

Using “Cheat Sheets” to Distinguish Ability from Knowledge: Evidence from a Randomized Control Trial in Chile

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Abstract

This paper proposes distributing “cheat sheets” (i.e. knowledge summaries) before university admission tests as a potential low cost and easily implementable alternative to improve the access to higher education for students from disadvantaged socioeconomic backgrounds, who may have knowledge gaps due to the lower quality of their secondary education. In order to empirically evaluate their impact I custom-designed a multiple-choice mathematical ability test intended to measure the individual’s ability while minimizing the reliance on previously acquired specific knowledge, and put together a two page “cheat sheet”, which outlines all the concepts necessary to successfully complete the exam. This test was subsequently used to evaluate the candidates applying for admission into the Commercial Engineering degree at the Pontificia Universidad Católica de Chile via the “Talento + Inclusión” (*Talent + Integration*) special access program for students from disadvantaged socioeconomic backgrounds. A staged randomized control trial was then used to measure the difference in academic performance (i.e. number of question answered questions) across the three parts of the test between students in the treatment and control groups, who receive a “cheat sheet” after the first or second parts of the test, respectively. Significant evidence is found which suggests that, apart from improving the overall performance of candidates, the use of “cheat sheets” was more beneficial for those talented students who were more likely to have had a secondary education of lower quality. All this has important implications for educational policies in Chile and elsewhere, suggesting that the use of “cheat sheets” could be a cheap and easily implementable remedy to facilitate the access to higher education for students with disadvantaged backgrounds.

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1. Introduction

Chile, albeit a middle-income country and an OECD member, faces substantial gaps in the provision of higher education. For example, while the OECD average net coverage of higher education (i.e. the ratio of students 18-24 years old enrolled in higher education) is 59%¹, the net coverage of higher education in Chile is 36.3%, and the net coverage for the poorest decile of the population is 16.4%¹. Moreover, the poorest students usually attend public or subsidized public schools, while richest students usually attend private schools of higher quality. Only 10% of public school graduates attend elite universities, versus 31% for private schools, resulting in a clear majority of private school students in high quality undergraduate institutions. Then, it is not surprising that the access to higher education is one of the most important current issues for Chilean society², and the main reason behind the notorious student protests which have taken place there during the last years³. Therefore, there is an on-going debate regarding which is the best way to increase the access to higher education and to ensure equality of opportunity. The first best solution would be to increase the quality of secondary education in public and subsidized secondary schools, and there are many efforts in this direction, however although necessary any such reforms will at best improve the access to higher education only in the long term. In view of this, there are also many initiatives directed at improving the access to higher education for talented students from disadvantaged backgrounds in the short and medium term. At the forefront of the debate is the role of the PSU, the current standardized admissions test, which some argue that due to its focus on knowledge may be discriminating against talented students from poor backgrounds who attended low quality public and subsidized secondary schools, and who cannot afford the test preparation courses ("preuniversitarios") which are widespread among private school students.⁴

In view of all of the above, this paper proposes distributing “cheat sheets” (i.e. knowledge summaries which outline the basic concepts necessary to successfully complete a test), as a potential low cost and easily implementable alternative to improve the access to higher education for students from disadvantaged socioeconomic backgrounds in the short term. The hypothesis is that although many students who attended public and subsidized secondary schools may have knowledge gaps due to the lower quality of their education, which may be hindering their performance in tests with respect to their peers from private secondary schools, if they are talented enough they may be able to partially offset their disadvantage when during during the

¹See OECD (2011).

²It is worth noting that although the access to higher education is at the forefront of the public debate in Chile at the moment, this is of course an issue which is considered key in almost any other country, including the United States (see for example Dickert-Conlin and Rubenstein (2007)). The findings of this paper are therefore relevant for and contribute to the overall academic debate on how to improve the access to higher education.

³See for example Loofbourow (2013).

⁴For a related study on the subject in Chile see Banerjee et al (2012), who using random assignment provide test preparation courses to students from disadvantaged backgrounds and evaluate their impact.

exam they have access to a knowledge summary which outlines the basic concepts necessary to successfully complete it⁵. This is fully compatible with Bloom’s seminal Taxonomy of Educational Objectives⁶, which classifies *Knowledge* as the first but lowest of educational goals, followed by *Comprehension* and *Application*. I.e., secondary students who do not *know* the answers to the questions proposed to them in a test may not necessarily be less talented or less prepared to succeed in higher education. On the contrary, if with the help of a “cheat sheet” they can overcome their knowledge gaps by quickly *comprehending* and *applying* the concepts outlined in it, this probably means that they are actually as talented (if not more) than their peers and likely to succeed when provided with the adequate means to overcome their knowledge gaps. Or in other words, “cheat sheets” may help to better distinguish knowledge from ability, as reflected on better comprehension and application of concepts.

In order to empirically evaluate the impact of “cheat sheets”, I custom-designed a multiple-choice mathematical ability test intended to measure an individual’s ability while minimizing the reliance on previously acquired specific knowledge⁷. Moreover, I also put together a two page knowledge summary, or “cheat sheet”, which outlines all the concepts which I considered necessary to successfully complete the test⁸. This test was subsequently used to evaluate the candidates applying for admission into the Commercial Engineering degree at the Pontificia Universidad Católica de Chile via the “Talento + Inclusión” (*Talent + Integration*) special access program for students from disadvantaged socioeconomic backgrounds⁹. The mathematical ability test was divided in three parts, which featured 15 analogous questions each (i.e. the first questions of each part were different but analogous)¹⁰, and candidates were randomly divided into treatment and control groups. All students took the first part of the test without any support materials, but then the “cheat sheet” was distributed to each of the candidates in the treatment group, who then had about ten minutes to examine it before the second part of the exam started. Students in the control group simply had a ten minute break after completing the first part of the test, but received the same “cheat sheet” after having completed its second part. Once they received the “cheat sheet” all students could keep it with them until the end of the test, when they had to return it. This staged randomization design allows to analyze the impact of the “cheat sheet” on student performance on the test, by looking at the differences in the number of questions answered

⁵It is worth noting that, as mentioned for example in Heckman (1995), latent ability alone cannot explain differences in test scores or wages among individuals, nor is independent of the individual’s context.

⁶See Bloom et al (1956) for a discussion of the original taxonomy, and Krathwohl (2002) for a proposed modern revision to it.

⁷As discussed for example in Bransford (1999) or Pellegrino (2001) this in itself is obviously far from a trivial task, but I trust that the result is satisfactory.

⁸The “cheat sheet” and the full mathematical ability test are included in the Appendix.

⁹See Díez-Amigo (2014) for a full description and analysis of this access program.

¹⁰For comparison purposes, the questions in each part of the test would ideally be the same. However, this would obviously raise some concerns even if the students do not know the answers to the test. Therefore, different but analogous questions are used. This means that the underlying concept of the question is the same, but the precise numbers or examples used differ from one part to another.

correctly across the three parts of the test between students in the control and treatment groups.

This paper only finds a significant difference in the number of questions answered correctly between students in the treatment and control group in Part II of the test. Since as described above this is precisely the part in which candidates in the control group did not yet have access to the “cheat sheet”, as opposed to students in the treatment group, this suggests that *ceteris paribus* having access to a knowledge summaries results in about one additional question answered correctly, out of a total of fifteen. Also, as expected it seems that students who attended a secondary school with a higher average score in the government-administered standardized evaluation test (SIMCE) tend to answer more questions correctly.

Moreover, this paper also finds a significant difference in the improvement (i.e. additional number of questions answered correctly) from Part I to Part II and from part II to Part III between students in the treatment and control groups. In particular, students in the treatment group on average answer correctly almost one additional question in Part II than in Part I, compared to students in the control group who did not have access to a “cheat sheet” during the second part of the test. Analogously, students in the control group on average answer correctly more than half an additional question in Part III than in Part II, after receiving a knowledge summary before the third part of the exam. This again suggests that having access to a knowledge summaries increases student performance on the test.

Although they make sense, the above described results are arguably trivial, since it would be surprising that students did worse in an exam when they have access to additional support materials. However, this paper also finds significant evidence that the performance of students who attended a secondary school with a lower average score in the government-administered standardized evaluation test (SIMCE) tend to answer more questions correctly improves significantly more when being able to use a “cheat sheet”. This is observable both in the significantly greater differential improvement from Part I to Part II for students in the treatment group (i.e. after they received the “cheat sheet” at the end of the first part), and in the significantly greater differential improvement from Part II to Part III for students in the control group (i.e. after they received the “cheat sheet” at the end of the second part). This means that *ceteris paribus* the use of “cheat sheets” seem to be particularly beneficial for students with a secondary education of worse quality.¹¹

Although the results are less robust than those presented above, this paper also finds some evidence of a positive differential impact of having access to a “cheat sheet” on candidates enrolled in the PENTA UC program for talented secondary school students. Since students enrolled in the PENTA UC program

¹¹Note that the fact that no differential impact is observed for the comparisons of Part III vs. Part I is consistent with the presented results, since all candidates completed both Part I and Part III in the same conditions no differential impact would be expected (although this would no longer be true if, for example, having access to the “cheat sheet” for a longer amount of time matters).

come from disadvantaged backgrounds and were already screened during their secondary education and identified as possessing “exceptional ability”, this suggests that *ceteris paribus* the use of “cheat sheets” may be particularly beneficial for talented students. Also, there is some evidence that while students from public schools or the lower quintiles of the income distribution may benefit from “cheat sheets”, they may need more time to do so than what was provided between the parts of the exam, for example because they may need some time to analyze and comprehend it. These results would point in the same direction of the results discussed above, however these relationships are confounded by the fact that the control group also received “cheat sheets” at the end of the second part, so that it is not possible to identify whether these are in fact delayed improvements in the treatment group, or if although unlikely for example the “cheat sheet” instead had a negative impact on the performance of some students in the control group after they received it.

Finally, for illustration purposes a simulation exercise is performed, consisting on analyzing which candidates which students would benefit from or would be worse off with the use of cheat sheets, as measured by whether they advanced to or were relegated from the group of top 20 candidates, which is the number of yearly vacancies in the special special access program. This is observed by comparing the rank of each candidate in Part I (which all students completed without a cheat sheet) and Part III (which all students completed with a cheat sheet), as defined by the number of correct answers relative to the other students who took the exam. The results of this exercise are not robust at the candidate level, since given the reduced number of questions in each part of the test and the left-skewed distribution of the number of correctly answered questions there are many ties which are broken randomly, but they provide an overview of how the introduction of “cheat sheet” affected the results of the test. In particular, it is worth noting that according to the results of the exercise the use of “cheat sheets” seems to mainly affect students close to the cut-off, but there are also cases of very big changes in ranking. For example, one student only answered correctly to 10 questions (66 %) in Part I and at that point would not have ranked in the top 100 among all candidates who took the test, but with the “cheat sheet” in Part III s/he answered correctly to all 15 questions (100 %) and made it to the top 10¹².

The rest of this paper is organized as follows: Section 2 presents the motivation and background for the paper; Section 3 provides a description of the mathematical ability test custom-designed for the analysis¹³; Section 4 provides a description of the randomized control trial design; Section 5 outlines the main findings; Section 6 discusses the robustness of the analysis; Section 7 concludes.

¹²It is worth noting that although s/he was in the treatment from Part I to Part II s/he only answered one additional question correctly, with the sharp improvement occurring from Part II to Part III. This again suggests that students may benefit from having more time to review the “cheat sheet”.

¹³The “cheat sheet” and the full mathematical ability test are included in the Appendix.

2. Motivation

Chile, albeit a middle-income country and an OECD member, faces substantial gaps in the provision of higher education. For example, while the OECD average net coverage of higher education (i.e. the ratio of students 18-24 years old enrolled in higher education) is 59%", the net coverage of higher education in Chile is 36.3%, and the net coverage for the poorest decile of the population is 16.4%¹⁴. Moreover, the poorest students usually attend public or subsidized public schools, while richest students usually attend private schools of higher quality. Only 10% of public school graduates attend elite universities, versus 31% for private schools, resulting in a clear majority of private school students in high quality undergraduate institutions. Also, lengthy degrees lasting 13.6 semesters on average make education comparatively costly, and there is great variance (3:1 to 5:1) in income among graduates with the same degree.¹⁵ The Pontificia Universidad Católica de Chile, the university in which this study was carried out and one of the top in the country, is a good example of the above, with 71.7% of students from households in the upper quintile of the income distribution, versus 3.4% from its lower quintile. The pattern is even more pronounced in the most prestigious degrees: for example, ordinary admission into its Commercial Engineering degree usually requires a score of 730 or more in the "Prueba de Selección Universitaria" (PSU), the standardized admission test administered at the national level. That score corresponds to the 98% percentile of the distribution, and not surprisingly, the overwhelming majority of the 250 new students admitted each year attended private secondary schools and belong to households in the two upper quintiles of the income distribution.¹⁶

Then, it is not surprising that the access to higher education is one of the most important current issues for Chilean society¹⁷, and the main reason behind the notorious student protests which have taken place there during the last years¹⁸. Therefore, there is an on-going debate regarding which is the best way to increase the access to higher education and to ensure equality of opportunity, both at the government and university levels. The first best solution would be to increase the quality of secondary education in public and subsidized secondary schools, and there are many efforts in this direction, however although necessary any such reforms will at best improve the access to higher education only in the long term. In view of this, there are also many initiatives directed at improving the access to higher education for talented students from disadvantaged backgrounds in the short and medium term. For example, an important barrier to access is the cost of higher education, which makes it prohibitive for many households. The government

¹⁴See OECD (2011).

¹⁵For more details about these stylized facts see Comisión de Financiamiento Estudiantil para la Educación Superior (2012).

¹⁶Sources: DEMRE (2011) and Dirección de Servicios Financieros Estudiantiles (2011).

¹⁷It is worth noting that although the access to higher education is at the forefront of the public debate in Chile at the moment, this is of course an issue which is considered key in almost any other country, including the United States (see for example Dickert-Conlin and Rubenstein (2007)). The findings of this paper are therefore relevant for and contribute to the overall academic debate on how to improve the access to higher education.

¹⁸See for example Loofbourow (2013).

has been expanding public funding, but this is many times only partial and doesn't cover the full tuition fees, and stipends to cover living expenses are very rare.¹⁹ Moreover, in order to address potential incentive problems many times the funding takes the shape of loans, but this may have information and risk aversion implications which are not clear, particularly in a middle- or low- income development country setting with high uncertainty regarding the returns to education²⁰. However, at the forefront of the debate is the role of the PSU, the current standardized admissions test, which some argue that due to its focus on knowledge may be discriminating against talented students from poor backgrounds who attended low quality public and subsidized secondary schools, and who cannot afford the test preparation courses ("preuniversitarios") which are widespread among private school students.²¹ There have been several attempts and proposals to reform the PSU²², and the Chilean Ministry of Education has recently included the school class ranking²³ together with the PSU score in the weighting formula to determining the final score for admission purposes, but this remains an open issue.

In view of all of the above, this paper proposes distributing "cheat sheets", i.e. knowledge summaries which outline the basic concepts necessary to successfully complete a test, as a potential low cost and easily implementable alternative to improve the access to higher education for students from disadvantaged socioeconomic backgrounds in the short term. The hypothesis is that although many students who attended public and subsidized secondary schools may have knowledge gaps due to the lower quality of their education, which may be hindering their performance in tests with respect to their peers from private secondary schools, if they are talented enough they may be able to partially offset their disadvantage when during the exam they have access to a knowledge summary which outlines the basic concepts necessary to successfully complete it²⁴. This is fully compatible with Bloom's seminal Taxonomy of Educational Objectives²⁵, which classifies *Knowledge* as the first but lowest of educational goals, followed by *Comprehension* and *Application*. I.e., secondary students who do not *know* the answers to the questions proposed to them in a test may not necessarily be less talented or less prepared to succeed in higher education. On the contrary, if with the help of a "cheat sheet" they can overcome their knowledge gaps by quickly *comprehending* and *applying* the

¹⁹See, for example, Sánchez (2011) for a pre-2014 reform discussion of the challenges facing the higher education system in Chile, or Williamson and Sánchez (2009), who discuss the necessary basic features of a potential government-funded public higher education system in Chile.

²⁰See Dinkelman and Martinez (2011), who using an experimental design evaluate the role of information about financial aid in the access to higher education in Chile, or Hoxby and Turner (2012) who also look at the issue in the United States using a randomized control trial.

²¹For a related study on the subject in Chile see Banerjee et al (2012), who using random assignment provide test preparation courses to students from disadvantaged backgrounds and evaluate their impact.

²²See for example Santelices et al (2011).

²³The ranking of students with respect with their secondary school peers.

²⁴It is worth noting that, as mentioned for example in Heckman (1995), latent ability alone cannot explain differences in test scores or wages among individuals, nor is independent of the individual's context.

²⁵See Bloom et al (1956) for a discussion of the original taxonomy, and Krathwohl (2002) for a proposed modern revision to it.

concepts outlines in it, this probably means that they are actually as talented (if not more) than their peers and likely to succeed when provided with the same means. Or in other words, “cheat sheets” may help to better distinguish knowledge from ability, as reflected on better comprehension and application of concepts.

3. Mathematical Ability Test

In order to empirically evaluate the impact of “cheat sheets”, I custom-designed a multiple-choice mathematical ability test intended to measure an individual’s ability while minimizing the reliance on previously acquired specific knowledge²⁶. The type of questions used in the test were inspired by those featured in the previous national standardized admissions test in use in Chile until 2002, the “Prueba de Aptitud Académica”, or *Academic Aptitude Test*. See, for example, Tapia Rojas et al (1996).. Moreover, I also put together a two page knowledge summary, or “cheat sheet”, which outlines all the concepts which I considered necessary to successfully complete the test²⁷. This test was subsequently used to evaluate the candidates applying for admission into the Commercial Engineering degree at the Pontificia Universidad Católica de Chile via the “Talento + Inclusión” (*Talent + Integration*) special access program for students from disadvantaged socioeconomic backgrounds²⁸.

The mathematical ability test was divided in three parts, which featured 15 analogous questions each (i.e. the first questions of each part were different but analogous)²⁹, and candidates were randomly divided into treatment and control groups. All students took the first part of the test without any support materials, but then the “cheat sheet” was distributed to each of the candidates in the treatment group, who then had about ten minutes to examine it before the second part started. Students in the control group simply had a ten minute break after completing the first part of the test, but received the same “cheat sheet” after having completed the second part. Once they received the “cheat sheet” all students could keep it with them until the end of the test, when they had to return it. For fairness purposes only the number of correct answers from the third part (which all students took with the aid of the “cheat sheet”) was considered for admission via the special access program, together with other criteria³⁰.

²⁶As discussed for example in Bransford (1999) or Pellegrino (2001) this in itself is obviously far from a trivial task, but I trust that the result is satisfactory.

²⁷The “cheat sheet” and the full mathematical ability test are included in the Appendix.

²⁸See Díez-Amigo (2014) for a full description and analysis of this access program.

²⁹For comparison purposes, the questions in each part of the test would ideally be the same. However, this would obviously raise some concerns even if the students do not know the answers to the test. Therefore, different but analogous questions are used. This means that the underlying concept of the question is the same, but the precise numbers or examples used differ from part to part.

³⁰Although the tests were strictly monitored to avoid cheating or copying among students, as a further precaution two versions of the tests were distributed, featuring the same questions in a different order

4. Randomized Control Trial

This staged randomization design allows to analyze the impact of the “cheat sheet” on student performance on the test, by looking at the differences in the number of questions answered correctly across the three parts of the test between students in the control and treatment groups. In particular, it is possible to compare the difference in the number of questions answered correctly between Part I and Part II in the treatment and control groups in order to measure the impact of the “cheat sheets” on academic performance. Analogously, it is also possible to compare the difference in the number of questions answered correctly between Part II and Part III in the treatment and control groups³¹. Also, for illustration purposes it is possible to compare how all students performed in the first part compared to the third part of the exam, and see which students would benefit from or be worse off with the use of “cheat sheets”. Finally, it is possible to analyze what is the relationship between the observable student characteristics and the improvement in performance with a “cheat sheet”, or with the likelihood of benefiting from or be worse off with it.

A total of 175 candidates took the mathematical ability test over the 2013 and 2014 academic year application periods. 57 students took it at the end of 2012 and 118 took it at the end of 2013, respectively. They were randomly divided into treatment and control groups³² consisting of 79 and 96 students, respectively. The balance across control and treatment groups is presented on Table I, but as expected the joint orthogonality hypothesis cannot be rejected for any of the observed student characteristics.³⁴

Table II presents the frequency histograms for the number of correct answers in each of the three parts of the mathematical ability test by treatment and control group. As it can be observed it seems that the

³¹Note however that the difference in performance between Part I and Part II need not be comparable with the difference in performance between Part II and Part III. For example if there is non-linear "learning by doing", or simply if students become tired towards the end of the exam.

³²For the 2013 application period students were assigned to treatment and control using a stratified randomization. The strata used were: (i) the math score obtained in the standardized test administered to secondary school students (SIMCE) (ii) whether the student attended a secondary school in the Santiago Metropolitan Region, (iii) whether the student attended a public or subsidized secondary school³³, (iv) whether the student attended the PENTA UC program for talented secondary school students, (v) the quintile of the income distribution to which the student belongs, and (vi) the student's gender (1 = male). Stratification guarantees balance across strata in the treatment and controls groups, and is particularly important in this case given the reduced population size, which may have caused balance problems if simple random assignment had been used. For the 2014 application period simple random assignment was used to divide the students in the cohort to treatment and control groups.

³⁴Note that three students who took the mathematical ability test but were found to be ineligible to participate in the special access program due to having attended a private school and/or belonging to the top quintile of the income distribution are excluded from the analysis. Also, it is worth noting that although all students took the test in their assigned group, there were a few students who signed up to take the test but did not show up on the day of the exam and were excluded from the special access program and this analysis. However, the number of no-shows was very limited and affected similarly both the treatment and control groups.

distribution may be skewed to the left and/or truncated at the maximum possible number of correct answers, particularly after the “cheat sheets” were distributed.

5. Findings

5.1. Do the “cheat sheets” impact the performance of students?

Table III analyzes the differences in the number of correct answers in each of the three parts of the mathematical ability test between treatment and control groups. The dependent variable in all regressions (columns) is the number of correct answers in each corresponding part of the test, and independent variables are listed on the left (rows). Apart from the treatment indicator (first row), several additional controls are included in the extended specifications (1.2, 2.2 and 3.2) for robustness purposes. In particular, the linear regression models presented in Table III are represented as

$$(.1) \quad y_{ik} = \beta_0 + \delta_1 T_i + year + e_i$$

$$(.2) \quad y_{ik} = \beta_0 + \delta_1 T_i + \sum_{h=1}^6 \beta_h x_{hi} + year + e_i$$

where y_{ik} is the number of questions answered correctly by student i in part $k = 1, 2, 3$ of the test, T_i is an indicator variable denoting whether the student was assigned to the control or treatment group, $year$ is an indicator variable denoting whether the student belongs to the 2014 cohort (year fixed effect), and $x_{hi} \in \{1, \dots, 6\}$ are student characteristics which as mentioned are included in the extended specifications (1.2, 2.2 and 3.2) for robustness purposes. These are the same variables used as strata in the random assignment, i.e.: (i) the math score obtained in the standardized test administered to secondary school students (SIMCE) (ii) whether the student attended a secondary school in the Santiago Metropolitan Region, (iii) whether the student attended a public school, as opposed to a subsidized one (private school students were not eligible to apply for special admission), (iv) whether the student attended the PENTA UC program for talented secondary school students, (v) whether the student belongs to the lower three quintiles of the income distribution, as opposed to the fourth quintile (fifth quintile students were not eligible to apply for special admission), and (vi) the student’s gender (1 = male). Huber-White heteroskedasticity-consistent standard errors are reported between parentheses.

Analogously to the above, Table IV analyzes the differences in the improvement (i.e. additional number of correct answers) across each of the three parts of the mathematical ability test between treatment and control groups. The dependent variable in all regressions (columns) is the number additional correct answers across

the corresponding parts of the test, and independent variables are listed on the left (rows)³⁵. As before, apart from the treatment indicator (x.0), several additional controls are included in the (x.1) specifications for robustness purposes. The (x.2) specifications further include the interaction terms between the treatment indicator and the additional controls. In particular, the linear regression models presented in Table IV are represented as

$$(.0) \quad y_{ikl} = \beta_0 + \delta_1 T_i + year + e_i$$

$$(.1) \quad y_{ikl} = \beta_0 + \delta_1 T_i + \sum_{h=1}^6 \beta_h x_{hi} + year + e_i$$

$$(.2) \quad y_{ikl} = \beta_0 + \delta_1 T_i + \sum_{h=1}^6 \beta_h x_{hi} + \sum_{h=1}^6 \gamma_h T_i x_{hi} + year + e_i$$

where y_{ikl} is the number of additional questions answered correctly by student i in part $k = 1, 2$ compared to part $l = 2, 3$ of the test, T_i is an indicator variable denoting whether the student was assigned to the control or treatment group, $year$ is an indicator variable denoting whether the student belongs to the 2014 cohort (year fixed effect), and $x_{hi}h = \{1, \dots, 6\}$ are student characteristics which as mentioned are included in the extended specifications (1.2, 2.2 and 3.2) for robustness purposes. Once again these are the same variables used as strata in the random assignment, i.e.: (i) the math score obtained in the standardized test administered to secondary school students (SIMCE) (ii) whether the student attended a secondary school in the Santiago Metropolitan Region, (iii) whether the student attended a public school, as opposed to a subsidized one (private school students were not eligible to apply for special admission), (iv) whether the student attended the PENTA UC program for talented secondary school students, (v) whether the student belongs to the lower three quintiles of the income distribution, as opposed to the fourth quintile (fifth quintile students were not eligible to apply for special admission), and (vi) the student's gender (1 = male). As before Huber-White heteroskedasticity-consistent standard errors are reported between parentheses.

As it can be observed on Table III this paper only finds a significant difference in the number of questions answered correctly between students in the treatment and control group in Part II of the test. Since as described above this is precisely the part in which candidates in the control group did not yet have access to the “cheat sheet”, as opposed to students in the treatment group, this suggests that *ceteris paribus* having access to a knowledge summaries results in about one additional question answered correctly, out of a total of fifteen. Also, as expected it seems that students who attended a secondary school with a higher average score in the government-administered standardized evaluation test (SIMCE) tend to answer more questions correctly. These results are robust to the inclusion of the additional controls.

³⁵For example, in columns (1.0, 1.1 and 1.2 the dependent variable is the number of additional correct answers for each students in Part II of the mathematical ability test, compared to Part I.

Moreover, as it can be observed on Table IV, this paper also finds a significant difference in the improvement (i.e. additional number of questions answered correctly) from Part I to Part II and from part II to Part III between students in the treatment and control groups. In particular, students in the treatment group on average answer correctly almost one additional question in Part II than in Part I, compared to students in the control group who did not have access to a “cheat sheet” during the second part of the test. Analogously, students in the control group on average answer correctly more than half an additional question in Part III than in Part II, after receiving a knowledge summary before the third part of the exam. This again suggests that having access to a knowledge summaries increases student performance on the test. These results are also robust to the inclusion of the additional controls.

5.2. Which types of students are impacted by the use of “cheat sheets”?

Although they make sense, the above described results are arguably trivial, since it would be surprising that students did worse in an exam when they have access to additional support materials. However, as it can also be observed on Table IV this paper also finds significant evidence that the performance of students who attended a secondary school with a lower average score in the government-administered standardized evaluation test (SIMCE) tend to answer more questions correctly improves significantly more when being able to use a “cheat sheet”. This is observable both in the significantly greater differential improvement from Part I to Part II for students in the treatment group (i.e. after they received the “cheat sheet” at the end of the first part), and in the significantly greater differential improvement from Part II to Part III for students in the control group (i.e. after they received the “cheat sheet” at the end of the second part). This means that *ceteris paribus* the use of “cheat sheets” seem to be particularly beneficial for students with a secondary education of worse quality.³⁶

Although the results are less robust than those presented above, this paper also finds some evidence of a positive differential impact of having access to a “cheat sheet” on candidates enrolled in the PENTA UC program for talented secondary school students. Since students enrolled in the PENTA UC program come from disadvantaged backgrounds and were already screened during their secondary education and identified as possessing “exceptional ability”, this suggests that *ceteris paribus* the use of “cheat sheets” may be particularly beneficial for talented students. Also, there is some evidence that while students from public schools or the lower quintiles of the income distribution may benefit from “cheat sheets”, they may need more time to do so than what was provided between the parts of the exam, for example because they may

³⁶Note that the fact that no differential impact is observed for the comparisons of Part III vs. Part I is consistent with the presented results, since all candidates completed both Part I and Part III in the same conditions no differential impact would be expected (although this would no longer be true if, for example, having access to the “cheat sheet” for a longer amount of time matters).

need some time to analyze and comprehend it. These results would point in the same direction of the results discussed above, however these relationships are confounded by the fact that the control group also received “cheat sheets” at the end of the second part, so that it is not possible to identify whether these are in fact delayed improvements in the treatment group, or if although unlikely for example the “cheat sheet” instead had a negative impact on the performance of some students in the control group after they received it.³⁷. Apart from the above, a few other significant relationships can be observed on Table IV, but no other robust causal relationships have been detected.

Table V further analyzes the relationship between the improvement (i.e. additional number of correct answers) across each of the parts of the mathematical ability test and the student characteristics, by looking separately at the treatment and control groups. Each column corresponds to one regression specification, and independent variables are listed on the left (rows). Two sets of specifications are presented stacked over each other. In the first set of regressions (,1) the dependent variable is the improvement between Part I and Part II of the test for students in the treatment group, who received the cheat sheet before taking the second part of the exam. In the second set of regressions (,2) the dependent variable is the improvement between Part II and Part III of the test for students in the control group, who received the cheat sheet before taking the third part of the exam. All six independent variables are first considered jointly (0.) and then separately (1. -6.). In particular, the linear regression models presented in Table V are represented as

$$(0.1) \quad y_i = \beta_0 + \sum_{h=1}^6 \beta_h x_{hi} + year + e_i \text{ if } T_i = 1$$

$$(1.1-6.1) \quad y_i = \beta_0 + \beta_h x_{hi} + year + e_i \text{ if } T_i = 1$$

$$(0.2) \quad y_i = \beta_0 + \sum_{h=1}^6 \beta_h x_{hi} + year + e_i \text{ if } T_i = 0$$

$$(1.2-6.2) \quad y_i = \beta_0 + \beta_h x_{hi} + year + e_i \text{ if } T_i = 0$$

where y_i is the number of additional questions answered correctly by student i in Part II compared to Part I (0,1) – (6,1) or in Part III compared to Part II (0,2) – (6,2), $year$ is an indicator variable denoting whether the student belongs to the 2014 cohort (year fixed effect), and $x_{hi}h = \{1, ..., 6\}$ are once again student characteristics. As before these are the same variables used as strata in the random assignment, i.e.: (i) the math score obtained in the standardized test administered to secondary school students (SIMCE) (ii) whether the student attended a secondary school in the Santiago Metropolitan Region, (iii) whether the student attended a public school, as opposed to a subsidized one (private school students were not eligible to apply

³⁷Once again, since all candidates completed both Part I and Part III in the same conditions no differential impact would be expected, although this would no longer be true if having access to the “cheat sheet” for a longer amount of time matters, as it seems that it might be the case.

for special admission), (iv) whether the student attended the PENTA UC program for talented secondary school students, (v) whether the student belongs to the lower three quintiles of the income distribution, as opposed to the fourth quintile (fifth quintile students were not eligible to apply for special admission), and (vi) the student’s gender (1 = male). As usual Huber-White heteroskedasticity-consistent standard errors are reported between parentheses.

As it can be observed on Table V, this approach again finds evidence that the performance of students who attended a secondary school with a lower average score in the government-administered standardized evaluation test (SIMCE) improves significantly more when being able to use a “cheat sheet”. This supports the above presented results and again suggests that *ceteris paribus* the use of “cheat sheets” may be particularly beneficial for students with a secondary education of worse quality. Apart from the above, a few other significant relationships can be observed on Table IV, but no other robust causal relationships have been detected.

5.3. Which students benefit from or are worse off with the “cheat sheets”?

For illustration purposes, let’s ignore the rest of the criteria used in the special admission program, and assume that the mathematical ability test would determined admission to the university. If only 20 slots were available, who would benefit from or be worse off the use of “cheat sheets?”. Or in other words, who would make it to the top 20 in Part I but be excluded from it on Part III?³⁸

Table VI presents a roster of all the students who benefit from or are worse off with the use of cheat sheets, as measured by whether they advanced to or were relegated from the group of top 20 candidates who would be admitted via the special access program, respectively. This is observed by comparing the rank of each candidate in Part I (which all students completed without a cheat sheet) and Part III (which all students completed with a cheat sheet), as defined by the number of correct answers relative to the other students who took the exam. Ties among students with the same number of correct students are resolved randomly, and the results of this exercise are not robust at the candidate level, since given the reduced number of questions in each part of the test and the left-skewed distribution of the number of correctly answered questions there are many ties which are broken randomly. However, they provide an overview of how the introduction of “cheat sheet” affected the results of the test. Each row corresponds to one student, for which the rank and number of correct answers in each of the three parts of the mathematical ability test are listed. The last column indicates whether the student was in the treatment or control group.

³⁸Note that in reality 20 special access vacancies were available for each of the 2013 and 2014 admission years, so that 40 vacancies would be available for the two cohorts.

As it can be observed on Table VI, according to the results of the exercise the use of “cheat sheets” seems to mainly affect students close to the cut-off, but there are also cases of very big changes in ranking. For example, one student only answered correctly to 10 questions (66 %) in Part I and at that point would not have ranked in the top 100 among all candidates who took the test, but with the “cheat sheet” in Part III s/he answered correctly to all 15 questions (100 %) and made it to the top 10³⁹.

Table VII then analyzes the relationship between student characteristics and the likelihood of benefiting from or being worse off with the use of cheat sheets, as measured by the likelihood of advancing to or being relegated from the group of top 20 candidates who would be admitted via the special access program, respectively. As above, this is obtained by comparing the rank of each candidate in Part I (which all students completed without a cheat sheet) and Part III (which all students completed with a cheat sheet), as defined by the number of correct answers relative to the other students who took the exam. Ties among students with the same number of correct students are resolved randomly⁴⁰. Each column corresponds to one regression specification, and independent variables are listed on the left (rows). Two sets of specifications are presented stacked over each other. In the first set of regressions (,1) the dependent variable is the binomial indicator of whether the student benefited from the use of a cheat sheet, i.e. whether s/he made it to the top 20 in Part III but not Part I. In the second set of regressions (,2) the dependent variable is the binomial indicator of whether the student was worse off with the use of a cheat sheet, i.e. whether s/he made it to the top 20 in Part I but not Part III. All six independent variables are first considered jointly (0.x) and then separately (1.x-6.x). In particular, the linear regression models presented in Table VI are represented as

$$(0.1) \quad y_{1i} = \beta_0 + \sum_{h=1}^6 \beta_h x_{hi} + year + e_i$$

$$(1.1-6.1) \quad y_i = \beta_0 + \beta_h x_{hi} + year + e_i$$

$$(0.2) \quad y_{2i} = \beta_0 + \sum_{h=1}^6 \beta_h x_{hi} + year + e_i$$

$$(1.2-6.2) \quad y_i = \beta_0 + \beta_h x_{hi} + year + e_i$$

where y_{1i} is an indicator variable equal to one if the student benefited from the use of a cheat sheet (i.e. whether s/he made it to the top 20 in Part III but not Part I), y_{2i} is an indicator variable equal to one if the student was worse off with the use of a cheat sheet (i.e. whether s/he made it to the top 20 in Part I but not

³⁹It is worth noting that although s/he was in the treatment from Part I to Part II s/he only answered one additional question correctly, with the sharp improvement occurring from Part II to Part III. This again suggests that students may benefit from having more time to review the “cheat sheet”.

⁴⁰Once again, this may affect which particular students make it or not to the top 20, but the results are in any case quantitatively comparable.

Part III), and *year* is an indicator variable denoting whether the student belongs to the 2014 cohort (year fixed effect). As before $x_{hi}h = \{1, \dots, 6\}$ are observable student characteristics. As usual these are the same variables used as strata in the random assignment, i.e.: (i) the math score obtained in the standardized test administered to secondary school students (SIMCE) (ii) whether the student attended a secondary school in the Santiago Metropolitan Region, (iii) whether the student attended a public school, as opposed to a subsidized one (private school students were not eligible to apply for special admission), (iv) whether the student attended the PENTA UC program for talented secondary school students, (v) whether the student belongs to the lower three quintiles of the income distribution, as opposed to the fourth quintile (fifth quintile students were not eligible to apply for special admission), and (vi) the student’s gender (1 = male). As usual Huber-White heteroskedasticity-consistent standard errors are reported between parentheses.

Unfortunately, the estimated coefficients from the above specification, presented on Table VII, are very sensitive to the above described random breaking of ties among students who answered correctly to the same number of questions, which can have a great impact on the characteristics of the candidates who would be “worse-off” and “better-off” with the use “cheat sheets”. Therefore, they are presented in this paper for illustration purposes but not further discussed.

6. Robustness

Given the relatively reduced number of students involved in the study, the main robustness concern is precision, i.e. limited statistical power. Although this would not affect the validity of the main results presented, which seem to be very robust, this would reduce the likelihood of observing smaller effect sizes, and therefore the lack of an observed significant effect in this study must be interpreted as lack of evidence, not as proof of non-existence. On a related note, given the limited size of the sample both the Central Limit Theorem and the Law of Large Numbers on which the standard linear regression models rely might not hold, potentially threatening the validity of the econometric models used. However, given that the pooled sample for academic years 2014 and 2014 features in excess of 150 observations this is considered unlikely, and no evidence of it is found.

Also, as already mentioned some students who signed up for the test and were included in the stratified random assignment did not show up for the test. However, the number of individuals who signed up but did not show up was very reduced, and no (differential) pattern is observable either among the no-shows or across the treatment and control groups, and therefore this is not considered a threat to internal validity.

Moreover, although the stratified random assignment seems to have been quiet successful and the balance

across treatment and control groups seems to be quite robust, the randomized control trial design only guarantees the exogeneity of the treatment, i.e. the use of cheat sheets in Part II of the test. All the other student characteristics studied are potentially endogenous, and therefore their relationship with the independent variables in the specifications above should be interpreted with care. That said, given that the pooled sample for academic years 2013 and 2014 features in excess of 150 observations the balance across treatment and control groups is not a big concern, and as already mentioned, as it can be observed on Table I the joint orthogonality hypothesis cannot be rejected for any of the observed student characteristics. Therefore this is not considered a serious concern, either.

Furthermore, note that the most robust comparison of treatment and control is that of the difference in the number of correctly answered questions between Part I and Part II of the exam (i.e. columns (1.x) in Table IV). This is because the comparison of Part III and Part II is confounded by the fact that the control group also received “cheat sheets” at the end of the second part, so that it is not possible to identify whether the observed impacts are delayed improvements in the treatment group, or if for example the “cheat sheet” instead had a negative impact on the performance of some students in the control group after they received it. Also, note that according to Table IV there is some evidence that some students in the treatment group improved significantly more from Part I to Part III, compared to their counterparts in the control group. This may indicate that receiving the “cheat sheet” earlier might have a positive impact on performance, for example because students have more time to examine it, suggesting that “cheat sheets” may be more effective to address knowledge gaps if more time is provided for the students to familiarize themselves with it before taking the test.

Regarding external validity it is worth noting that all the observations in this analysis correspond to students from disadvantaged backgrounds who believed both that they may not be able to obtain admission in a prestigious undergraduate program in Chile and that they were nonetheless talented enough to prevail among their peers and obtain admission through an special access program. This means that apart from maybe being talented these students may be more motivated, confident, risk-averse, etc. than their peers, so that the impact of using “cheat sheets” for the general student population may differ.

Also, although as noted there were many observable differences among candidates, which were large enough to allow for the identification of some significant effects, the students in this study were relatively similar to each other, as for example there were no students from elite private schools. This may also pose a threat for external validity, as the impact of “cheat sheets” may be larger when including students with really good secondary education in the analysis. Or conversely, these students may benefit even more from having a knowledge summary, reducing the differential impact with respect to students from disadvantaged backgrounds.

Moreover, the students who took the mathematical ability test were not aware that “cheat sheets” would be provided. It is conceivable to think that if they had known about this fact, they may have prepared for the exam in a different manner. This may affect the external validity of the results presented.

Finally, note also that the distribution of the number of correct answers may be skewed to the left and/or truncated on the right. This might point towards the format of the mathematical ability test custom-designed for this study to be too easy, either because the number of questions was too low or the time allowance was too long. However, for policy purposes these concerns would be easily addressed by either increasing the number of questions or decreasing the time allowance, so that the weight of the distribution is shifted to the left.

7. Conclusion

This paper proposes distributing “cheat sheets” (i.e. knowledge summaries which outline the basic concepts necessary to successfully complete a test), as a potential low cost and easily implementable alternative to improve the access to higher education for students from disadvantaged socioeconomic backgrounds in the short term. The hypothesis is that although many students who attended public and subsidized secondary schools may have knowledge gaps due to the lower quality of their education, which may be hindering their performance in tests with respect to their peers from private secondary schools, if they are talented enough they may be able to partially offset their disadvantage when during the exam they have access to a knowledge summary which outlines the basic concepts necessary to successfully complete it.

In order to empirically evaluate the impact of “cheat sheets”, I custom-designed a multiple-choice mathematical ability test intended to measure an individual’s ability while minimizing the reliance on previously acquired specific knowledge. Moreover, I also put together a two page knowledge summary, or “cheat sheet”, which outlines all the concepts which I considered necessary to successfully complete the test⁴¹. This test was subsequently used to evaluate the candidates applying for admission into the Commercial Engineering degree at the Pontificia Universidad Católica de Chile via the “Talento + Inclusión” (*Talent + Integration*) special access program for students from disadvantaged socioeconomic backgrounds. A staged randomized control trial design allows to analyze the impact of the “cheat sheet” on student performance on the test, by looking at the difference in performance across the three parts of the test between students in the control and treatment groups (the latter receive a “cheat sheet” after the first part of the test, while the former receive it after its second one).

⁴¹The “cheat sheet” and the full mathematical ability test are included in the Appendix.

This paper only finds a significant difference in the number of questions answered correctly between students in the treatment and control group in Part II of the test. Since this is precisely the part in which candidates in the control group did not yet have access to the “cheat sheet”, as opposed to students in the treatment group, this suggests that *ceteris paribus* having access to a knowledge summaries results in improved academic performance. Also, as expected it seems that students who attended a secondary school with a higher average score in the government-administered standardized evaluation test (SIMCE) tend to answer more questions correctly.

Moreover, this paper also finds a significant difference in the improvement (i.e. additional number of questions answered correctly) from Part I to Part II and from part II to Part III between students in the treatment and control groups. In particular, students in the treatment group perform significantly better in Part II than in Part I, compared to students in the control group who did not have access to a “cheat sheet” during the second part of the test. Analogously, students in the control group perform significantly better in Part III than in Part II, after receiving a knowledge summary before the third part of the exam. This again suggests that having access to a knowledge summaries increases student performance on the test.

Although they make sense, the above described results are arguably trivial, since it would be surprising that students did worse in an exam when they have access to additional support materials. However, this paper also finds significant evidence that the performance of students who attended a secondary school with a lower average score in the government-administered standardized evaluation test (SIMCE) tend to answer more questions correctly improves significantly more when being able to use a “cheat sheet”. This is observable both in the significantly greater differential improvement from Part I to Part II for students in the treatment group (i.e. after they received the “cheat sheet” at the end of the first part), and in the significantly greater differential improvement from Part II to Part III for students in the control group (i.e. after they received the “cheat sheet” at the end of the second part). This means that *ceteris paribus* the use of “cheat sheets” seem to be particularly beneficial for students with a secondary education of worse quality.

Although the results are less robust than those presented above, this paper also finds some evidence of a positive differential impact of having access to a “cheat sheet” on candidates enrolled in the PENTA UC program for talented secondary school students. Since students enrolled in the PENTA UC program come from disadvantaged backgrounds and were already screened during their secondary education and identified as possessing “exceptional ability”, this suggests that *ceteris paribus* the use of “cheat sheets” may be particularly beneficial for talented students. Also, there is some evidence that while students from public schools or the lower quintiles of the income distribution may benefit from “cheat sheets”, they may need more time to do so than what was provided between the parts of the exam, for example because they may need some time to analyze and comprehend it.

Finally, for illustration purposes a simulation exercise is performed, consisting on analyzing which candidates which students would benefit from or would be worse off with the use of cheat sheets, as measured by whether they advanced to or were relegated from the group of top 20 candidates, which is the number of yearly vacancies in the special special access program. This is observed by comparing the rank of each candidate in Part I (which all students completed without a cheat sheet) and Part III (which all students completed with a cheat sheet), as defined by the number of correct answers relative to the other students who took the exam. The results of this exercise are not robust at the candidate level, since given the reduced number of questions in each part of the test and the left-skewed distribution of the number of correctly answered questions there are many ties which are broken randomly, but they provide an overview of how the introduction of “cheat sheet” affected the results of the test. In particular, it is worth noting that according to the results of the exercise the use of “cheat sheets” seems to mainly affect students close to the cut-off, but there are also cases of very big changes in ranking.

All the above has important implications for educational policies in Chile and elsewhere, suggesting that the use of “cheat sheets” would be a cheap and easily implementable remedy to facilitate the access to higher education for students with disadvantaged backgrounds who may have knowledge gaps due to a secondary education of lower quality. It is worth noting however that this would be a complement, but not a substitute to deeper educational reform. In particular, in the medium and long term the first best solution would of course be to improve the quality of secondary education and/or the design of admissions tests, but the use of “cheat sheets” could help mitigate the access to higher education problems of students from disadvantaged backgrounds in the short term.

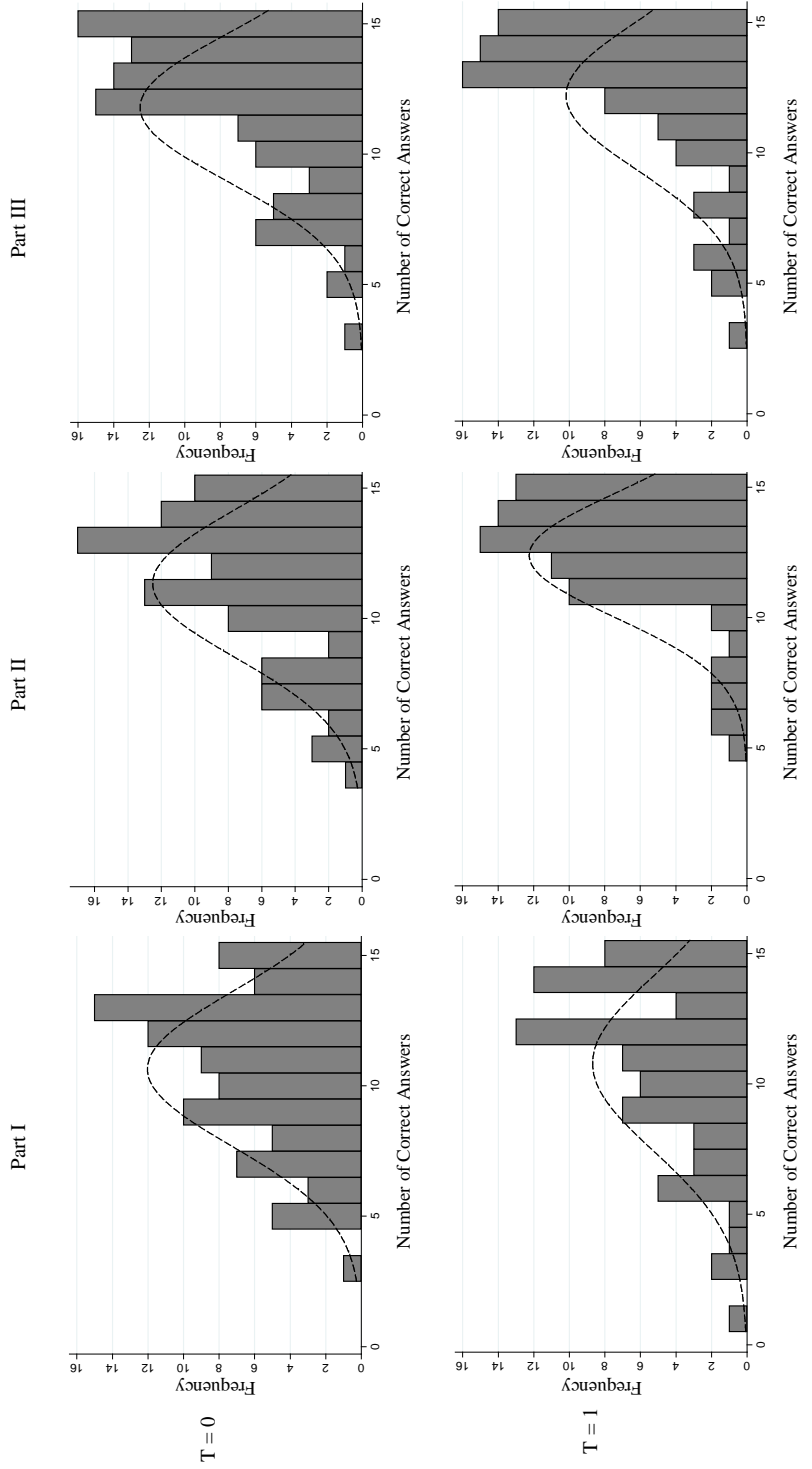
TABLE I
BALANCE ACROSS CONTROL AND TREATMENT GROUPS

	Control (Cheat Sheet in Part III)	Treatment (Cheat Sheet in Part II)	p-value
Secondary School Standardized Math Test Score (SIMCE)	290.52 (5.58)	290.00 (4.96)	0.95
Region (1 = Santiago Metropolitan Region)	0.17 (0.04)	0.16 (0.04)	0.94
Secondary School Type (1 = Public)	0.36 (0.05)	0.28 (0.05)	0.27
PENTA UC Program Fellow (1 = Yes)	0.04 (0.02)	0.07 (0.03)	0.52
Income Distribution Quintile (1 = I)	0.24 (0.05)	0.18 (0.05)	0.35
Income Distribution Quintile (1 = II)	0.26 (0.05)	0.33 (0.06)	0.35
Income Distribution Quintile (1 = III)	0.33 (0.05)	0.27 (0.05)	0.45
Gender (1 = Male)	0.42 (0.05)	0.47 (0.06)	0.53
Observations	89	73	

NOTES. Candidates seeking to enter the undergraduate degree via the special admission program for students from disadvantaged socioeconomic backgrounds took a multiple-choice mathematical test, which was custom-designed to try to measure the individual's ability while minimizing the reliance on previously acquired knowledge. The objective was to try to identify talented individuals who may have had a secondary education of poor quality, but who would otherwise be able to successfully complete the undergraduate degree. The mathematical test was divided in three parts, which featured 15 analogous questions each (i.e. the first questions of each part were different but analogous), and candidates were randomly divided into stratified treatment and control groups. All students took the first part of the test without any support materials, but then a "cheat sheet" (i.e. knowledge summaries outlining the basic concepts needed to successfully answer the test questions) was distributed to each of the candidates in the treatment group, who then had about ten minutes to examine it before the second part started. Students in the control group simply had a ten minute break after completing the first part of the test, but received the same "cheat sheet" after having completed the second part. Once they received the "cheat sheet" all students could keep it with them until the end of the test, and for fairness purposes only the number of correct answers from the third part (which all students took with the aid of the "cheat sheet") was considered for admission via the special access program, together with several other criteria. However, this staged randomization design allows to analyze the impact of the cheat sheet on the students' performance on the test. The above table provides an overview of the balance between control and treatment groups after the stratified random assignment. Each cell presents the mean of the balance variable (row) in group (column), and standard errors are reported between parentheses. Balance variables are: (i) the math score obtained in the standardized test administered to secondary school students (SIMCE) (ii) whether the student attended a secondary school in the Santiago Metropolitan Region, (iii) whether the student attended a public school, as opposed to a subsidized one (private school students were not eligible to apply for special admission), (iv) whether the student attended the PENTA UC program for talented secondary school students, (v) whether the student belongs to the lower three quintiles of the income distribution, as opposed to the fourth quintile (fifth quintile students were not eligible to apply for special admission), and (vi) the student's gender (1 = male). Reported p-values are for joint orthogonality test across control and treatment groups each of the corresponding balance variables.

FIGURE II

FREQUENCY HISTOGRAM OF NUMBER OF CORRECT ANSWERS IN EACH OF THREE PARTS OF MATHEMATICAL ABILITY TEST BY TREATMENT AND CONTROL GROUP



NOTES. The graphics above are frequency histograms for the number of correct answers in each of the three parts of the mathematical ability test (columns) by control and treatment groups (rows). As already mentioned, the mathematical test was divided in three parts, which featured 15 analogous questions each (i.e. the first questions of each part were different but analogous), and candidates were randomly divided into stratified treatment and control groups. All students took the first part of the test without any support materials, but then a "cheat sheet" (i.e. knowledge summaries outlining the basic concepts needed to successfully answer the test questions) was distributed to each of the candidates in the treatment group, who then had about ten minutes to examine it before the second part started. Students in the control group simply had a ten minute break after completing the first part of the test, but received the same "cheat sheet" after having completed the second part. Once they received the "cheat sheet" all students could keep it with them until the end of the test, and for fairness purposes only the number of correct answers from the third part (which all students took with the aid of the "cheat sheet") was considered for admission via the special access program, together with several other criteria. The vertical axes show the number of observations in each bin (i.e. the number of students who answered correctly the corresponding number of times), and the horizontal axes denote the number of correct answers in each part of the test. $T = 0$ denotes the control group (first row) and $T = 1$ denotes the treatment group. The dotted lines depict the fitted normal distributions for each subpopulation.

TABLE III

DIFFERENCES IN NUMBER OF CORRECT ANSWERS IN EACH OF THREE PARTS OF MATHEMATICAL ABILITY TEST BETWEEN TREATMENT AND CONTROL GROUPS

	Part I		Part II		Part III	
	(1.1)	(1.2)	(2.1)	(2.2)	(3.1)	(3.2)
Number of Correct Answers in Each Part of the Test						
Treatment (1 = Cheat Sheet in Part II)	0.164 (0.502)	-0.019 (0.443)	1.075 (0.410)***	1.064 (0.381)***	0.425 (0.450)	0.261 (0.429)
Secondary School Standardized Math Test Score (SIMCE)		0.031 (0.011)***		0.024 (0.008)***		0.023 (0.010)**
Region (1 = Santiago Metropolitan Region)		-0.013 (0.651)		-0.421 (0.579)		-0.022 (0.541)
Secondary School Type (1 = Public)		-0.442 (0.480)		-0.408 (0.407)		-0.607 (0.484)
PENTA UC Program Fellow (1 = Yes)		0.558 (0.589)		-0.349 (0.605)		-0.034 (0.574)
Income Distribution Quintile (1 = I)		-1.361 (0.720)*		-0.916 (0.631)		-1.173 (0.678)*
Income Distribution Quintile (1 = II)		-0.574 (0.634)		-0.214 (0.525)		-0.195 (0.579)
Income Distribution Quintile (1 = III)		-0.257 (0.499)		-0.044 (0.414)		-0.173 (0.483)
Gender (1 = Male)		1.753 (0.459)***		1.281 (0.394)***		1.380 (0.444)***
Admission Year (1 = 2014)	-0.539 (0.500)	-0.091 (0.427)	-0.645 (0.411)	-0.210 (0.361)	-0.453 (0.445)	-0.122 (0.414)
Constant Term	10.986 (0.433)***	1.817 (3.324)	11.750 (0.370)***	4.323 (2.605)*	12.077 (0.390)***	5.104 (2.996)*
R ²	0.01	0.35	0.05	0.34	0.01	0.26
Observations	162	152	162	152	162	152

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

NOTES. This table analyzes the differences in the number of correct answers in each of the three parts of the mathematical ability test between the randomly assigned treatment and control groups. As already mentioned, the mathematical test was divided in three parts, which featured 15 analogous questions each (i.e. the first questions of each part were different but analogous), and candidates were randomly divided into stratified treatment and control groups. All students took the first part of the test without any support materials, but then a "cheat sheet" (i.e. knowledge summaries outlining the basic concepts needed to successfully answer the test questions) was distributed to each of the candidates in the treatment group, who then had about ten minutes to examine it before the second part started. Students in the control group simply had a ten minute break after completing the first part of the test, but received the same "cheat sheet" after having completed the second part. Once they received the "cheat sheet" all students could keep it with them until the end of the test, and for fairness purposes only the number of correct answers from the third part (which all students took with the aid of the "cheat sheet") was considered for admission via the special access program, together with several other criteria. The dependent variable in all regressions (columns) is the number of correct answers in each corresponding part of the test, and independent variables are listed on the left (rows). Apart from the treatment indicator (first row), several additional controls are included in the extended specifications (1.2, 2.2 and 3.2) for robustness purposes. These are: (i) the math score obtained in the standardized test administered to secondary school students (SIMCE) (ii) whether the student attended a secondary school in the Santiago Metropolitan Region, (iii) whether the student attended a public school, as opposed to a subsidized one (private school students were not eligible to apply for special admission), (iv) whether the student attended the PENTA UC program for talented secondary school students, (v) whether the student belongs to the lower three quintiles of the income distribution, as opposed to the fourth quintile (fifth quintile students were not eligible to apply for special admission), and (vi) the student's gender (1 = male). A 2014 admission year fixed effect is included (base category is admission year 2013). Huber-White heteroskedasticity-consistent standard errors are reported between parentheses.

TABLE IV

DIFFERENCES IN IMPROVEMENT (ADDITIONAL CORRECT ANSWERS) ACROSS PARTS OF MATHEMATICAL ABILITY TEST BETWEEN TREATMENT AND CONTROL GROUPS

	Part II - Part I			Part III - Part II			Part III - Part I		
	(1.0)	(1.1)	(1.2)	(2.0)	(2.1)	(2.2)	(3.0)	(3.1)	(3.2)
Improvement (Additional Correct Answers)									
Treatment (1 = Cheat Sheet in Part II)	0.911 (0.274)***	1.083 (0.294)***	10.834 (3.300)***	-0.650 (0.273)**	-0.804 (0.309)**	-11.782 (3.331)***	0.261 (0.276)	0.280 (0.281)	-0.948 (2.330)
Secondary School Standardized Math Score		-0.006 (0.004)	0.002 (0.003)		-0.001 (0.004)	-0.008 (0.003)**		-0.007 (0.003)**	-0.005 (0.003)*
Region (1 = Santiago Metropolitan Region)		-0.408 (0.378)	0.007 (0.455)		0.398 (0.422)	0.441 (0.467)		-0.009 (0.428)	0.448 (0.512)
Secondary School Type (1 = Public)		0.034 (0.333)	0.323 (0.320)		-0.198 (0.368)	0.270 (0.396)		-0.165 (0.314)	0.593 (0.390)
PENTA UC Program Fellow (1 = Yes)		-0.907 (0.424)**	-1.446 (0.348)***		0.315 (0.360)	0.319 (0.464)		-0.592 (0.517)	-1.126 (0.501)**
Income Distribution Quintile (1 = I)		0.446 (0.391)	0.422 (0.423)		-0.257 (0.461)	-0.999 (0.566)*		0.188 (0.461)	-0.577 (0.583)
Income Distribution Quintile (1 = II)		0.360 (0.376)	0.575 (0.464)		0.019 (0.364)	-0.712 (0.523)		0.379 (0.401)	-0.137 (0.545)
Income Distribution Quintile (1 = III)		0.213 (0.352)	0.310 (0.412)		-0.129 (0.350)	-0.273 (0.489)		0.084 (0.404)	0.037 (0.537)
Gender (1 = Male)		-0.472 (0.260)*	-0.353 (0.305)		0.100 (0.281)	0.183 (0.340)		-0.373 (0.272)	-0.170 (0.316)
Admission Year (1 = 2014)	-0.106 (0.275)	-0.119 (0.282)	-0.093 (0.317)	0.192 (0.282)	0.088 (0.312)	0.420 (0.369)	0.086 (0.279)	-0.031 (0.307)	0.328 (0.425)
Secondary School Standardized Math Score			-0.032 (0.007)***			0.027 (0.008)***			-0.005 (0.006)
* Treatment			-0.843 (0.728)			-0.302 (0.789)			-1.145 (0.821)
Region (1 = Santiago Metropolitan Region)			0.222 (0.698)			1.547 (0.681)**			1.769 (0.549)***
Secondary School Type (1 = Public)			1.488 (0.667)**			0.155 (0.989)			1.643 (0.807)**
PENTA UC Program Fellow (1 = Yes)			-0.857 (0.822)			2.017 (0.953)**			1.160 (0.930)
Income Distribution Quintile (1 = I)			-0.974 (0.793)			1.730 (0.717)**			0.756 (0.829)
Income Distribution Quintile (1 = II)			-1.007 (0.693)			0.722 (0.705)			-0.285 (0.824)
Income Distribution Quintile (1 = III)			-0.407 (0.532)			-0.165 (0.580)			-0.572 (0.570)
Gender (1 = Male)			0.080 (0.544)			-0.717 (0.592)			-0.637 (0.592)
Admission Year (1 = 2014)			-0.290 (0.836)			2.745 (1.136)**			2.455 (0.995)**
* Treatment			2.506 (1.270)*			0.781 (1.166)			3.287 (0.908)***
Constant Term	0.765 (0.209)***	0.16 (0.270)	0.33 (0.836)	0.326 (0.228)	0.06 (0.247)***	0.18 (0.908)***	1.091 (0.247)***	0.09 (0.908)***	0.20 (0.995)**
R ²	0.07	0.16	0.33	0.04	0.06	0.18	0.01	0.09	0.20
Observations	162	152	152	162	152	152	162	152	152

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

NOTES. See next page.

TABLE IV

DIFFERENCES IN IMPROVEMENT (ADDITIONAL CORRECT ANSWERS) ACROSS PARTS OF MATHEMATICAL ABILITY TEST BETWEEN TREATMENT AND CONTROL GROUPS

NOTES. This table analyzes the differences in the improvement (additional correct answers) across each of the parts of the mathematical ability test between the randomly assigned treatment and control groups. As already mentioned, the mathematical test was divided in three parts, which featured 15 analogous questions each (i.e. the first questions of each part were different but analogous), and candidates were randomly divided into stratified treatment and control groups. All students took the first part of the test without any support materials, but then a “cheat sheet” (i.e. knowledge summaries outlining the basic concepts needed to successfully answer the test questions) was distributed to each of the candidates in the treatment group, who then had about ten minutes to examine it before the second part started. Students in the control group simply had a ten minute break after completing the first part of the test, but received the same “cheat sheet” after having completed the second part. Once they received the “cheat sheet” all students could keep it with them until the end of the test, and for fairness purposes only the number of correct answers from the third part (which all students took with the aid of the “cheat sheet”) was considered for admission via the special access program, together with several other criteria. The dependent variable in all regressions (columns) is the number of additional correct answers across corresponding parts of the test, and independent variables are listed on the left (rows). For example, in columns (1.0, 1.1 and 1.2 the dependent variable is the number of additional correct answers for each student in Part II of the mathematical ability test, compared to Part I. Apart from the treatment indicator (x.0), several additional controls are included in the (x.1) specifications for robustness purposes. The (x.3) specifications further include the interaction terms between the treatment indicator and the additional controls. The latter are: (i) the math score obtained in the standardized test administered to secondary school students (SIMCE) (ii) whether the student attended a secondary school in the Santiago Metropolitan Region, (iii) whether the student attended a public school, as opposed to a subsidized one (private school students were not eligible to apply for special admission), (iv) whether the student attended the PENTA UC program for talented secondary school students, (v) whether the student belongs to the lower three quintiles of the income distribution, as opposed to the fourth quintile (fifth quintile students were not eligible to apply for special admission), and (vi) the student’s gender (1 = male). A 2014 admission year fixed effect is included (base category is admission year 2013). Huber-White heteroskedasticity-consistent standard errors are reported between parentheses.

TABLE V
RELATIONSHIP BETWEEN IMPROVEMENT (ADDITIONAL CORRECT ANSWERS) ACROSS PARTS OF MATHEMATICAL ABILITY TEST AND STUDENT CHARACTERISTICS

Part I – Part II (Treatment = 1, i.e. Cheat Sheet from Part II)	(0.1)	(1.1)	(2.1)	(3.1)	(4.1)	(5.1)	(6.1)
Secondary School Standardized Math Test Score (SIMCE)	-0.029 (0.007)***	-0.027 (0.004)***					
Region (1 = Santiago Metropolitan Region)	-0.836 (0.573)		-0.472 (0.595)				
Secondary School Type (1 = Public)	0.101 (0.626)			-0.870 (0.548)			
PENTA UC Program Fellow (1 = Yes)	0.042 (0.574)				-0.617 (0.598)		
Income Distribution Quintile (1 = I)	-0.435 (0.712)					1.118 (0.653)*	
Income Distribution Quintile (1 = II)	-0.398 (0.649)					0.667 (0.535)	
Income Distribution Quintile (1 = III)	-0.696 (0.563)					0.442 (0.598)	
Gender (1 = Male)	-0.760 (0.440)*						-0.670 (0.427)
Admission Year (1 = 2014)	-0.013 (0.446)	-0.208 (0.452)	-0.179 (0.514)	-0.212 (0.536)	-0.240 (0.517)	-0.331 (0.467)	-0.190 (0.506)
Constant Term	10.988 (2.175)***	9.685 (1.530)***	1.803 (0.442)***	2.004 (0.469)***	1.809 (0.450)***	1.290 (0.440)***	2.045 (0.521)***
R ²	0.39	0.33	0.01	0.04	0.01	0.04	0.04
Observations	68	68	73	68	73	73	73
Part III – Part II (Treatment = 0, i.e. Cheat Sheet from Part III)	(0.2)	(1.2)	(2.2)	(3.2)	(4.2)	(5.2)	(6.2)
Secondary School Standardized Math Test Score (SIMCE)	-0.008 (0.003)**	-0.006 (0.003)**					
Region (1 = Santiago Metropolitan Region)	0.441 (0.464)		0.351 (0.474)				
Secondary School Type (1 = Public)	0.270 (0.394)			0.012 (0.366)			
PENTA UC Program Fellow (1 = Yes)	0.319 (0.461)				0.071 (0.499)		
Income Distribution Quintile (1 = I-III)	-0.999 (0.562)*					-0.551 (0.537)	
Income Distribution Quintile (1 = V)	-0.712 (0.519)					-0.435 (0.506)	
Income Distribution Quintile (1 = III)	-0.273 (0.486)					-0.224 (0.452)	
Gender (1 = Male)	0.183 (0.338)						-0.016 (0.338)
Admission Year (1 = 2014)	0.420 (0.367)	0.356 (0.322)	0.368 (0.354)	0.437 (0.356)	0.418 (0.355)	0.451 (0.347)	0.408 (0.336)
Constant Term	2.745 (1.128)**	1.965 (0.898)**	0.155 (0.242)	0.182 (0.322)	0.179 (0.267)	0.493 (0.346)	0.194 (0.307)
R ²	0.10	0.05	0.02	0.02	0.01	0.03	0.01
Observations	84	86	89	85	89	88	89

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Notes. See next page.

TABLE V

RELATIONSHIP BETWEEN IMPROVEMENT (ADDITIONAL CORRECT ANSWERS) ACROSS PARTS OF MATHEMATICAL ABILITY TEST AND STUDENT CHARACTERISTICS

NOTES. This table analyzes the relationship between improvement (additional correct answers) across each of the parts of the mathematical ability test and the student characteristics. Each column corresponds to one regression specification, and independent variables are listed on the left (rows). Two sets of specifications are presented stacked over each other. In the first set of regressions (x.1) the dependent variable is the improvement between Part I and Part II of the test for students in the treatment group, who received the cheat sheet before taking the second part of the exam. In the second set of regressions (x.2) the dependent variable is the improvement between Part II and Part III of the test for students in the control group, who received the cheat sheet before taking the third part of the exam. All six independent variables are first considered jointly (0.x) and then separately (1.x-6.x). These are: (i) the math score obtained in the standardized test administered to secondary school students (SIMCE) (ii) whether the student attended a secondary school in the Santiago Metropolitan Region, (iii) whether the student attended a public school, as opposed to a subsidized one (private school students were not eligible to apply for special admission), (iv) whether the student attended the PENTA UC program for talented secondary school students, (v) whether the student belongs to the lower three quintiles of the income distribution, as opposed to the fourth quintile (fifth quintile students were not eligible to apply for special admission), and (vi) the student's gender (1 = male). A 2014 admission year fixed effect is included (base category is admission year 2013). Huber-White heteroskedasticity-consistent standard errors are reported between parentheses.

TABLE VI

ROSTER OF STUDENTS WHO BENEFIT FROM OR ARE WORSE OFF WITH THE USE OF CHEAT SHEETS

	Part I			Part II			Part III		
	Rank	Correct Answers	Rank	Rank	Correct Answers	Rank	Rank	Correct Answers	Treatment
Students Who Are Better Off With Cheat Sheet (i.e. in Top 20 on Part III but not on Part I)	22	14	28	14	15	8	15	15	1
	25	14	17	15	15	10	15	15	0
	31	14	7	15	15	2	15	15	1
	40	13	52	13	13	5	15	15	0
	42	13	74	13	13	3	15	15	0
	44	13	14	15	15	6	15	15	1
	49	13	78	13	13	9	15	15	0
	65	12	118	11	15	1	15	15	1
	68	12	61	13	13	18	15	15	1
	69	12	38	14	15	20	15	15	0
	72	12	93	12	12	12	15	15	0
	88	11	71	13	13	19	15	15	1
	103	10	121	11	15	4	15	15	1
Total: 13									
Students Who Are Worse Off With Cheat Sheet (i.e. in Top 20 on Part I but not on Part III)	1	15	43	14	15	26	15	15	0
	3	15	20	15	15	25	15	15	0
	4	15	41	14	14	57	14	14	1
	7	15	26	14	14	79	13	13	1
	8	15	15	15	15	78	13	13	0
	10	15	24	14	14	53	14	14	1
	11	15	21	15	15	24	15	15	0
	12	15	9	15	15	33	14	14	0
	13	15	5	15	15	32	14	14	1
	16	15	32	14	14	36	14	14	0
	18	14	62	13	13	85	13	13	1
	19	14	16	15	15	49	14	14	0
	20	14	35	14	14	40	14	14	1
Total: 13									

NOTES. As already mentioned, the mathematical test was divided in three parts, which featured 15 analogous questions each (i.e. the first questions of each part were different but analogous), and candidates were randomly divided into stratified treatment and control groups. All students took the first part of the test without any support materials, but then a "cheat sheet" (i.e. knowledge summaries outlining the basic concepts needed to successfully answer the test questions) was distributed to each of the candidates in the treatment group, who then had about ten minutes to examine it before the second part started. Students in the control group simply had a ten minute break after completing the first part of the test, but received the same "cheat sheet" after having completed the second part. Once they received the "cheat sheet" all students could keep it with them until the end of the test, and for fairness purposes only the number of correct answers from the third part (which all students took with the aid of the "cheat sheet") was considered for admission via the special access program, together with several other criteria. This table presents a roster of all the students who benefit from or are worse off with the use of cheat sheets, as measured by whether they advanced to or were relegated from the group of top 20 candidates who would be admitted via the special access program, respectively. This is observed by comparing the rank of each candidate in Part I (which all students completed without a cheat sheet) and Part III (which all students completed with a cheat sheet), as defined by the number of correct answers relative to the other students who took the exam. Ties among students with the same number of correct students are resolved randomly. Each row corresponds to one student, for which the rank and number of correct answers in each of the three parts of the mathematical ability test are listed. The last column indicates whether the student was in the treatment or control group.

TABLE VII

RELATIONSHIP BETWEEN STUDENT CHARACTERISTICS AND THE LIKELIHOOD OF BENEFITING FROM AND BEING WORSE OFF WITH THE USE OF CHEAT SHEETS

	(0.1)	(1.1)	(2.1)	(3.1)	(4.1)	(5.1)	(6.1)
1 = Student Better Off With Cheat Sheet							
Secondary School Standardized Math Test Score (SIMCE)	0.001 (0.000)*	0.001 (0.000)					
Region (1 = Santiago Metropolitan Region)	-0.062 (0.054)		-0.050 (0.044)				
Secondary School Type (1 = Public)	-0.048 (0.045)			-0.039 (0.044)			
PENTA UC Program Fellow (1 = Yes)	-0.067 (0.036)*			-0.090 (0.026)***			
Income Distribution Quintile (1 = I)	-0.008 (0.058)				-0.035 (0.058)		
Income Distribution Quintile (1 = II)	0.023 (0.064)				-0.000 (0.059)		
Income Distribution Quintile (1 = III)	0.085 (0.072)				0.078 (0.067)		
Gender (1 = Male)	0.035 (0.053)						0.033 (0.044)
Admission Year (1 = 2014)	0.005 (0.051)	-0.007 (0.049)	-0.009 (0.047)	-0.017 (0.048)	-0.021 (0.047)	-0.002 (0.047)	-0.017 (0.047)
Constant	-0.112 (0.117)	-0.073 (0.116)	0.095 (0.040)**	0.109 (0.044)**	0.099 (0.041)**	0.066 (0.045)	0.077 (0.044)*
R ²	0.05	0.01	0.01	0.00	0.01	0.03	0.00
N	152	154	162	153	162	161	162
1 = Student Worse Off With Cheat Sheet							
Secondary School Standardized Math Test Score (SIMCE)	0.002 (0.001)**	0.002 (0.001)***					
Region (1 = Santiago Metropolitan Region)	-0.030 (0.047)		-0.050 (0.050)				
Secondary School Type (1 = Public)	0.106 (0.052)**			0.172 (0.063)***			
PENTA UC Program Fellow (1 = Yes)	0.083 (0.124)				0.148 (0.146)		
Income Distribution Quintile (1 = I)	-0.094 (0.086)					-0.164 (0.086)*	
Income Distribution Quintile (1 = II)	-0.089 (0.085)					-0.160 (0.085)*	
Income Distribution Quintile (1 = III)	-0.167 (0.076)**					-0.206 (0.079)**	
Gender (1 = Male)	0.000 (0.043)						0.033 (0.044)
Admission Year (1 = 2014)	0.020 (0.054)	0.011 (0.047)	-0.009 (0.051)	0.010 (0.052)	-0.008 (0.050)	-0.018 (0.048)	-0.017 (0.047)
Constant	-0.381 (0.218)*	-0.550 (0.205)***	0.095 (0.039)**	0.022 (0.049)	0.077 (0.043)*	0.237 (0.083)***	0.077 (0.040)*
R ²	0.23	0.13	0.01	0.08	0.02	0.07	0.00
N	152	154	162	153	162	161	162

* p<0.1; ** p<0.05; *** p<0.01

NOTES. See next page.

TABLE VII

RELATIONSHIP BETWEEN STUDENT CHARACTERISTICS AND THE LIKELIHOOD OF BENEFITTING FROM AND BEING WORSE OFF WITH THE USE OF CHEAT SHEETS

NOTES. This table analyzes the relationship between student characteristics and the likelihood of benefiting from or being worse off with the use of cheat sheets, as measured by the likelihood of advancing to or being relegated from the group of top 20 candidates who would be admitted via the special access program, respectively. This is obtained by comparing the rank of each candidate in Part I (which all students completed without a cheat sheet) and Part III (which all students completed with a cheat sheet), as defined by the number of correct answers relative to the other students who took the exam. Ties among students with the same number of correct answers are resolved randomly. Each column corresponds to one regression specification, and independent variables are listed on the left (rows). Two sets of specifications are presented stacked over each other. In the first set of regressions (x.1) the dependent variable is the binomial indicator of whether the student benefited from the use of a cheat sheet, i.e. whether s/he made it to the top 20 in Part III but not Part I. In the second set of regressions (x.2) the dependent variable is the binomial indicator of whether the student was worse off with the use of a cheat sheet, i.e. whether s/he made it to the top 20 in Part I but not Part III. All six independent variables are first considered jointly (0.x) and then separately (1.x-6x). These are: (i) the math score obtained in the standardized test administered to secondary school students (SIMCE) (ii) whether the student attended a secondary school in the Santiago Metropolitan Region, (iii) whether the student attended a public school, as opposed to a subsidized one (private school students were not eligible to apply for special admission), (iv) whether the student attended the PENTA UC program for talented secondary school students, (v) whether the student belongs to the lower three quintiles of the income distribution, as opposed to the fourth quintile (fifth quintile students were not eligible to apply for special admission), and (vi) the student's gender (1 = male). A 2014 admission year fixed effect is included (base category is admission year 2013). Huber-White heteroskedasticity-consistent standard errors are reported between parentheses.

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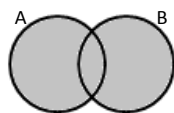
Appendix A: Basic Math Concepts “Cheat Sheet” (Spanish Original)

CONSEJOS GENERALES

- Lee cuidadosamente el enunciado de cada pregunta, prestando especial atención a los paréntesis y operadores matemáticos. ¡Es muy importante no malinterpretar el enunciado de la pregunta o las posibles respuestas! Siempre resuelve la operación dentro de los paréntesis primero.
- Por simplicidad en esta prueba la división se representa mediante el símbolo “/”, mientras que el operador multiplicativo se omite y se usan paréntesis para separar los múltiplos. Es decir, $3 / 3 = 1$, y $(3)(3) = 9$.

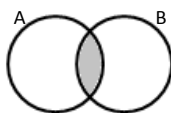
CONJUNTOS

Unión de Conjuntos



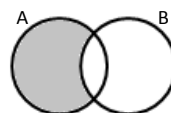
$$A \cup B$$

Intersección de Conjuntos



$$A \cap B$$

Diferencia de Conjuntos



$$A - B$$

PORCENTAJES

$$X\% = X/100$$

$$\rightarrow \text{Por ejemplo, } 20\% = 20 / 100 = 0,2$$

$$\text{“X\% de Y”} = (X/100)(Y)$$

$$\rightarrow \text{Por ejemplo, “20\% de 50”} = (20 / 100) (50) = 10$$

$$\text{“sube un X\%” significa } (100 + X)\%$$

$$\rightarrow \text{Por ejemplo, si 50 aumenta un 20\%, tenemos } (100 + 20)\% \text{ de } 50 = 60$$

$$\text{“baja un X\%” significa } (100 - X)\%$$

$$\rightarrow \text{Por ejemplo, si 50 baja un 20\%, tenemos } (100 - 20)\% \text{ de } 50 = 40$$

$$\text{“A es X\% más grande que B” significa que } [(A-B) / B] (100) = X\%$$

$$\rightarrow \text{Por ejemplo, “375 es un 25\% más grande que 300”, ya que } [(375-300) / 300] (100) = 0.25 = 25\%, \text{ o lo que es lo mismo, } 375 = (1,25)(300) = (1 + 0,25) (300), \text{ es decir, 375 es un 125\% de 300}$$

$$\text{“B es X\% más pequeño que A” significa que } [(A-B) / A] (100) = X\%$$

$$\rightarrow \text{Por ejemplo, “150 es un 25\% más pequeño que 200”, ya que } [(200-150) / 200] (100) = 0.25 = 25\%, \text{ o lo que es lo mismo, } 150 = (0,75) (200) = (1 - 0,25) (200), \text{ es decir, 150 es un 75\% de 200}$$

RAZONES

$$\text{“razón de X a Y” es } X:Y=X/Y$$

$$\rightarrow \text{Por ejemplo, razón de 8 a 4 es } 8:4=8/4=2/1=2:1$$

$$[(X)(Y)]/[(X)(Z)]=Y/Z$$

$$\rightarrow \text{Por ejemplo, } 8/6=[(2)(4)]/[(2)(3)]=4/3$$

$$[X/Y]/[Z/W]=[(X)(W)]/[(Y)(Z)]$$

$$\rightarrow \text{Por ejemplo, } [10/5]/[6/3]=[(10)(3)]/[(5)(6)]=30/30=1$$

$$\text{“X/Y = Z/W” implica que } X=(Z)(Y) / W$$

$$\rightarrow \text{Por ejemplo, si } X/2=4/6, \text{ esto implica que } X=(4)(2) / 6=8/6=4/3$$

$$\text{“X/Y = Z/W” puede ser leído como “X es a Y como Z es a W”}$$

$$\rightarrow \text{Por ejemplo, } X/2=4/6 \text{ puede ser leído como “X es a 2 como 4 es a 6”}$$

$$\text{“X en Y horas” implica “(1/Y)X por hora”, o “[(1/Y)X] / hora”}$$

$$\rightarrow \text{Por ejemplo, “10 en 5 horas” implica “2 por hora”, o “2/hora”}$$

EXPONENTES

$$X^{(-a)} = 1/X^a$$

$$(X^a)(X^b) = X^{(a+b)}$$

$$(X^a)^b = X^{(a)(b)}$$

$$X^a/X^b = (X^a)(X^{(-b)}) = X^{(a-b)}$$

$$(X^a)(Y^a) = [(X)(Y)]^a$$

$$X^a/Y^a = (X^a)(Y^{(-a)}) = [X/Y]^a$$

ÁLGEBRA

$$A=a \rightarrow X^A = X^a$$

$$aX + b = cX + d \Leftrightarrow aX - cX = (a-c)X = d - b$$

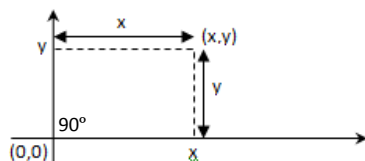
$$aX = b \Leftrightarrow X = b/a$$

$$aX + b > cX + d \Leftrightarrow aX - cX = (a-c)X > d - b \rightarrow \text{Por ejemplo, } 2X + 1 > X + 2 \Leftrightarrow 2X - X = (2-1)X = X > 2 - 1 = 1$$

$$\text{Si } a > 0, \text{ entonces } aX > b \Leftrightarrow X > b/a, \rightarrow \text{Por ejemplo, } 2X > 4 \Leftrightarrow X > 4/2=2, \text{ pero } -2X > 4 \Leftrightarrow X < 4/(-2)=(-2)$$

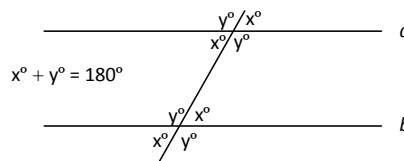
GEOMETRÍA

Eje de Coordenadas (x,y)

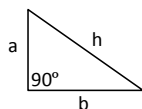


Ángulos

NOTA: Las líneas a y b son paralelas

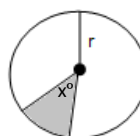


Teorema de Pitágoras



$$h^2 = a^2 + b^2$$

Área de un círculo y volumen de un cilindro



r = radio

d = diámetro

h = altura

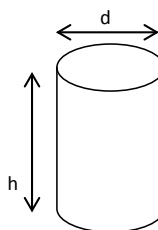
Área de una sección de un círculo (sombreada)

$$\text{área sección determinada por el ángulo } x^\circ = (x/360) (\pi r^2)$$

Medida de ángulos interiores de un polígono

La suma de los ángulos interiores de un polígono de n lados es $(n-2)(180^\circ)$

\rightarrow Por ejemplo, los ángulos interiores de un triángulo suman 180° , los de un cuadrado suman 360° , etc.



$$d = 2r$$

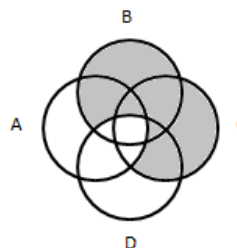
$$\text{área círculo} = \pi r^2$$

$$\text{volumen cilindro} = h \pi r^2$$

Appendix B: Mathematical Ability Test Part I (Spanish Original)

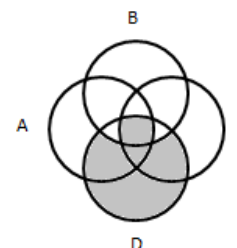
1. En la figura de la derecha A, B, C y D son círculos de igual tamaño. El área sombreada representa:

- A. $(A \cup D) - (B \cap C)$
- B. $(A \cup B) - (C \cap D)$
- C. $(A \cap B) - (C \cup D)$
- D. $(B \cup C) - (A \cap D)$
- E. $(A \cap B) - (C \cap D)$



2. En la figura de la derecha A, B, C y D son círculos de igual tamaño. El área sombreada representa:

- A. $(B - D) \cup [(A \cap C) \cap (B \cup D)]$
- B. $(D - B) \cup [(A \cap B) \cap (C \cap D)]$
- C. $(C - D) \cup [(A \cap B) \cup (C \cap D)]$
- D. $(C - B) \cup [(A \cap B) \cup (C \cap D)]$
- E. $(A - D) \cup [(A \cap B) \cap (C \cap D)]$



3. El precio inicial de un auto era de seis millones de pesos. El precio del auto subió un 20% con respecto a su precio inicial, pero después bajó un 20% con respecto a su precio máximo. ¿Cuál es la diferencia entre el precio inicial y el precio actual del auto?

- A. \$ 120.000
- B. \$ 150.000
- C. \$ 0
- D. \$ 300.000
- E. \$ 240.000

4. Se considera que el precio de una mercancía es “estable” si la diferencia entre su precio mínimo y su precio máximo no es mayor que un 10% de su precio medio. Según la información de la tabla, ¿qué mercancías tienen precios “estables”?

- A. B y C
- B. B y D
- C. A y B
- D. A y C
- E. Ninguna

Mercancía	Pr. Mínimo	Pr. Medio	Pr. Máximo
A	\$ 114	\$ 120	\$ 125
B	\$ 47	\$ 50	\$ 51
C	\$ 9	\$ 10	\$ 11
D	\$ 77	\$ 70	\$ 85

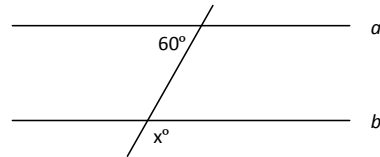
5. Si la razón de mujeres a hombres en un comité de 30 miembros es de 3:2, y el 50% por ciento de las mujeres son chilenas y el 25% de los hombres son extranjeros, ¿cuántos miembros del comité son chilenos?

- A. 16
- B. 22
- C. 24
- D. 18
- E. 20

6. Diez obreros realizan una obra en siete días. ¿En cuántos días se hubiese realizado una obra un 30% más grande si se hubiesen ocupado cinco obreros?
- A. 12,6 días
 - B. 14,8 días
 - C. 20,6 días
 - D. 16,4 días
 - E. 18,2 días
7. Una llave de agua llena la piscina A en seis horas, y otra llave de agua llena la piscina B, que es un 50% más grande que la piscina A, en la mitad de tiempo. ¿Cuánto tardarían en llenar la piscina A las dos llaves de agua al mismo tiempo?
- A. 1,5 horas
 - B. 3 horas
 - C. 2 horas
 - D. 1 hora
 - E. 2,5 horas
8. ¿Cuál es el valor de $[(X^A)(X^{(-B)})]^B$ cuando $X=4$, $A=3$, $B=2$?
- A. 9
 - B. 16
 - C. 36
 - D. 25
 - E. 4
9. $[(X^{10})(Y^{(-1)})] / [(Y^5)(X^5)]$ es igual a:
- A. X^{15} / Y^4
 - B. X^5 / Y^4
 - C. X^5 / Y^6
 - D. X^{15} / Y^6
 - E. X^{10} / Y^4
10. Si $4X-5X+8 > 3X+20$, entonces:
- A. $X < 5$
 - B. $X < -1$
 - C. $X < 2$
 - D. $X < 1$
 - E. $X < -3$

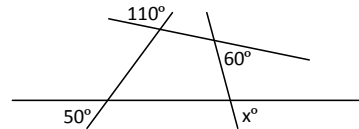
11. En la figura de la derecha las líneas a y b son paralelas.
¿Cuántos grados mide el ángulo x° ?

- A. $x^\circ = 130^\circ$
- B. $x^\circ = 120^\circ$
- C. $x^\circ = 140^\circ$
- D. $x^\circ = 135^\circ$
- E. $x^\circ = 125^\circ$



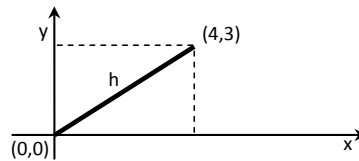
12. ¿En la figura de la derecha, cuántos grados mide el ángulo x° ?

- A. $x^\circ = 85^\circ$
- B. $x^\circ = 70^\circ$
- C. $x^\circ = 80^\circ$
- D. $x^\circ = 75^\circ$
- E. $x^\circ = 65^\circ$



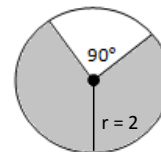
13. En el eje de coordenadas (x,y) a la derecha,
¿cuál es la longitud de la línea h entre los puntos $(0,0)$ y $(4,3)$?

- A. $h=5$
- B. $h=6$
- C. $h=4$
- D. $h=3$
- E. $h=7$



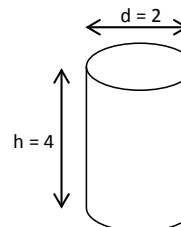
14. El círculo de la derecha tiene un radio $r = 2$.
¿Cuál es el área de la zona sombreada?

- A. 4π
- B. 16π
- C. 9π
- D. 3π
- E. 2π



15. El cilindro de la derecha tiene una base circular de diámetro $d = 2$,
y una altura $h = 4$. ¿Cuál es su volumen?

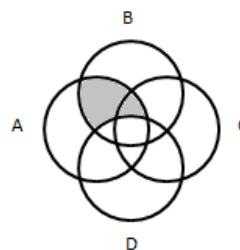
- A. 4π
- B. 16π
- C. 9π
- D. 3π
- E. 2π



Appendix C: Mathematical Ability Test Part II (Spanish Original)

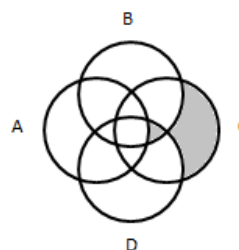
16. En la figura de la derecha A, B, C y D son círculos de igual tamaño. El área sombreada representa:

- A. $(A \cup C) - D$
- B. $(B \cap D) - A$
- C. $(C \cup D) - B$
- D. $(B \cap C) - A$
- E. $(A \cap B) - D$



17. En la figura de la derecha A, B, C y D son círculos de igual tamaño. El área sombreada representa:

- A. $[D - (B \cap C)] \cup [(A \cup D) - C]$
- B. $[B - (A \cup C)] \cap [(B \cup C) - D]$
- C. $[C - (B \cup D)] \cup [(B \cap D) - A]$
- D. $[B - (C \cap D)] \cap [(A \cap B) - C]$
- E. $[C - (A \cup B)] \cup [(B \cup D) - A]$



18. El precio inicial de un auto era de ocho millones de pesos. El precio del auto subió un 10% con respecto a su precio inicial, pero después bajó un 20% con respecto a su precio máximo. ¿Cuál es la diferencia entre el precio inicial y el precio actual del auto?

- A. \$ 720.000
- B. \$ 960.000
- C. \$ 540.000
- D. \$ 380.000
- E. \$ 800.000

19. Se considera que el precio de una mercancía es “estable” si la diferencia entre su precio mínimo y su precio máximo no es mayor que un 30% de su precio medio. Según la información de la tabla, ¿qué mercancías tienen precios “estables”?

- A. A y B
- B. B y C
- C. A y C
- D. C y D
- E. Ninguna

Mercancía	Pr. Mínimo	Pr. Medio	Pr. Máximo
A	\$ 69	\$ 80	\$ 94
B	\$ 44	\$ 40	\$ 57
C	\$ 9	\$ 10	\$ 11
D	\$ 95	\$ 110	\$ 126

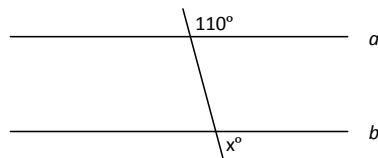
20. Si la razón de mujeres a hombres en un comité de 70 miembros es de 4:3, y el 20% por ciento de las mujeres son extranjeras y el 60% de los hombres son chilenos, ¿cuántos miembros del comité son extranjeros?

- A. 18
- B. 16
- C. 14
- D. 22
- E. 20

21. Cinco obreros realizan una obra en diez días. ¿En cuántos días se hubiese realizado una obra un 20% más pequeña si se hubiesen ocupado veinte obreros?
- A. 2 días
 - B. 8 días
 - C. 5 días
 - D. 6 días
 - E. 4 días
22. Una llave de agua llena la piscina A en ocho horas, y otra llave de agua llena la piscina B, que es un 25% más pequeña que la piscina A, en un 50% más de tiempo. ¿Cuánto tardarían en llenar la piscina B las dos llaves de agua al mismo tiempo?
- A. 2 horas
 - B. 3 horas
 - C. 2,5 horas
 - D. 4 horas
 - E. 3,5 horas
23. ¿Cuál es el valor de $[(X^{(-A)}) / (X^B)]^A$ cuando $X=3$, $A=2$, $B=(-4)$?
- A. 121
 - B. 144
 - C. 100
 - D. 81
 - E. 64
24. $[(Y^{(-6)}) / (X^{(-2)})] [(X^3) / (Y^2)]$ es igual a:
- A. X^5 / Y^8
 - B. X / Y^4
 - C. X^5 / Y^4
 - D. Y^8 / X^5
 - E. $X / Y^{(-4)}$
25. Si $6X-4X + 5 < X + 10$, entonces:
- A. $X > 4$
 - B. $X < 3$
 - C. $X < 4$
 - D. $X > 5$
 - E. $X < 5$

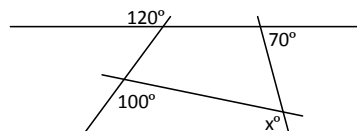
26. En la figura de la derecha las líneas a y b son paralelas.
¿Cuántos grados mide el ángulo x° ?

- A. $x^\circ = 60^\circ$
- B. $x^\circ = 80^\circ$
- C. $x^\circ = 70^\circ$
- D. $x^\circ = 50^\circ$
- E. $x^\circ = 40^\circ$



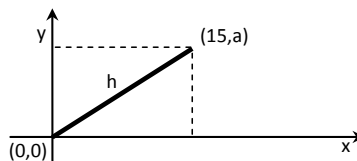
27. ¿En la figura de la derecha, cuántos grados mide el ángulo x° ?

- A. $x^\circ = 125^\circ$
- B. $x^\circ = 130^\circ$
- C. $x^\circ = 115^\circ$
- D. $x^\circ = 110^\circ$
- E. $x^\circ = 120^\circ$



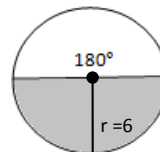
28. En el eje de coordenadas (x,y) a la derecha, si la línea entre los puntos $(0,0)$ y $(15,a)$ tiene una longitud $h=17$,
¿cuál es el valor de a ?

- A. $a=9$
- B. $a=10$
- C. $a=8$
- D. $a=11$
- E. $a=7$



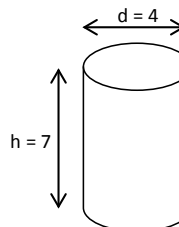
29. El círculo de la derecha tiene un radio $r = 6$.
¿Cuál es el área de la zona sombreada?

- A. 18π
- B. 16π
- C. 20π
- D. 12π
- E. 14π



30. El cilindro de la derecha tiene una base circular de diámetro $d = 4$,
y una altura $h = 7$. ¿Cuál es su volumen?

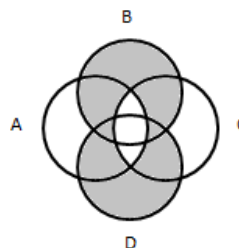
- A. 24π
- B. 28π
- C. 32π
- D. 36π
- E. 20π



Appendix D: Mathematical Ability Test Part III (Spanish Original)

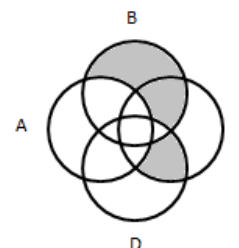
31. En la figura de la derecha A, B, C y D son círculos de igual tamaño. El área sombreada representa:

- A. $[A \cap C] - [D \cup B]$
- B. $[B \cup D] - [A \cap C]$
- C. $[C \cup D] - [A \cap B]$
- D. $[B \cup C] - [A \cup D]$
- E. $[A \cup B] - [C \cap D]$



32. En la figura de la derecha A, B, C y D son círculos de igual tamaño. El área sombreada representa:

- A. $[(A \cup C) - (B \cup D)] \cup [A - (B \cup D)]$
- B. $[(B \cap C) - (A \cap D)] \cup [C - (B \cup C)]$
- C. $[(A \cup B) - (C \cup D)] \cup [A - (C \cap D)]$
- D. $[(C \cap D) - (A \cup B)] \cup [B - (A \cup D)]$
- E. $[(A \cap D) - (C \cap D)] \cup [A - (C \cap D)]$



33. El precio inicial de un auto era de diez millones de pesos. El precio del auto bajó un 25% con respecto a su precio inicial, pero después subió un 35% con respecto a su precio mínimo. ¿Cuál es la diferencia entre el precio inicial y el precio actual del auto?

- A. \$ 125.000
- B. \$ 115.000
- C. \$ 135.000
- D. \$ 155.000
- E. \$ 145.000

34. Se considera que el precio de una mercancía es “estable” si la diferencia entre su precio mínimo y su precio máximo no es mayor que un 25% de su precio medio. Según la información de la tabla, ¿qué mercancías tienen precios “estables”?

- A. B y C
- B. C y D
- C. A y D
- D. B y D
- E. Ninguna

Mercancía	Pr. Mínimo	Pr. Medio	Pr. Máximo
A	\$ 18	\$ 20	\$ 22
B	\$ 52	\$ 60	\$ 68
C	\$ 61	\$ 70	\$ 79
D	\$ 113	\$ 130	\$ 145

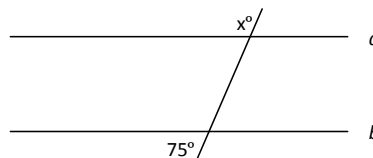
35. Si la razón de mujeres a hombres en un comité de 45 miembros es de 4:5, y el 20% por ciento de las mujeres son chilenas y el 60% de los hombres son extranjeros, ¿cuántos miembros del comité son chilenos?

- A. 12
- B. 14
- C. 10
- D. 16
- E. 18

36. Seis obreros realizan una obra en veinte días. ¿En cuántos días se hubiese realizado una obra un 40% más pequeña si se hubiesen ocupado ocho obreros?
- A. 10 días
 - B. 8,5 días
 - C. 10,5 días
 - D. 9,5 días
 - E. 9 días
37. Una llave de agua llena la piscina A en 12 horas, y otra llave de agua llena la piscina B, que es un 75% más pequeña que la piscina A, en la mitad de tiempo. ¿Cuánto tardarían en llenar la piscina A las dos llaves de agua al mismo tiempo?
- A. 8 horas
 - B. 2 horas
 - C. 4 horas
 - D. 10 horas
 - E. 6 horas
38. ¿Cuál es el valor de $[(X^A)(X^B)]^B$ cuando $X=2$, $A=1$, $B=(-3)$?
- A. 16
 - B. 32
 - C. 64
 - D. 4
 - E. 2
39. $[(Y^4)(X^{(-3)})] / [(Y^5) / (X^4)]$ es igual a:
- A. Y^9 / X^7
 - B. X / Y
 - C. X^7 / Y^9
 - D. Y / X
 - E. X^7 / Y
40. Si $5X - 7X - 6 > 16 - 4X$, entonces:
- A. $X < 21$
 - B. $X > 7$
 - C. $X < 3$
 - D. $X > 11$
 - E. $X < 9$

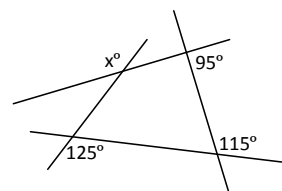
41. En la figura de la derecha las líneas a y b son paralelas.
¿Cuántos grados mide el ángulo x° ?

- A. $x^\circ = 115^\circ$
- B. $x^\circ = 100^\circ$
- C. $x^\circ = 110^\circ$
- D. $x^\circ = 120^\circ$
- E. $x^\circ = 105^\circ$



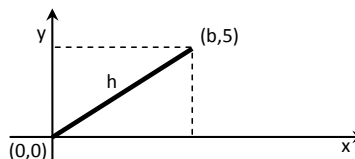
42. ¿En la figura de la derecha, cuántos grados mide el ángulo x° ?

- A. $x^\circ = 150^\circ$
- B. $x^\circ = 145^\circ$
- C. $x^\circ = 160^\circ$
- D. $x^\circ = 140^\circ$
- E. $x^\circ = 155^\circ$



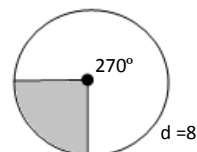
43. En el eje de coordenadas (x,y) a la derecha, si la línea entre los puntos $(0,0)$ y $(b,5)$ tiene una longitud $h=13$,
¿cuál es el valor de b ?

- A. $b=12$
- B. $b=7$
- C. $b=10$
- D. $b=8$
- E. $b=9$



44. El círculo de la derecha tiene un diámetro $d = 8$.
¿Cuál es el área de la zona sombreada?

- A. 16π
- B. 8π
- C. 2π
- D. 4π
- E. π



45. El cilindro de la derecha tiene una base circular de radio $r = 3$,
y una altura $h = 5$. ¿Cuál es su volumen?

- A. 30π
- B. 40π
- C. 45π
- D. 35π
- E. 50π

