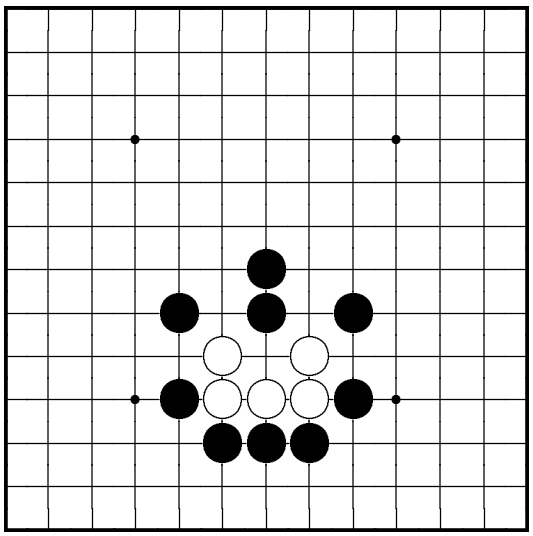

Figure 1: Ancient go problem on a 13×13-board: Can White escape?

Some sources trace the origins of the oriental board game go (Weiqi in Chinese) back to ancient China before 2300 BC. Not everyone trusts these sources, but go is generally agreed to be older than 3000 years. It has a rich history tightly tied into oriental culture. Go is a competition game par excellence. The rules are

simple, yet there exist virtually infinitely many play styles, and great strategic and tactical skills are required to play well. In spite of its abstract nature, go is deemed to help develop skills that are useful in concrete life. It has been studied intensely by Japanese generals and businessmen alike. Opponents of unequal strength can play a game of go that is challenging to both parties through a system of handicapping. From very early on there have been professional go teachers. An interesting sideline is that, in contrast to chess and in spite of serious efforts, no computer programs today play go well, even not at amateur level.

From the 11th century AD in France, and later throughout western Europe, military exercises evolved into contests, known as tournaments. These started out as mock battles where knights practiced their abilities and showed their courage. Although initially rough on the participants and with little rewards, tournaments became more civilized events with strict rules, weaponry that was rendered harmless, and prizes presented to the victors. The word tournament is nowadays also used as a general term for a certain way of organizing sports competitions.

From sports, arts, and the military, the concept of competitions eventually spread to the scientific world. In the 18th century, academies were the major scientific institutions, later to be succeeded by universities. Leading scientists such as Huygens, Newton, and Euler pursued academic careers in Paris, London, Berlin, and St. Petersburg. Besides meetings and publications, the academies organized successful prize competitions to encourage the solution of important mathematical and scientific problems. Mathematicians like Daniel Bernoulli, d'Alembert, and Lagrange have won several of these prizes.

4 Competition in Education

It is not surprising that education and competition are intimately related. On one hand, it is natural for children to compete and, therefore, understandable that competition is put to educational use. On the other hand, competition may be found so important in adult life, that a society especially educates their young to compete. For instance, in Sparta, the most prosperous Greek city in the 8th and 7th centuries BC, physical education was dominated by contests, in particular the Olympic Games, where Spartans often won more than half of the top honors.

Marcus Verrius Flaccus, a Roman teacher famous in the late 1st century BC, is credited to have introduced the principle of competition among his students as a pedagogical aid. He awarded attractive books as prizes. The Italian scholar Battista Guarino (1434–1513) writes in his account of proper educational techniques, *De ordine docendi et studendi*, that teachers should refrain from physically punishing pupils, and that students are stimulated best by competition, which can be intensified by pairing them off.

Pierre de Coubertin, a French baron who also had great interest in literature, education, and sociology, struggled for seven years to revive the Olympic Games. The first of these modern Olympics were held in Athens, Greece, in 1896. While Olympic preparations were in progress and most likely inspired by these efforts, Eötvös University in Budapest, Hungary, organized the first national mathematics contest ever in 1894. From there the idea of science contests

for students spread through central Europe. William Lowell Putnam started a mathematics competition for North-American college students in 1938. These national and regional contests eventually gave rise to the International Mathematics Olympiad (IMO), which was first hosted by Romania in 1959. Other disciplines subsequently established their own international olympiads: physics in 1967, chemistry in 1969, informatics in 1989, biology in 1990, and astronomy in 1996.

Education theorists do not agree on whether competitive desires should be encouraged or constrained. One theory claims that, since competition is part of every culture and since education should transmit culture, it is necessary to incorporate competition into education to help children get used to it in later life. Another theory views competition as opposed to collaboration and, therefore, as an evil element in culture that should be curtailed. At school this often results in an ambiguous attitude towards competition, which confuses students, who will then try to compete successfully without making it appear they compete.

It may help to distinguish two views of competition. In one view, all other competitors are perceived as the focus of competition; they need to be defeated. In the second view, the focus is oneself or some external entity (such as the clock or a mathematical problem). The latter view is more conducive to teamwork, which has become even more important in modern society.

4.1 Classification of Competitions

Education and competition can be combined in many ways. I will now consider organized competition events. Below, I present a list of attributes and dimensions that can be used to classify contests (presented in no particular order). The list shows the diverse possibilities for contests and it may also serve as a checklist.

1. intended objectives, accomplished effect,
2. part of the curriculum versus outside the curriculum,
3. fun-oriented versus serious,
4. artificial context versus realistic context,
5. educational value versus public-relations value,
6. spectator event versus participatory event,
7. teacher participation, parent participation,
8. organized by students versus organization involves no students,
9. for individuals or teams,
10. inter- versus intra-school, national versus international,
11. compete against others versus compete against “oneself”,
12. skill-oriented versus knowledge-oriented versus luck-oriented,
13. gender neutrality,

14. cultural and language dependence,
15. limited rewards versus abundant prizes, awards, certificates
16. one-time versus periodic,
17. single-day event versus multiple-day event,
18. fixed format versus free format,
19. instant feedback versus delayed feedback,
20. single-round versus multi-round tournament,
21. criteria for participation (e.g. limited age group),
22. variety in knowledge and skills of competitors,
23. aimed at everyone versus aimed at talented students,
24. diversified difficulty levels (depending on age or school grade),
25. handicapping to compensate for differences between competitors,
26. special training versus spontaneous participation,
27. larger event including non-competitive elements versus isolated contest,
28. degree of institutionalization (official rules, supervising body),
29. follow-up to participants (defined improvement process),
30. bound to school topics or not,
31. single-discipline versus multi-disciplinary,
32. (commercially) sponsored, government funded, self-supporting.

Some educators point out that students can be put off by competitions, but may still perform well in society in later life. For instance, it has been found that performance at the IMO is uncorrelated to later accomplishments in mathematics. Not all IMO winners become good mathematicians or even good at anything, and not all good contemporary mathematicians have performed well in the IMO (if at all).

Among the educators encouraging competitions, there is no general agreement as to what constitutes the best way of putting competitions to good use in education. Some find that education in school is best served by a break in style, which can be accomplished through a competition that is only loosely coupled to the curriculum (as opposed to an exam). The idea here is that the beneficial effect of a competition derives precisely from the fact that it is a change from the regular curriculum.

Others argue that competitions are an effective way of motivating students and providing them with feedback and that, therefore, competitions should be based on the actual material taught in school, should be incorporated into the curriculum, and the competition results should be used to evaluate students (like an exam).

Fun contests (partly involving luck and distorted rules) allow poor students to do well, thereby boosting their confidence. However, good students, who like to have control over their fate, often dislike such contests.

In spite of the contradictory opinions about the relevance of competitions to education and about how to conduct such competitions, I believe that the availability of good competitions is beneficial for education in almost any discipline. A good competition should challenge the participants to give their best, or preferably more than that. If the regular curriculum is not sufficiently challenging, then good students should be encouraged to participate in extracurricular competitions. In Germany and The Netherlands (and possibly elsewhere), the new framework being developed for upper secondary education allows students to count competition results towards their final exam.

It is my experience that enthusiastic organizers are more important to the success of a competition than most of the other variables. It should be noted, however, that organizing a good competition is a major challenge, which must not be underestimated. The three main phases for holding a contest are: preparation, execution, and follow-up. The initial phase prepares the entire framework: competition rules, competition tasks, judging procedures, etc. The rules should be as complete and transparent as possible, to avoid misleading the participants. The middle phase is where the actual competition is carried out: the participants do the competing and are evaluated. Especially the final phase, where results are analyzed and presented to the participants, is important for the effect of a competition, but it is very time-consuming and currently often receives too little attention.

4.2 Computing Science Competitions

Computing science (CS) is a relatively young discipline, inextricably linked to modern technology. It is highly relevant to modern society and still growing in importance. CS 'automatically' attracts the attention of youngsters. In most countries, however, CS has not (yet) established a firm position in secondary education among the other (older) disciplines. But almost everywhere a process of rapid change has set in, to catch up, as it were. One way of satisfying the natural interest in CS is to organize competitions for those that have learned the basics through self-study. In that case, the competition serves (also) as a public-relations vehicle, because it may help students decide on choosing a CS career. The International Olympiad in Informatics (IOI) is an annual CS contest for secondary school students that currently intends to fulfill this role.

The IOI has the format of an exam where the competitors work individually on a set of CS assignments and at the end hand in their work for evaluation. Currently, it involves only a small subset of CS, namely algorithmic programming problems. The event is spread out over several days, two of which are competition days, the other days being used for excursions and international contacts. The follow-up phase, for instance, the availability of fully documented solutions to all IOI assignments, is still underdeveloped.

A major obstacle for every international contest aimed at pre-university students is the language barrier. It needs to be crossed twice: once when presenting the competition tasks, and for the second time when judging the competitors' work. At the IOI, the second crossing is mostly avoided by requiring the participants to hand in their solutions as programs that can be executed by a

computer. This explains in part why the subject matter at the IOI is restricted to programming. By the way, this is less restrictive than may at first seem to be the case, because, besides programming skills, also good knowledge of CS theory is needed to solve the problems. The differences in CS knowledge and skills between the participants at the IOI are considerable. The difficulty of IOI assignments has steadily increased and currently the harder problems are challenging even for an average third-year undergraduate CS student (particularly, in view of the limited time for solving them).

Many of the national CS contests all over the world were started in response to the IOI, though it should be noted that in some countries national CS competitions existed before the IOI. Besides the objective of providing a CS challenge to talented young people, the IOI also strives to foster friendly international relationships and to attract attention to the field of CS. The IOI is hosted in a participating country, which is responsible for finding funds and organizing the contest and all accompanying events.

The CS situation at the university level is much better. Consequently, competitions play a different role there. In fact, many academics at best tolerate CS competitions at universities. How many publications that address the special issues surrounding any kind of student competition have you seen in well-known academic journals?

Dating back to the 1970s, the ACM International Collegiate Programming Contest (ICPC) has become a prestigious CS competition for teams of university students. Thousands of teams participate in national and regional contests leading up to the annual world finals. Like the IOI, the ICPC works with a bundle of programming problems that have to be solved in a limited time. For that purpose, each team has a single computer; thus, resource management is an integral part of the contest. In contrast to the IOI, the teams can hand in their programs during the contest and they receive feedback from the judges concerning the correctness. If a submission fails, the team receives a penalty but may continue working on that problem.

At the ICPC, the language barrier is considered irrelevant, and all material is presented in English. The ICPC also contains some extra features that are avoided in the IOI, such as simple problems in disguise (which need to be spotted early to make efficient use of the computer), problems requiring some trickery to solve, and difficult problems that possibly will not be solved by any team at all. The ICPC is usually carried out in two days, the first being used for practicing. The world finals usually are combined with some other non-competitive CS event. Since university students have often already chosen for a (CS) career, the direct public-relations value of the ICPC is less important than the fun part and the honor when winning. The ICPC is organized by the ACM, an independent international professional CS association, through funding of long-term commercial sponsors.

The incorporation of competitive elements in CS education is clearly lagging behind other developments that are felt to be more important. Also the use of CS elements in competitions for other disciplines is still underdeveloped. For instance, at the International Physics Olympiad (IPhO), it goes without saying that a certain fluency in mathematics is required to perform well. But it is, as yet, unimaginable that an IPhO problem would involve the writing of a program for some kind of physics simulation. Even the use of text editors is still avoided.

4.3 Competitions and Technology

Some people are eager to point out that advances in technology hardly affect the fundamental human values. Consequently, they say, technology should play a subordinate role in competitions that are intended to enhance education. Social interaction, cooperation, exploitation, cultural diversity, negotiation, and power are more important aspects of the human condition (than, e.g., knowing how to program a computer). Their relevance is largely independent of technology. However, the details of how these values 'operate' are technology dependent (e.g., power can be exerted through e-mail). Being able to use commonly available technology in everyday life is an important skill. Competitions can force students to deal with fundamental human values, using modern technology.

On the other hand, society is more and more dependent on technology. The only way in which this situation can be sustained in the longer run, is by integrating advanced technology into the school curriculum. However, the success of modern technology also works to its disadvantage. Engineers are persuaded to make technology more and more invisible, thereby reducing the attraction to engineering disciplines. Competitions are an excellent vehicle for incorporating technology into the future curriculum, and for opening the 'high-tech box' in an enjoyable way.

5 Concluding Remarks

I am convinced

- that competitions have much to offer in education (no matter what your point of view is),
- that competitions are a good measure of how well a discipline is accepted and integrated into the curriculum (a healthy, diverse set of competition events is a positive sign, whereas a lack of good competitions may in some cases be interpreted as a negative sign),
- that competitions should be further developed (in all diversity; you can use the checklist to put together a competition of your own liking),
- that organizing a good competition is a major challenge, (in particular, the follow-up is important but very labor-intensive),
- that competitive desires can be exploited to incorporate technology into the curriculum (however, competition should not be the only way to do so),
- that competitions should enjoy broader acceptance in the (international) arena of education, and
- that competitions should receive more support and attention from the academic and industrial worlds and from governments.

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Sources

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