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The Technology-Eight Competition: An analysis of Year 8 Students’ Quiz Results

Abstract
Teknikåttan is a Swedish science, mathematics and technology tournament for 15-year-old students. Each year, approximately 30% of the target group participates in the tournament, which is organized by 11 Swedish universities that offer engineering education. The present survey study investigates whether the initial quiz results can be used to evaluate young people’s knowledge in relevant subjects and whether such an evaluation can broaden the collective understanding of young people’s knowledge. This study looks at how students in Stockholm scored in the 2014 tournament and how the answers related to different subjects. Gender differences were analyzed as well. The results showed great variation in how the students responded to the 15 different questions. The most difficult question was related to chemistry and had 15% correct answers, and the easiest question was related to mathematics and had 86% correct answers. Girls and boys answered statistically differently in 10 of 15 questions. In contrast to other national and international data, boys performed better than girls on the majority of the questions. This paper argues that Teknikåttan results can be used as an evaluation tool to complement other more formal tools, yielding information on other aspects of students’ knowledge in science, mathematics and technology. The quiz could be enhanced as a tool if the questions were somewhat better tailored to the study parameters. Other variables, such as nationality and the influence of particular schools, are discussed as considerations that may be important in future evaluation studies.
INTRODUCTION

An ever-pressing issue for Swedish society is whether the country will continue to be in the forefront of the technical development and, if so, how. We believe that it is important for the next generation to become the driving force in taking on this challenge, but we often worry about this generation’s academic performance, their interest in pursuing a science or technology career and how their abilities match the competencies working life demands.

Sweden has experienced a period when international comparative studies have shown that Swedish students’ knowledge in math, science and technology has been decreasing compared to that of students in other countries. Such a decrease has been revealed by many surveys, such as the oft-cited Programme for International Student Assessment (PISA), performed by the Organization for Economic Cooperation and Development (OECD; www.oecd.org/pisa/keyfindings), and the Trends in International Mathematics and Science Study (TIMSS), performed by the International Association for Educational Achievement (IEA; www.iea.nl). Recently, however, we see an upturn in the results in the 2015 TIMSS and PISA surveys for both science and mathematics, which may indicate a trend reversal (Skolverket 2016a, 2016b). Nevertheless, something has unquestionably been changed in Swedish schools and the school system during the past two decades, leading to undesirable outcomes.

The difficulty of finding relevant data for measuring Swedish students’ performance—or at least the development of their performance—is well known, as the school curricula and assessment system have been modified twice since the early nineties (Gustafsson et al., 2014).

A related issue is the decreasing interest in science and technology careers among young people in Sweden, a trend that is congruent with most of the Western world. Though the relationship is not clear (Potvin and Hasni, 2014), some studies suggest that a reduction in content knowledge in a subject diminishes the likelihood that students will evince great interest in that subject (Skolverket, 2007). These two circumstances have led to an evolution of creative initiatives aimed at enhancing the position of science and technology in young people’s minds. Many stakeholders have decided to play a role in this area, where currently industry, municipalities, science centers, universities and schools predominate. In 2008, the Swedish government appointed industry and university representatives and other interested parties to participate in the Teknikdelegationen initiative to develop strategies to circumvent a future shortage of engineers in Sweden. In a published report, the group identified 223 Swedish initiatives aimed at increasing interest in science and technology (Teknikdelegationen, 2009). The authorities have also undertaken initiatives to improve the quality of science, math and technology education, including “Matematiklyftet” (Mathematics “Lift”), “NT-utvecklare” (Science and Technology Developers), “NTA” (Science and Technology For All) and “Teknik och naturvetenskapscentrum” (Centre for Education in Technology and Science) (Skolverket, 2011).

In this study, we consider the possibility of using one of these recent initiatives to generate a better understanding of students’ science, technology and mathematics knowledge. We have chosen the Technology-Eight Competition (Teknikåttan) initiative, a competition for 15-year-old students organized by 11 Swedish universities that offer engineering education programs. In the competition’s initial phase, competing students answer a multiple-choice questionnaire. The questionnaire results are used to select the best classes, which go on to the next level of the competition, i.e. to the regional and later on to the national levels. The questionnaires are fairly easy to study, as the results are compiled and saved after each year’s competition. The participant names are not given, but it is possible to analyze the results by gender, class and school.

The gender issue is a question often raised when discussing knowledge in and attitudes towards science and technology, mainly because it is an area in which clear gender differences have been observed, especially when it comes to how the different genders think of and choose their career paths (Buccheri, Gürber & Brühwiler, 2011; Schreiner & Sjöberg, 2010; Yang & Barth, 2015) technology, engineering, and mathematics. The issue is therefore addressed in the present study.
The questions analyzed are not devised by experts on either the school curriculum or in assessments but by professors from Swedish engineering universities. This means that the questions may not accurately reflect the content of the school curriculum, although the Teknikåttan guidebook advises that they broadly should; rather, the questions represent the knowledge university professors think is important for a 15-year-old to have. These professors are, after all, those who will take the students to the next level of understanding when they enter tertiary education.

**Background**

**A decline in science and technology knowledge among Swedish children**

The results of various international studies have clearly shown a negative trend regarding young Swedish students’ performance in science, technology and mathematics subjects over the past 20 years. According to the TIMSS results, Swedish eighth-grade students’ scores decreased steadily, both in mathematics and in science, at every measure point between 1995 and 2011, i.e. 1995, 2003, 2007 and 2011. However, in the most recent study the trend was broken and the Swedish students’ performance did not decrease this time. (Skolverket, 2016b) although the performance was not among the top ranked countries as in the 90’s. TIMSS measures knowledge based on the countries’ specific curricula. The PISA surveys (www.oecd.org/pisa/keyfindings) also revealed a significant decrease in science and mathematics knowledge among Swedish 15-year-old students until the survey performed 2012, and the upturn was confirmed for the survey done in 2015 (Skolverket 2016a). These international comparisons reveal that many countries have experienced a different trend and have overtaken Sweden during the past decade. In 2012, Sweden was outperformed in the PISA tests by 25 out of 34 participating OECD countries (Skolverket, 2013). This was the first time Sweden performed below average in the PISA studies. In 2015 Sweden were outperformed by 20 OECD countries and performed on average in the study.

Unfortunately, there are few national studies able to measure knowledge development over time, owing to factors such as changes in curricula and the fact that a relative grading system has been replaced by a targeting system, which has been shown to give poorer equivalence (Gustafsson et al., 2014). Gustafsson et al. also pointed out the importance of introducing a national evaluation system for Swedish school; the lack of such an evaluation mechanism makes it difficult to determine any positive or negative development explicitly, according to the Swedish set criteria.

The reasons for the observed decline in results are therefore not fully understood and are considered to be a mix of many reasons. A report on the Swedish situation (Gustafsson et al., 2016) considers some key factors, including reforms, such as the transfer of responsibility for schools from the state to the municipalities and the introduction of private schools without clear rules for school start-up companies. Other related issues include teachers who do not meet the training requirements and a new curriculum and assessment system.

In order to see whether students’ preconditions for learning have changed over time, Svensson (2008) analyzed 13-year-old Swedish students’ verbal, inductive and spatial skills during seven different years between 1961 and 2005. Svensson found that verbal skills increased during the period between 1961 and 1985 but decreased during the period between 1985 and 2005. The same trend was seen for spatial skills, but for inductive skills, the 13-year old students performed better in 2005 than in 1961, and the trend has remained positive over time. The study concluded that the preconditions most likely had not changed, at least not when discussing the results in mathematics, as the inductive skills were meant to be most relevant for mathematics performance. This study’s findings strengthen the hypothesis that school-related issues or interest-attitude issues are responsible for the decline in academic results.
The fact that the results in recent international studies have improved is likely to bring with it a number of studies that attempt to identify the factors for this rise, which in turn can confirm the causes of the previous decline.

**Decreasing interest in science and technology and its relationship to learning**

Sweden has a long tradition of having a highly educated population and a strong and innovative industry sector, which means that the country has for centuries relied upon the school system to produce engineers and other related professionals who are crucial for technical development. Therefore, the low enrollment numbers in European science and engineering programs over the past decade—too low to meet the estimated future demand (EU, 2004)—and young people’s diminished interest in pursuing STEM (science, technology, engineering and mathematics) careers (Barmby et al., 2008) have caused great concern. Although the number of students applying for engineering studies in Sweden has increased substantially over the last few years (UKÄ 2016), the lack of engineers is still a problem throughout the developed world. Students in industrialized countries have been found to have less interest in STEM careers than students in less industrialized countries (Schreiner & Sjöberg, 2010). Schreiner and Sjöberg (2005) also discussed the change in how young people think about their jobs, which has shifted from something a person does for a living to something that will help one develop as a person and must therefore be interesting and meaningful. DeWitt & Archer (2015) looked at students’ science capital and the factors that influence students to choose a science career; they suggested that schools can play a role in influencing students’ science capital by showing that a career in science offers opportunities to a broad range of personalities.

The ways in which attitudes affect learning (and vice versa) is another core interest area for educational researchers (Saleh & Kihne, 2011; Barmby et al., 2008). Previous studies have argued that one of the most important factors influencing people’s attitudes is their self-esteem (i.e., the way in which they value their own performance and abilities (George, 2000), although it is not clear whether self-esteem necessarily correlates to knowledge.

Other studies have also indicated a correlation between performance and self-efficacy (one’s belief in one’s own ability to learn) (Skolverket, 2007), showing that in TIMSS 2007, a correlation between self-efficacy and performance was seen for both fourth-grade and eighth-grade students. However, Potvin & Hasni’s (2014) recent literature review showed that previous studies have not shown consensus on this. So, it seems less likely that the decrease in knowledge is fully responsible for the negative attitudes towards science and engineering or for the decrease in interest in a science or technology career, or vice versa; however, good knowledge seems to be one important precondition for a high level of interest.

**Gender differences**

For many decades, girls have shown better performance and better grades than boys among students graduating from compulsory school in Sweden (grade 9). Currently, (2014–2015 and 2015-2016), this is true for all science, technology and mathematics subjects (www.skolverket.se/statistik-och-utvardering). The difference is about 10 %, and a little less in mathematics. However, boys have performed better in international studies, especially with regard to spatial skills (Ganley, Vasilyeva & Dulaney, 2014), which has been identified as a key determinant of success in engineering education (Sheryl, 2009). However, Svenssson’s (2006) study on the Swedish national context shows that the gender differences in spatial skills favoring boys disappeared over time, and in 2005, girls were found to perform better than boys on tests measuring spatial skills.

Another important issue to address, then, is that many studies show that female and male students differ when it comes to self-efficacy regarding their ability to learn science subjects. The Swedish Agency of Education (Skolverket, 2008) concluded from the 2007 TIMSS test that 15-year-old stu-
dents overall have low self-efficacy regarding science learning, but that boys had higher self-efficacy in learning physics and chemistry than biology, and that girls had higher self-efficacy in learning biology. Another study which evaluated Swedish compulsory schooling in 2003 (Skolverket, 2004), showed similar results, based on interviews with 16-year-olds. The study found that all students considered physics and chemistry difficult to learn, but that girls found these subjects more challenging than boys did. Potvin and Hasni (2014) also found in their international review that boys seemed to prefer learning, and thus have a more positive attitude towards learning, physics and technology, whereas girls preferred learning biology. Adolfsson (2011) analyzed the data collected in the TIMSS tests from 1995 and 2007 and found that the attitudes towards science subjects had decreased among both boys and girls during that period. High-performing boys were the group most positive towards physics, while high-performing girls were the group most positive towards biology. The analysis also found that low-performing boys were the group least positive towards biology, whereas low-performing girls were the group least positive towards physics.

The higher level of knowledge in science and technology among girls is not reflected in how the different genders choose higher education and professions. Though the number is growing, there is still a lack of girls enrolled in STEM higher education worldwide (Pearson, Frehill & McNeely, 2015). According to Pearson et al. (2015), UNESCO stated in 2007 that women are the least integrated into the STEM workforce, and this fact is causing a significant loss of scientific human capital for development and progress.

Girls are often highly represented in biology-oriented areas. In the more male-dominated STEM areas, such as engineering, in Sweden, about 30% of students today are female (UKÄ 2016), but the proportion is considerably less in programs that are most oriented towards physics and computer science. Yang and Barth (2015) discussed and analyzed women’s greater tendency to choose areas of study in biology than in the more male-dominated fields like engineering, arguing that this depends both on how women relate to people-oriented and thing-oriented subjects and professions, i.e., how much interaction with people is involved, and in what way each subject area relates to how a woman is expected to be, given that it is often expected that women have a profession in which they make a positive social impact.

Technology-Eight Competition

Within the subjects of science, technology and mathematics, one of the largest tournaments for students in Sweden is the Technology-Eight Competition (Teknikåttan). The goal of this competition is to increase interest and awareness in science, technology and math among 15-year-old students.

The tournament started in 1993 at Linköping University as a response to the observed decline in interest in these subjects. Other technical universities in the country soon joined, and since 1995, the tournament has been nationwide. Currently, 11 universities with technical educational programs collaborate on the initiative¹ (Hultgren et al., 2001; Teknikåttan, 2016).

In line with its main purpose, the tournament seeks to involve as many eighth-grade students as possible and encourage them to reflect on issues rooted in science and technology. The tournament is organized in three rounds. The first round is an individual quiz, the second round is a regional contest at the local university and the third and final round is held at one of the 11 universities. The second and third rounds involve practical tasks in addition to theoretical questions.

¹ The following universities collaborate in organizing Teknikåttan: KTH Royal Institute of Technology (Stockholm), Faculty of Engineering LTH (Lund), Linnaeus University (Växjö and Kalmar), Chalmers University of Technology (Gothenburg), University West (Trollhättan), Linköping University, Mälardalen University College (Västerås and Eskilstuna), Dalarna University College (Borlänge and Falun), Karlstad University, Uppsala University and Umeå University.
More than 30,000 students participated in the 2014 tournament, representing approximately 1,500 classes from 570 schools—or in other words, one-third of all lower secondary schools in Sweden. We have investigated the results of participants in the Stockholm area, including 3,439 students from 52 different schools, in great detail.

This study is focused on the initial round, the quiz, which is the part of the tournament that affords students the least opportunity for activity and interaction with others, as they answer the quiz questions individually. However, this is also the activity through which the universities engage with the greatest number of students, making it very important for the tournament to inspire the students at this stage.

The quiz consists of 15 multiple-choice questions (with four alternatives for each question), which the students answer individually on paper (Appendix A). The quiz was distributed to the schools by the local university a few days before the contest, and then by the teachers to all competing classes. The contest was administered on a pre-defined day, on which all participating classes completed the quiz at the same time. The teachers then collected the answer forms and sent them back to the university, where they were graded.

A very important aspect of Teknikåttan’s structure is that it serves as a link between the universities and schools. Since a large proportion of all 15-year-olds in Sweden take part in the contest, it offers a perfect opportunity for universities to influence teaching by highlighting, to some extent, what universities consider relevant knowledge in the subject areas for science, technology and mathematics. Indirectly, the questions represent areas that are valued relatively highly or that constitute basic knowledge for further study at the various universities, as university teachers are unlikely to make up questions that have little relevance to future learning in these subjects. In the second and third rounds, teachers from the schools also meet with teachers from the universities, potentially leading to further collaboration. The questions are also available over the Internet, which makes them useful as a pedagogical tool even for teachers whose students are not participating in the competition (Blomqvist, 2010).

**INVESTIGATION**

This investigation is a descriptive study that intends to contribute to the discussion regarding knowledge development in science, technology and mathematics among Swedish 15-year old students. This is done by analyzing data collected from the initial 2014 Teknikåttan quiz, which has been stored and is therefore available for us to use in investigating patterns in students’ answers.

The overall aim of the investigation is to establish whether useful information can be gleaned from the materials and used to develop a better understanding of the participants. Specifically, we explore whether the quiz results might offer hints about students’ interests and attitudes towards different areas in science and technology.

This research aims to answer the following research question: What patterns do the Teknikåttan results reveal about students’ understanding of science, mathematics and technology, with respect to differences in subject knowledge and gender differences?

The answers to the research question will be used to consider whether and how the Teknikåttan quiz results can be used to generate insights into how well students understand science, mathematics and technology, as well as whether the quiz needs to be reformulated in order to be useful in this respect.
Method
In 2014, 3,439 students representing 52 different schools sat the initial quiz in the Stockholm area. As mentioned above, all participating students completed the quiz at their schools, and the quizzes were then sent to a local Teknikåttan university, in this case KTH, where they were marked and the results stored in a database.

In order to analyze the results, the authors categorized the questions by subject: chemistry, physics, mathematics, biology or technology. The subject areas associated with each question are listed in order of their relevance to the question (see Table 1).

Descriptive analysis of the questions giving the highest and the lowest scores
Two questions were selected for further descriptive analysis, as they represented the two extremes in scores. The questions on which students scored highest and lowest were studied in order to determine the particular kinds of questions students found easy or difficult.

Statistical analysis of the differences in boys’ and girls’ responses
Possible differences between the boys’ and girls’ responses were analyzed statistically through hypothesis testing, which was undertaken according to the methods described by Cohen, Manion and Morrison (2011) and Box, Hunter and Hunter (1978). The null hypothesis was that the probability of answering a question correctly was equal for boys and girls. The hypothesis was tested by calculating the 95 % confidence interval for the estimate of the proportion of correct answers.

In order to calculate the confidence interval, the following assumptions were made: (1) boys and girls answered correctly, according to a binomial distribution, with the probabilities (p) p-boys and p-girls, and (2) that students’ answers were independent.

The number of students (n) was high enough to reasonably approximate the distribution of correct answers to be given by the normal distribution, N (np, np (1-p)).

The confidence interval for the estimated proportion of correct answers can be expressed, using the normal distribution approximation, as

$$\hat{p} \pm z \sqrt{\frac{1}{n} \hat{p}(1-\hat{p})}$$

where z is the $\frac{1-\alpha}{2}$ percentile of a standard normal distribution.

As characteristic of multiple-choice quizzes like this, some participants will answer correctly by guessing. As a precaution, the proportion of correct answers was thus adjusted to account for guessing by subtracting one-third of the incorrect answers from the correct answers. The assumption was that only guessing and correct answers occurred. The results found when correcting for guessing were very similar to those found without this correction. Therefore, the confidence intervals were calculated without any correction. These numbers are easier to understand because no negative intervals are included.

Results and discussion
Overall results
Figure 1 presents the overall results from the initial quiz, providing a visual picture of the percentage of students who correctly answered each of the 15 quiz questions in the first round of the 2014 tournament in the Stockholm area. This figure represents the base results for all further analyses. The
questions are marked by both numbers and names, which represent the subjects on which they focus. The variation in correct answers for different questions was high, ranging between 15% and 86%. Seven out of the 15 questions were answered correctly more than 50% of the time.

Figure 1. Proportion of correct answers given for each question.

The mean score of all questions was 50%, i.e., on average about half of the students answered the question correctly. An analysis of the questions singly shows that for seven questions, less than 50% of the participants answered correctly, and for eight questions, more than 50% of the participants answered correctly.

Descriptive analysis according to subject area

Table 1 shows how the questions were categorized as well as the percentage of correct answers in each subject area.

As Table 1 shows, 11 out of the 15 questions in the quiz were related to the subject of physics, whereas biology was highlighted in two questions, and chemistry and technology were the main subjects in only one question each. Mathematical knowledge was required by only one question. Because of the small number of questions representing each subject, it is difficult to analyze how the subjects’ relevance affected the answers; however, it can be noted that the variation in results for the physics questions was relatively high. On the other hand, the only question in which chemistry was the main subject had the overall lowest score, which may be a sign of the difficulty students felt about the subject of chemistry (Skolverket, 2014a). The biology questions, on the other hand, both seem to be have been easier than average. It can also be stated that even though the competition is named “Teknikåttan,” or Technology-Eight, very few questions were categorized as belonging to the subject of technology, reflecting the fact that the professors designing the competition do not focus only on the school subject of technology, but rather the wider concept of engineering, also including engineering sciences; physics, chemistry, biology and mathematics.
Table 1. Categorization of questions from the initial quiz and results as a percentage of correct answers according to subject area.

<table>
<thead>
<tr>
<th>Question number</th>
<th>Subject area</th>
<th>Result (% correct answers)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Biology</td>
<td>66.15</td>
</tr>
<tr>
<td>2</td>
<td>Physics</td>
<td>62.08</td>
</tr>
<tr>
<td>3</td>
<td>Physics, Math</td>
<td>86.07</td>
</tr>
<tr>
<td>4</td>
<td>Biology, Technology, Chemistry</td>
<td>65.77</td>
</tr>
<tr>
<td>5</td>
<td>Physics, Technology, Biology</td>
<td>48.44</td>
</tr>
<tr>
<td>6</td>
<td>Physics, Chemistry</td>
<td>26.26</td>
</tr>
<tr>
<td>7</td>
<td>Physics, Technology</td>
<td>21.37</td>
</tr>
<tr>
<td>8</td>
<td>Physics</td>
<td>34.84</td>
</tr>
<tr>
<td>9</td>
<td>Physics, Technology</td>
<td>48.65</td>
</tr>
<tr>
<td>10</td>
<td>Physics</td>
<td>83.40</td>
</tr>
<tr>
<td>11</td>
<td>Physics</td>
<td>38.56</td>
</tr>
<tr>
<td>12</td>
<td>Physics, Biology</td>
<td>33.73</td>
</tr>
<tr>
<td>13</td>
<td>Technology, Physics</td>
<td>53.50</td>
</tr>
<tr>
<td>14</td>
<td>Chemistry, Biology</td>
<td>14.63</td>
</tr>
<tr>
<td>15</td>
<td>Physics</td>
<td>60.60</td>
</tr>
</tbody>
</table>

Descriptive analysis of the extreme cases

Case 1: High-score question

As shown in Figure 1 and Table 1, Question 3 had the highest overall score, with 86% of students giving the correct answer. The question was as follows (with the correct answer in bold):

3. Back again
You have just attended a concert by One Direction at Ullevi in Gothenburg when you find out that Lady Gaga will perform at the Friends Arena in Stockholm. The distance between Gothenburg and Stockholm is approximately 500 km.¹ How much time will it take to travel between the two cities if you drive at an average speed of 100 km/h?
   A) 3 hours
   B) 10 hours
   **C) 5 hours**
   D) 18 hours

¹Note: In the original text, the distance was given as 50 mil, as the Scandinavian unit mil is equivalent to 10 km. The students thus had to first convert from mil to km before calculating the travel time.

Figure 2 shows the percentage of students who selected each option. The high percentage of correct replies indicates that the majority of students found this deductive problem easy. The question is formulated in such a way that makes it possible to deduce the correct answer using problem-solving skills and information given in the text. The question involved both physics and mathematics. This kind of problem-solving is taught in many course books, and, according to the national steering documents, this content is very important and necessary for the further understanding of mathematics and physics (Skolverket, 2014b; Skolverket, 2014c). This may be one reason why this question was found to be the easiest for students.
Case 2: Low-score questions
As shown in Figure 1 and Table 1, Question 14 had a remarkably low score, with only 15 % of students giving the correct answer. This percentage is significantly lower than would be expected if the majority were guessing, suggesting that most of the students in fact misunderstood the concepts of chemical reactions. The question was as follows (with the correct answer in bold):

**14. Chemical reactions**
Atoms and molecules move all around us and inside us. Different chemical reactions are constantly taking place. Which of the following alternatives is NOT a chemical reaction?

A) When you mix syrup and water for a drink  
B) When fireworks explode in the sky  
C) When the battery in your mobile phone discharges while you are checking out Instagram  
D) When your muscles work while exercising

Figure 3 shows the distribution of answers, illustrating that the majority of the students (55 %) believed that the discharge of a battery does not involve a chemical reaction. This result indicates that there is a real misconception concerning chemical reactions among students, which needs to be addressed by their teachers. Chemistry generally has been shown to be perceived to be a difficult subject, and attitudes among young people towards chemistry and chemistry careers are not particularly positive (Skolverket, 2014). Thus, it may be worth developing ways in which chemistry questions can be asked to stimulate young people’s interest in the subject.
Gender differences

Figure 4 provides an overview of the overall scores for each of the 15 questions. This is similar to Figure 1, except that the results here are shown as two separate bars, representing boys’ and girls’ responses. Boys scored higher than girls in 11 out of the 15 questions. Table 2 presents boys’ and girls’ results.
at a 95 % confidence interval. The table shows that the girls’ and boys’ answers were significantly different in 10 of the 15 questions. Girls earned significantly higher scores on one question, while boys scored significantly higher in 9 of the 15 questions. This result contrasts with those of the international comparison studies and those of national tests and grades, in all of which girls outperform boys.

Of the four questions on which girls scored higher than boys, three were related to biology. In fact, these were the only biology-related questions on the quiz.

Table 2. Confidence intervals for all questions. Null hypothesis: The probability of answering question J correctly is equal for boys and girls. Question J is a substitute for all the different questions.

<table>
<thead>
<tr>
<th>Question</th>
<th>Girls</th>
<th></th>
<th>Boys</th>
<th></th>
<th>Null hypothesis can be significantly rejected</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Proportion correct answers</td>
<td>Confidence interval</td>
<td>Proportion correct answers</td>
<td>Confidence interval</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0.703</td>
<td>0.681 - 0.724</td>
<td>0.622</td>
<td>0.599 - 0.645</td>
<td>yes</td>
</tr>
<tr>
<td>2</td>
<td>0.566</td>
<td>0.543 - 0.590</td>
<td>0.674</td>
<td>0.652 - 0.696</td>
<td>yes</td>
</tr>
<tr>
<td>3</td>
<td>0.838</td>
<td>0.820 - 0.855</td>
<td>0.877</td>
<td>0.862 - 0.893</td>
<td>yes</td>
</tr>
<tr>
<td>4</td>
<td>0.675</td>
<td>0.652 - 0.697</td>
<td>0.645</td>
<td>0.622 - 0.667</td>
<td>no</td>
</tr>
<tr>
<td>5</td>
<td>0.444</td>
<td>0.421 - 0.468</td>
<td>0.523</td>
<td>0.500 - 0.547</td>
<td>yes</td>
</tr>
<tr>
<td>6</td>
<td>0.245</td>
<td>0.225 - 0.266</td>
<td>0.278</td>
<td>0.257 - 0.299</td>
<td>no</td>
</tr>
<tr>
<td>7</td>
<td>0.178</td>
<td>0.160 - 0.197</td>
<td>0.245</td>
<td>0.225 - 0.265</td>
<td>yes</td>
</tr>
<tr>
<td>8</td>
<td>0.300</td>
<td>0.278 - 0.322</td>
<td>0.395</td>
<td>0.372 - 0.418</td>
<td>yes</td>
</tr>
<tr>
<td>9</td>
<td>0.474</td>
<td>0.450 - 0.498</td>
<td>0.499</td>
<td>0.475 - 0.522</td>
<td>no</td>
</tr>
<tr>
<td>10</td>
<td>0.836</td>
<td>0.818 - 0.854</td>
<td>0.832</td>
<td>0.815 - 0.850</td>
<td>no</td>
</tr>
<tr>
<td>11</td>
<td>0.341</td>
<td>0.319 - 0.364</td>
<td>0.428</td>
<td>0.405 - 0.452</td>
<td>yes</td>
</tr>
<tr>
<td>12</td>
<td>0.345</td>
<td>0.322 - 0.367</td>
<td>0.330</td>
<td>0.308 - 0.352</td>
<td>no</td>
</tr>
<tr>
<td>13</td>
<td>0.482</td>
<td>0.458 - 0.505</td>
<td>0.587</td>
<td>0.563 - 0.610</td>
<td>yes</td>
</tr>
<tr>
<td>14</td>
<td>0.130</td>
<td>0.114 - 0.146</td>
<td>0.174</td>
<td>0.156 - 0.192</td>
<td>yes</td>
</tr>
<tr>
<td>15</td>
<td>0.553</td>
<td>0.529 - 0.576</td>
<td>0.657</td>
<td>0.635 - 0.680</td>
<td>yes</td>
</tr>
</tbody>
</table>

Two of the questions—those for which the differences were most prominent—were studied more closely: Question 1, on which girls scored significantly higher than boys (70 % of girls answered correctly, while 65% of boys answered correctly), and Question 15, on which boys scored significantly higher than boys (55 % of girls answered correctly, while 65% of boys answered correctly). These two questions were as follows:
1. Aerial tourists
Birds are one example of animals that travel extensively. Many birds migrate, but only one of the following birds is migratory. Which one is it?
   A) House sparrow
   B) Wagtail
   C) Bullfinch
   D) Great tit

15. Mail delivery
You are sitting on a train that passes a platform at a high speed. A box is placed on the platform. You want to drop a small package in the box. When should you drop the package?
   A) Just above the box, since the package will fall straight down.
   B) Just after you pass the box, since the air resistance will blow the package backwards.
   C) Just before you reach the box, since the package has a forward speed.
   D) Just outside of the box, since the turbulence under the train will cause the package to be sucked in towards the train.

Question 1, on which girls scored higher than boys, is a pure biology question. It requires little or no problem-solving skills, but factual knowledge is needed. Question 15, in which boys scored higher than girls, is related to physics. The results are in line with the literature (Adolfsson, 2011), where girls have been found to have greater self-esteem in biology and boys have been found to have better self-esteem in physics.

Conclusions
How does this study contribute to our understanding of young people’s achievement in science, technology and mathematics?

The findings indicate that the quiz can be used to measure differentiation in knowledge. The results illustrate significant variation in scores for different questions—for example, the most difficult question received only 15 % correct answers, and the least difficult question received 86 %. This in itself tells us that differences can be analyzed according to question type. Only 6 of the 15 questions were answered correctly by more than 50 % of the students, which may be regarded as an inappropriately low score if the aim is to make the participants aware of their actual knowledge or problems they can solve.

When analyzing the subject’s impact on the students’ score, some interesting results were found. We found that most of the questions were associated mainly with the subject of physics, whereas only a few of the questions were associated mainly with other subjects. Therefore, it was not possible to draw conclusions about whether a particular subject was more difficult or easier overall. However, the only chemistry question in the quiz turned out to be the most difficult question, with only 15 % of the students giving the correct answer; this also indicates a misconception. This is consistent with other reports (Skolverket, 2004) showing that chemistry is often hard to understand. In order to perform a more detailed analysis on subject specific relationships, more data is required—in this case, this means a more even distribution of questions representing different subjects, as well as a greater number of questions. If the results were to be integrated over a period of several years, they may reveal students’ tendencies to give more correct answers in certain subjects.

The main conclusion that can be drawn from observing the subjects represented by the questions is that the team of professors that created the 2014 quiz had a preference towards physics. This might be a coincidence, or it might be the result of physics being seen as the main subject influencing engineering education.
We can also analyze differences between different student groups. In this study, we demonstrated that girls scored better than boys on biology-oriented questions, whereas boys scored better on physics-oriented questions. Those correlations are in line with the literature with regard to gender differences in both self-esteem and self-efficacy in the different subjects; in this study, we can see a correlation between self-efficacy and performance. It may also be worth considering other parameters that resemble gender categorization that may be useful for complementing the picture on 15 year-old students’ performance, such as national background, sociocultural conditions or the ways in which the results differ geographically across the participating classes and schools. Schools and classes can be compared if the data is analyzed for all participating schools and regions.

When analyzing gender differences, we found that statistically boys performed better overall on this quiz. This is contrary to the fact that girls achieve higher grades in all of the subjects of interest, i.e., in chemistry, biology, mathematics, technology and physics. It is obviously interesting to reflect upon the reasons for these results, even though we do not claim that our discussion covers all possible explanations. Again, this may be a consequence of attitude or interest correlating with performance. As seen in many studies and surveys, girls are less likely to choose technology careers (Schreiner & Sjøberg, 2005; Yang & Barth, 2015), and girls have lower self-efficacy in the subjects of physics and chemistry (Skolverket, 2008). Thus, girls might experience a disadvantage simply by participating in a competition named Teknikåttan, were the name is likely to be associated with the subjects of technology, physics and chemistry.

Furthermore, the use of multiple choice questions is complicated by the potential for guessing (Ventouras, Triantis, Tsiakas & Stergiopoulos, 2011). It is possible that girls might guess more than boys if their self-esteem or self-efficacy are not as positive as boys’, i.e., in answers to multiple choice questions, these self-esteem and self-efficacy issues are more visible than in school knowledge tests and grades.

Differences in how girls and boys tend to address questions and problems have been observed in previous studies. Wernersson’s (2010) report exploring why boys underperform in school suggests that boys and girls use different methodologies and different abilities when they solve problems. Girls tend to use a more generalizable approach, whereas boys tend to use more focused and distinct abilities. This difference might possibly influence how the students replied to this questionnaire, which contains more focused multiple-choice questions.

**Concluding Remarks**

Both competence and interest in science and technology have been waning in Sweden over the last 20 years. In order to reverse this negative trend, many initiatives have been undertaken, both by various stakeholders aiming to increase interest in science and technology and by authorities who wish to improve educational outcomes among Swedish students. In order to understand this negative trend, it is also important to consider the results of international and national evaluation studies. Gustafsson (2014) argued that the lack of a national monitoring system could be one major reason why Swedish school outcomes have been allowed to decline as much as they have.

Teknikåttan offers a unique opportunity to study 15-year-old students’ knowledge in science, mathematics and technology, as this is an annual tournament in which almost 30 % of all Swedish students participate. The competition is not intended to be used as a formal national evaluation tool, nor will it ever be, but the present study shows that data from the Teknikåttan tournament can usefully complement national and international studies and thereby broaden our understanding of how students develop their competences in science, technology and mathematic subjects. This study covers only the Stockholm region, which means that we cannot draw any firm conclusions for the whole country. In future studies results from all regions will be included.
The research questions asked in this study were:
1. whether any patterns could be seen in how students replied in the first-round quiz containing
   15 multiple-choice questions, specifically in terms of different subjects and
2. whether any differences in answers could be seen regarding gender.

The data collected was not sufficient enough to draw any firm conclusions regarding the first ques-
tion. The data yielded a clearer answer to the second research question, as it was statistically demon-
strated that girls and boys replied differently in 10 of the 15 questions. In contrast to other national
and international studies, boys scored higher than girls overall, as shown in 9 of the 15 questions,
leading to reflection on why this is the case. In this regard, analysis of the Teknikåttan results can
provide a complementary picture of young people’s knowledge.

As stated previously, this study does not analyze the knowledge measured by the quiz. However, if
the quiz really does represent the kind of knowledge that is highly valued by the universities, then it
is worth starting a discussion between schools and universities regarding the cause of the gender dif-
ferences seen in the answers to certain questions.

Finally, the present paper discusses how Teknikåttan can be used to evaluate students’ knowledge
in science, mathematics and technology. We conclude that the Teknikåttan data can be used as an
alternative evaluation mechanism, but that the contest would have to be more rigorously structured
in order for specific areas to be investigated fully.

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Flygturister
Ett exempel på djur som reser mycket är fåglarna. Många fåglar är flyttfåglar, men bara en av följande fåglar är en flyttfågel, vilken?

A) Gråsparv  
B) Sädesärla  
C) Domherre  
D) Talgoxe

Voyager
Rymdfarkosten Voyager 1 skickades ut från jorden 1977 och är den rymdsond som har äkt längst bort från jorden. Nyligen lämnade den solsystemet. Om inget kommer i vägen, när kommer den stanna?

A) Aldrig  
B) Om 50 år  
C) När bränslet tar slut  
D) När den når nästa solsystem

Andra hållet
Du har just varit på en konsert med One Direction på Ullevi i Göteborg och får reda på att Lady Gaga ska spela på Friends Arena i Stockholm. Avståndet mellan Göteborg och Stockholm är ungefär 50 mil. Hur lång tid tar det att åka mellan de båda städerna om man kör med en medelfart som är 100 km/h?

A) 3 timmar  
B) 10 timmar  
C) 5 timmar  
D) 18 timmar

Gumaelius and Nymark

2014 teknikåttan.se
Geocaching är en modern och världsomspännande variant av skattjakt utomhus med hjälp av en GPS-mottagare. Ett av följande alternativ är INTE nödvändigt för att GPS-systemet ska fungera. Vilket?

A) Satelliter
B) Atomur
C) Kompass
D) Radiomottagare

Medicin genom huden
Plåster kan ha andra användningsområden än att skydda och ta upp blod ifrån sår. Förrådsvänjning är ett exempel och där tillsätts en aktiv substans till plåstret och när kroppens blod genom huden. Vad är det viktigaste skälet till att man använder dessa plåster i stället för att ta in medicinen genom munnen?

A) Många tycker att plåster är snygga
B) Tabletter kan ge fräskador på tungan
C) Medicinen tillförs blodet under lagom lång tid
D) Det minskar risken för att man glömmer ta medicinen

Eko
Vad av följande använder sig INTE av ljudvågor för att lokalisera föremål?

A) Delfin
B) Fiskebåtar
C) Fladdermus
D) Kommunikationssatellit

Spår i luften
Efter flygplan syns ofta vita linjer. Vad består dessa huvudsakligen av?

A) Kabinens ventilationsluft
B) Oförbränt flygbränsle
C) Koldioxid
D) Vattendroppar

Omlöpssbana
Runt jorden på ungefär 40 mils höjd snurrar rymdstationen ISS. Vilket av följande påståenden om ISS är sant?

A) För att inte ramla ner behövs hela tiden stora propellrar som håller stationen svävande.
B) Så långt ut i rymden när inte jordens dragningskraft och rymdstationen svävar fritt 40 mil ovanför Houston.
C) Rymdstationen snurrar runt jorden flera varv varje dygn.
D) För att hålla rymdstationen uppe är stora rum fyllda med helium.
Genom cyberrymden

När du spelar online-spel på datorn överförs data mellan spelarna på många olika sätt. På vilket av följande sätt kan datorbilden vanligtvis INTE överföras mellan spelarna?


Fritt fall

2012 hoppade Felix Baumgartner från en höjd av 39 km. Hans fart ökade till över 1300 km/h, men minskade långt innan han utlöste fallskärmen. Varför minskade farten?


På tivoli

Du är på Gröna Lund och åker Fritt Fall. I denna åkattraktion sitter du i en vagn som dras högst upp i ett torn, och sedan släpps ned och ”faller fritt”. Precis när vagnen släpps ramlar din mobiltelefon ur din ficka. Vad av nedanstående stämmer för telefonen under den första sekunden?


Luftorientering

Fåglar kan använda många olika sätt för att hitta rätt under sin flytt. Vilket av dessa fyra sätt kan de INTE använda?

Kemiska reaktioner

Atomer och molekyler åker hit och dit runt omkring oss och inuti oss. Hela tiden sker det olika kemiska reaktioner. Vilket av följande alternativ är **inte** en kemisk reaktion?

A) När du blandar saft och vatten
B) När en nyårsraket exploderar på himlen.
C) När mobilbatteriet laddas ur medan du kollar på Instagram.
D) När dina muskler arbetar när du tränar.

Vandrande pinne

Segway är ett av våra senast uppfunna transportmedel. Konstruktionen ser ganska ranglig ut, men ett utmärkande kännetecken för en Segway är förmågan att kunna balansera sig själv. Vilken komponent är nödvändig i den tekniska lösningen hos en Segway för att den skall klara att hålla balansen under färd?

A) Förgasare  B) Gyroskop
C) Gps   D) Kamera

Postgång

Du sitter i ett tåg som åker förbi en perrong i hög fart. På perrongen ligger en låda. Du tänker släppa ett litet paket i lådan. När ska du släppa paketet?

A) Precis ovanför lådan, paketet faller rakt ner.
B) Strax efter lådan eftersom luftmotståndet bläser paketet bakåt.
C) Strax före lådan eftersom paketet har en fart framåt.
D) Strax utanför lådan. Virvlarna under tåget gör att paketet sugs mot tåget.