Abstract — In engineering, it is important for students to develop strong problem analysis skills; however, this skill development may be hindered by a reliance on memorization. In this study, a survey was used to investigate undergraduate engineering student perspectives towards their curriculum and memorization and their styles using Bigg’s revised two-factor Study Process Questionnaire (R-SPQ-2F).

The majority of the participants are characterized as students having good study habits, a deep motivation, and deep strategies when approaching their education. They generally recognize the decreasing importance of memorization as they progress in the engineering curriculum. There is also a fairly large subset of students that are classified as deep motivation but surface strategy. Most students believe that at least 50% of an exam should contain questions similar sample problems or assignment questions and surface learners tend to perceive exams to be unfair if too many questions are dissimilar. There was no observed correlation between grades and the R-SPQ-2F results in the courses examined. These results tend to support the hypothesis that surface strategies, including memorization, are being employed by undergraduate students as a means of obtaining adequate performance in lieu of problem analysis skill development.

Keywords: Problem analysis, Memorization, Student perception, Student learning styles, Deep and surface learning.

1. INTRODUCTION

The ability to quickly recall relevant facts or processes is a valuable tool in any learner’s toolbox; however, quick recall is insufficient on its own when solving engineering problems. Indeed, Woods [10] distinguishes between “exercises”, which require remembering or retrieving a plan relying on the recognition that the situation is one the solver has experienced before, and “problems”, which require the creation or development of a plan as a result of the newness of the situation. This definition implies that a focus on quick recall of known solutions, facts, or processes without associated understanding (henceforth referred to as ‘memorization’) is insufficient for tackling engineering problems, and therefore it would be inappropriate for students to complete an Engineering degree by relying on only memorization.

That said, there is evidence that surface approaches to learning, including memorization, play a large role in Engineering students study methods (e.g., see [6] and the references therein). Anecdotally, there is a growing concern that these memorization approaches are being developed at the expense of deeper learning approaches. If true, there exists a very real possibility that students are relying on memorization to complete Engineering courses, even where deeper learning approaches are more appropriate (e.g., analysis or design focused courses).

If it exists, this reliance on memorization at the expense of deeper learning is likely a complex issue with a number of different contributing factors. One such factor could be the nature of the course assessments: as Ramsden famously said in [8], “the assessment is the curriculum, as far as the students are concerned.” Other factors such as mental health, workload, and financial pressures may also have an impact.

As a first step to understanding this complicated issue, this study aims to obtain a snapshot of student perceptions of the role of memorization in the successful completion of their courses and how those perceptions relate to the students’ grades and learning approach (deep vs. surface). Two research questions are posed in this work:

1) What are student perceptions around the role of memorization in Engineering courses and assessments?

2) Does student perception of the role of memorization correlate to their learning approaches and motives, and subsequently to their performance in Engineering courses?

To assist in answering these questions, a survey was distributed to all engineering undergraduate students at the authors’ institution. The core of the survey focused on student perceptions of memorization as a tool in their
various courses and assessments. Students were also asked to complete the Revised, Two-Factor Study Process Questionnaire (R-SPQ-2F) [1] to assess their levels of deep vs. surface learning approaches and motives.

1.1. R-SPQ-2F as a Tool to Assess Deep vs Surface Approaches to Learning

In [7], Marton and Saljo discuss deep and surface approaches to learning, but never explicitly define them. Biggs [3] explains that a deep approach is one which is motivated by an intrinsic desire to understand the content, while a surface approach is motivated by extrinsic desires to, for example, obtain a degree or avoid failure. Beyond this motivational aspect, differentiation between deep and surface approaches become murkier.

Crucially, the context of the course content, the teaching approach, and the assessment approach all help to determine the specifics of what a deep or surface approach may actually look like. In particular, in [3] Biggs explains that, although rote learning is often automatically categorized as a surface approach, there are cases where memorization is valuable and could be considered part of a deep learning strategy; for example, “… a decision to ensure accurate recall of already understood information say, for a high stress situation such as an examination …”. Thus, the important differentiator is when rote learning or memorization is used as a means to “reproduce without understanding” versus when it is used to “code for meaning”.

The R-SPQ-2F is adopted from Bigg’s earlier study process questionnaire (SPQ) [2] and is one of several study strategy inventories used to assess student learning styles [4]. The R-SPQ-2F [1] is designed to determine what a student’s predisposition is (i.e., not whether they actually adopt deep or surface approaches, but what approach they are likely to adopt based on the current circumstances) through a series of 20 questions. To assess the learning approach, the R-SPQ-2F measures four subscales: Deep Motive (DM), Deep Strategy (DS), Surface Motive (SM) and Surface Strategy (SS). The deep and surface subscales are combined to generate overall Deep Approach (DA) and Surface Approach (SA) scores.

Broadly speaking, students with a high DM score are motivated by an intrinsic interest in the material, while students with a high SM score are extrinsically motivated (e.g., by a desire to pass the course). These scores align closely with the traditional view of deep versus surface learning.

The R-SPQ-2F goes further in an attempt to assess strategy. A student with a high DS score is one who adopts a strategy designed to maximize the meaning of the content, while a student with a high SS score adopts a strategy of using a memorization-based approach to learn a narrow band of material.

It should be noted that the deep and surface subscales are not exclusive (e.g., an individual can have a high DS and a high SS score). Additionally, a student could have a high DM but a low DS and vice versa. The implications of such scores are not clear and may require additional reflection.

Equally importantly, deep or surface learning approaches do not necessarily correlate to high or low grades. Indeed, research suggests that final grades are not a good indicator of the quality of learning. For example, a surface approach may result in higher grades with less knowledge retention (e.g., see [6]). Furthermore, the nature of the assessment may lend itself to a surface approach, causing poor performance from a deep learner who is not strategic in their approach to the assessment [5].

In the current study, the R-SPQ-2F was administered to student participants and their scores were used as a method of quantifying learning approach, which was then correlated to their perceptions of memorization and performance.

2. METHODOLOGY

This study was approved by the University of Guelph’s Research Ethics Board. A survey developed by the authors (See Appendix A) was administered via email to all undergraduate students enrolled in the engineering program at the University of Guelph. Students gave informed consent for survey participation and a second informed consent for access to final grade data.

The survey was organized into three parts: Student Demographics, the R-SPQ-2F, and Perceptions of Assessment and Memorization. Demographic data included program, year of study, gender, full-time/part-time status, and overall average. Students were also asked to use a 5-point scale to self-report study habits (e.g., hours spent studying, attendance in lectures, tutorials, and completion of homework). Options for selecting percentages was divided into categories of <25%, 25–50%, 50–75%, 75–90%, >90%. When selecting the importance of memorization, a 5-point Likert scale from not important to very important was used.

Following the demographics questions, students were asked to complete the R-SPQ-2F study process questionnaire (20 questions – see ref [1]) based on all courses they have taken. For questions that refer to the course being studied, students were asked to give the answer that would apply to the subject(s) most important to them.

In the last part of the survey, students were asked about their perceptions of the “fairness” of exams based on the similarity of exam questions to assignment questions. They were also asked about their perceptions of the importance of memorization to the successful
completion of high school, complementary studies electives, and engineering courses using a 5-point scale.

Student survey responses were reviewed qualitatively to obtain insights into student perspectives around the role of memorization in the engineering curriculum. Student scores from the R-SPQ-2F were tabulated according to [1]. Additionally, three ratios (DA:SA, DM:SM, and DS:SS) were calculated for each student, allowing for the relative deep versus surface score in each subscale to be reflected in one number. A ratio greater than one indicates that the deep component is stronger than the surface component. Ratios and course grade data were analyzed with Pearson Correlation tests; and the DA:SA ratio was analyzed with respect to key survey responses around memorization using a Mann-Whitney Test in Minitab 17.1.0 software. The Mann-Whitney test was used to determine differences in perceptions of deep compared to shallow students.

3. RESULTS

A total of 97 students responded to the survey and the request to access grade information with 5 additional students completing the survey but not consenting to grade access. Overall, participants are full-time engineering students (98%) entering the program straight out of high school (87%) and reflect the program distribution within the School of Engineering. The majority of participants were enrolled in 2nd year (46%) with 19% in 4th year and approximately 10% in each of 1st, 3rd, and 5th year. (Note: Students enrolled in the co-op program are considered in their 5th year prior to graduation.) More participants are female (54%) than male (46%).

In general, students participating in the survey can be characterized as “good” students: nearly three-quarters of students stated they have an overall average above 70% and attend over 90% of classes and tutorials, while half of students stated they complete over 75% of ungraded assignments. Indeed, the average final grade data of the participants is generally higher than the final grade data of the general engineering student population.

In the survey, students were asked to rate the importance of memorization in successfully completing high school, complementary studies electives (CSE), engineering courses (ENGG), and their overall success in the engineering program (Overall). From Fig. 1, it is evident that students generally believe that memorization is important to the successful completion of the various courses. Interestingly, about 60% of students consistently believe that memorization is important, but the level of importance decreases with the increasing level of education. In particular, 30% of students believe that to successfully complete high school, memorization is very important, whereas this drops to less than 10% when assessing the engineering program. As 1st year students do not take CSEs, there was a greater proportion of participants responding as “don’t know” which accounts for the decrease in the number of respondents in Fig. 1 for the CSEs.

The results of the R-SPQ-2F study process questionnaire are illustrated in Fig. 2, where the overall deep and surface approach scores are presented by year of study. The dashed line in Fig. 2 indicates a 1:1 ratio of a deep to surface approach score; generally, scores above the dashed line can be considered as an indication of a deeper approach whereas scores below the dashed line would indicate a more surface approach. From the distribution of scores, there is a wide range of deep and surface approach scores across all years.
divided into four quadrants: SM-DS, DM-DS, DM-SS, and SM-SS. The DM-DS quadrant would represent a deep motivation and deep strategy approach to learning, whereas the SM-SS quadrant would represent a surface approach with a greater reliance on memorization. In total, 18% of respondents’ scores were within the SM-SS quadrant, 57% of student scores were within the DM-DS quadrant, 4% in the SM-DS quadrant, and 21% in the DM-SS quadrant.

Fig. 3. Distribution of R-SPQ-ZF results based on the ratio of deep to surface scores for strategy and motivation.

In order to link the perceived role of memorization with student learning approaches, the ratio of deep to surface approach scores was plotted against the perceived importance of memorization in completing the overall engineering program (Fig. 4). Again, the dashed line indicates a 1:1 ratio of deep to surface scores. Overall, the negative slope indicates that the students with a greater surface approach rated memorization as having a greater importance in their learning. Since memorization is believed to be somewhat or very important for 68% of respondents, this trend implies that there are still a significant number (n=40) of “deep approach” students that believe memorization is important. Conversely, there are few students (n=5) with a surface approach that believe memorization has little to no importance to successfully completing the program.

The relative importance of memorization perceived by deep and surface learners is reflected in students’ perceptions of how closely exam content should match homework and assignment problems and the “fairness” of exams. Participants were asked what percentage of exam and test questions should be closely aligned (e.g., same, same with different numbers, quite similar in other ways) with assignment and sample problems. Fig. 5 shows student response to this question according to the student’s learning approach. Students characterized as having a surface approach (DA:SA < 1), favoured a greater proportion of the exam having similarities to previous problems compared to students with a deep approach (p=0.014). Approximately equal numbers of deep and surface learners believed more than 75% of the exam questions should be similar to previous questions. Overall, the majority of students believe at least half of the questions on a test should be similar to previous assessments. Only deep learners believed that less than 25% of the exam should be similar. This is consistent with the idea that students relying on memorization would want to see more questions similar to previous questions that could be memorized.

Fig. 4. Deep to Surface Approach Ratio and the importance of memorization in successfully completing the engineering program.

Fig. 5. The proportion of an exam that should be closely aligned to assignment and sample problems based on the number of deep or surface respondents.

Students may judge an exam to be unfair when too many questions are different from assignment or sample problems. In general, most students feel that less than 25% of engineering exams at the University of Guelph are unfair, as shown in Fig. 6. When comparing the degree of exam unfairness between deep and surface learners, a
greater proportion of the surface learners feel that more than 75% of exams are unfair. That is, there is a much greater drop-off in the number of deep learners that perceive engineering exams are unfair compared with the students categorized as surface learners. That said, there was no significant difference between deep and surface responses (p = 0.19).

It is natural to hope that a deep approach to learning would yield higher grades (relative to a more surface approach based on memorization). To determine if this link between final grades and student approach is present, a statistical analysis of the final grade data for six common core engineering courses (including courses in 1st, 2nd, and 3rd year) was completed, with the results presented in Table 1. This table displays subsets of students who completed informed consent to relate their survey responses to grade data, and who had also completed the course selected for analysis. Each sub-table displays the results of a Pearson correlation test examining the relation between the three ratios calculated from the survey and the student’s final grade in that course.

Based on the Pearson Correlation Coefficient and p values, there is no statistically significant relationship between the approach, motivation, or strategy adopted by a student and the final course grade. This finding is consistent with the literature, implying that final grades are not necessarily indicative of the degree or durability of learning achieved [9].

4. DISCUSSION

The majority of our student respondent population had a DA:SA ratio greater than one, indicating deep motivation and strategies to learning. These students were a self-selected group willing to participate in a study on learning, and therefore might be expected to have scores that reflected a deeper learning approach.

The students’ responses indicated a perception that memorization has an important role in successfully completing the engineering program but less so than required for high school. The decrease in the level of importance for memorization may reflect that the required knowledge for completing a problem or design can be committed to memory or memorized, but the successful application of that knowledge requires a deeper understanding of the material.

<table>
<thead>
<tr>
<th>Course</th>
<th>n</th>
<th>DA:SA ratio</th>
<th>DM:SM ratio</th>
<th>DS:SS ratio</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>50</td>
<td>-0.038</td>
<td>0.004</td>
<td>-0.073</td>
<td>0.792</td>
</tr>
<tr>
<td>2</td>
<td>49</td>
<td>0.007</td>
<td>0.056</td>
<td>-0.029</td>
<td>0.963</td>
</tr>
<tr>
<td>3</td>
<td>22</td>
<td>-0.055</td>
<td>-0.004</td>
<td>-0.090</td>
<td>0.8018</td>
</tr>
<tr>
<td>4</td>
<td>39</td>
<td>0.087</td>
<td>0.011</td>
<td>0.137</td>
<td>0.604</td>
</tr>
<tr>
<td>5</td>
<td>26</td>
<td>0.257</td>
<td>0.112</td>
<td>0.3367</td>
<td>0.204</td>
</tr>
<tr>
<td>6</td>
<td>28</td>
<td>0.246</td>
<td>0.372</td>
<td>0.081</td>
<td>0.207</td>
</tr>
</tbody>
</table>

The majority of students show a deep motivation, suggesting a stronger desire to learn the material; however, a relatively large percentage (21%) of students lean toward a more surface strategy (Fig. 3). While there could be a number of explanations for this observation, we hypothesize that the nature of specific courses and the engineering curriculum in general encourage students to adopt a surface strategy to be successful. Historically,
this is true where engineering students have shown a tendency to adopt a surface approach [6].

Assessment design can become challenging, particularly when trying to balance skill development with student success. Depending on the nature of the assessments, the cognitive load of the students, and the course learning outcomes, teaching and assessment patterns may in fact encourage a memorization approach. If students believe that an exam should closely reflect similar problems already practiced through sample problems or assignments, assessing their skill on new, unseen problems may be considered unfair, especially for students that rely on a surface approach. However, to truly assess skill in problem analysis, it is important to expose students to unfamiliar problems [10]. The challenge then becomes creating an assessment that suitably assesses the skill with new problems without students perceiving the assessment as grossly unfair.

The R-SPQ-2F survey results do not correlate to grades/performance in any of the six courses included in this study (Table 1). There are a number of possible reasons that might explain this result, including extrinsic motivational factors that encourage students adopt strategies including memorization. The lack of correlation of learning approach to grades also suggests that the methods of assessment and the resulting performance metric for those assessments are not identifying those students who are approaching problem analysis material with a surface strategy.

The R-SPQ-2F survey results did illustrate a difference between students who are surface learning (DA:SA<1) and those who are deep learning (SA:SA>1): surface learning students are more likely to believe that a high proportion of exam questions should be closely related to a previous assessment or sample problem. This result suggests a that the R-SPQ-2F may be a tool that can be used to identify students who adopt a surface, and thus memorization, approach to learning.

Limitations of this study include those associated with any study that employs a voluntary survey; i.e., that the resulting pool of respondents may be biased since their participation likely stems from intrinsic motivation (e.g., interest in the survey’s topic) and therefore that those respondents do not represent the responses of all engineering undergraduate students. Another potential limitation of this study is that, in an effort to consolidate the classification of results, the authors have chosen to present the survey data in the form of ratios. The authors recognize that this may result in the loss of information in the form of the actual numeric result in any given section but feel that it offers advantages to viewing the results in a more cohesive manner.

5. CONCLUSIONS

This study has demonstrated that the majority of engineering undergraduate student participants tend to have deep motivation and adopt deep strategies when they approach their education. They generally recognize the decreasing importance of memorization as they progress in the engineering curriculum. That said, there is also a fairly large subset of students that are classified as deep motivation but surface strategy. There was no observed correlation between grades and the SPQ results, but correlations were observed between SPQ results and student perception of fairness of exams.

Future work will look at whether or not the assessment strategies used to determine the final grade are enabling and even encouraging students to adopt surface approaches to learning.

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References


APPENDIX A: STUDENT SURVEY

The following survey questions, in addition to the R-SPQ-2F, was sent to students in order to assess their perceptions on the role of memorization in the engineering program.

1. I have read the consent form and I agree to complete the following survey.
2. I have read the consent form and I grant permission to link my grades to my survey information.

Student Demographics

1. Which Engineering Program are you currently enrolled in?
2. What year of the program are you currently in?
3. Did you enter the School’s engineering program straight out of high school or did you do something after high school before entering School’s program?
4. What is your gender?
5. What is your approximate overall average grade to this point in your engineering program?
6. Are you a Full-time or Part-time student?
7. Estimate the average total number of hours per week that you spend on your studies (including attending scheduled classes).
8. What percentage of your scheduled lectures do you typically attend?
9. What percentage of your scheduled tutorials do you typically attend?
10. What percentage of assigned but ungraded assignments do you typically complete?

Perceptions of Assessment and Memorization

1. What percentage of your university exams and tests are known to be very similar one year to the next?
2. What percentage of exam and test questions should be closely aligned (same, same with different numbers, quite similar in other ways) with assignment and sample problems?
3. What percentage of engineering exams and tests do you judge to be unfair because the questions (or too many questions) are too different from assignment and sample problems?
4. How important was memorization to your success as a high school student?
5. How important is memorization to your success in your university science and mathematics courses outside of the school?
6. How important is memorization to your success in your university complementary studies courses outside of the school?
7. How important is memorization to your success in your university engineering courses within the school?
8. How important is memorization to your overall success as an engineering student?
9. Rate your problem analysis skills?
10. Why do you feel this way? (comment box)