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On the average perception of perceived averages

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ABSTRACT

The Chemical Engineering curriculum at Polytechnique Montreal is structured to gradually provide more and more autonomy to the students. The third-year Unit Operations is taught using an outcomes-based approach and represents a turning point in the undergraduate curriculum where rubrics-based assessments overtake normative assessments. This begs the question: is it really necessary to divulge the average to students following assessments? Those from a more industrial background see the average as an unnecessary crutch for students, while the more academically inclined see it as a useful pedagogical tool to provide feedback and help students determine if they have attained their learning objectives. To settle this debate, we set into motion a yearlong study during which the average results to tests were withheld. Students were asked to predict their grade and the class average, and provide feedback on the assessment process. Results show that students are able to predict the average, but have difficulty predicting their individual performance (especially before a test, where more than 50% of students are off by a factor of more than 10%). Students award more importance to their personal sense of learning satisfaction than their position with respect to the average, and do not systematically use the average to plan study time (despite preferring to know it). Thus, it may be possible to substitute alternate frames of reference to the class average in an outcomes-based course, but this is not necessarily desirable and should at the very least be the subject of a more open discussion.

1. Introduction and context

1.1. *Polytechnique Montreal's undergraduate chemical engineering curriculum*

The 120-credit Chemical Engineering undergraduate curriculum at Polytechnique Montreal is a 4-year program constructed as a learning program-based approach (Prégent et al., 2009). This has allowed for a high level of synergy between the various core classes in the curriculum. Ten years ago, this synergy allowed for the creation of several outcomes-based classes. The undergraduate curriculum committee accomplished this by first outlining 12 criteria that define the competence of a chemical engineering graduate, and then formulating a pedagogical design for course sequencing. Therefore, it is possible to monitor the evolution of a future engineer's competence over a series of classes, specifically through the use of rubrics (Stevens and Levi, 2005; Huba and Freed, 2000). The curriculum is structured to promote student autonomy and develop certain skills that are specific to chemical engineers. Overall, the implemented strategy aims to change the type of support available to students throughout their academic career. In the beginning, considerable support is offered; this gradually changes from support to mentoring as the student advances in his/her career. This evolution is linked not only to progression of the course content, but the assessment frequency and structure used, transitioning from a normalized approach (comparing students to each other) toward a criterion-based approach (comparison of students based on pre-established criteria).

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1.1.1. First year

Most students registered in the first year of the Chemical Engineering bachelor program have completed college or a similar level of schooling (K + 13). The transition from college to university is an important step that requires students to make many adjustments. To make this easier for new students, we conduct courses with a traditional framework that is largely similar to what they already know. At the beginning of the program, courses have several assessments (graded tutorials) that account for a small percentage of the final course grade. This strategy forces the students to work steadily, thus preparing for their exams more easily. Autonomy is therefore limited at first to promote their integration into the academic world and contribute to the development of good working habits.

Evaluations are corrected using traditional normative methods, which means scaling the grades so they are well distributed. In general, the grades are distributed along a normal curve. At the end of the assessment, the average, the standard deviation and a histogram showing the distribution of grades are presented to the students. These statistics help guide the professors when giving out final grades (A*, A, B+, B, C+, C, D+, D, F) for the course. In addition, using these statistics, students can determine how well they did in the course. At the end of their first year, the students complete an integrative project. This is the first course in which we begin assessing their skills using set rubrics.

1.1.2. Second year

In the second year, the professors give the students more autonomy. The courses have fewer assessments of lesser weight and more recommended sets of problems, pushing the students to study on their own. The nature of the assessments helps incorporate the concepts learned in the first year. For certain assessments, set rubrics are used. The schemes are provided to students before any evaluation, allowing them to clearly understand the criteria used to formulate their final grades. Since the grader makes use of rubrics, he/she is able to compare student performance in terms of these set criteria, thus greatly diminishing correction bias and forming a clearer picture of competence development over a course sequence (Tardif, 2006). Following the evaluation, each student receives his or her completed assessment grid. The average can be calculated based on the various grades obtained, but it has no direct impact on the students' final grade. Situating their performance on the assessment grid scale (clearly defined criteria) is what is most important, not a comparison to the group average. However, the average can help the students to see where they stand compared to the group and therefore to make more effort, if needed.

1.1.3. Third year

In the third year, professors push the students to further develop their autonomy, with very little formal support, especially in situations they have already encountered. When students have questions about a course, they are encouraged to find the answer themselves or with the help of fellow classmates. As a last resort, they are invited to consult their professors. The majority of assessments evaluate skills using set rubrics and some more traditional exams are also employed. As in the 2nd year, the professors give out the class average for information purposes, but do not use it to determine the various final grades for the course. The main course for third year students involves designing unit operations in chemical engineering and is worth 13 credits out of 30 for the year. In this course, students carry out a project worth 6 credits, in which the assessment is based exclusively on a set rubric. Using this format, it is possible to evaluate the students' skills based on precise criteria and not by comparing students with one another. The assessment grids for this particular class have been optimized over the past ten years and the clarity of the criteria used makes it possible to unambiguously define our expectations from the beginning. The students are therefore able to produce better quality work than with a more traditional method of assessment. When giving out the final letter grades for the course, the professors never use an average. The student's grade is compared to the predetermined expectations without taking into consideration the performance of the other students. Nonetheless, for the few remaining normative evaluations (quizzes namely), averages are still disclosed to the students.

1.1.4. Fourth year

For fourth year students, we conduct courses where the students are very autonomous in the majority of decisions they make. The support offered by the professors is minimal and focuses mainly on orienting the students to useful resources, because the required expertise may be outside of the competency of the professor involved in the different industrially-oriented projects. The assessment criteria are clearly defined from the beginning and directly related to industrial standards. Professors and the department's industrial partners have jointly developed these criteria and the assessment focuses only on the students' skills. In the course-project (capstone design project), both the professors and the industrial partners grade the students without taking into consideration the performance of other students. In this case, there is no average calculated.

1.2. Debate on the necessity of divulging class averages

This evolution from mostly normative to essentially outcomes-based evaluation brings about a pertinent question: is it still necessary to divulge the class average to students following a given evaluation in an outcomes-based class environment, specifically in the third year of the above-described curriculum? Indeed, in a traditional, normative (curve-based) class, the class average may be seen as a useful tool allowing the student to situate himself/herself with respect to his/her colleagues. However, in an outcomes-based context, the average has no bearing on the student's final performance. In fact, since students are compared to pre-established criteria, it is possible that a large number of students receive grades below or above expectations. Moreover, some faculty members have brought up the point that, once on the job market, a young engineer's performance (and remuneration) will typically not be based on a comparison with colleagues, but rather on his/her ability to meet or exceed goals set forth by management. This philosophy is reflected in the fourth-year teaching approach. On the other hand, companies may compare one individual to another in a hiring context, though hiring may also be based on set criteria for teamwork, communication or specific technical skills. As stated previously, a transition from normative to outcomes-based evaluations takes place in the second year of the Polytechnique curriculum, though averages remain divulged for a small set of evaluations in the third year (despite having no bearing on the final grade). The