
July 3-5, 2017
Valley Lodge
Magaliesburg
South Africa

Editor: Janet Liebenberg
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Editor: Janet Liebenberg
Published by the SACLA 2017 Organising Committee
Computer Science and Information Systems
Potchefstroom Campus
North-West University
Private Bag X6001
Potchefstroom
2520

ISBN: 978-1-86822-846-1

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Message from the Conference Chair

Welcome to the 46th Annual Conference of the South African Computer Lecturers’ Association (SACLA 2017). I trust that you will have an energizing and enlightening conference at Valley Lodge, Magaliesburg.

The goal of SACLA-conferences is to provide participants with an opportunity to share ideas, while maintaining a high level of academic input from all involved. You are encouraged to participate fully at the conference and to use the breaks and evenings to interact with colleagues from your own and other institutions.

The accepted papers reflect current trends in teaching and learning in Computer Science and Information Systems. This is in keeping with the theme of SACLA 2017, Keeping Education Relevant: Infinite possibilities.

We are fortunate to have an international keynote speaker from the USA, Grandon Gill. In addition, we have scheduled a workshop on ‘The South African Computing Accreditation Board (SACAB) – Implementation and Documentation’.

On behalf of the SACLA community, I wish to express our deepest appreciation to our sponsors, AdaptIT, IITPSA, IBM, Oracle and SAP.

A successful conference requires the effort of many individuals. We would like to thank the members of the program committee for their hard work. We are grateful to the authors who submitted their papers to this conference. I also wish to extend my sincere thanks to all members of the organising committee and congratulations for a job well done.

We hope that everyone will have a good time at Valley Lodge.

Estelle Taylor
SACLA 2017 Conference Chair
Message from the Program Committee Chair

It is with great pleasure that I compile the papers after an intense period of reviewing. I extend my thanks and appreciation to the reviewers who provided extensive and insightful reviews.

I commend the authors for meeting the deadlines that are so important for the smooth running of the process of submissions and review. I thank the authors for using this forum to share and participate in the event.

This year we received 63 papers for review. The program committee consisted of both local and international experts in the fields of Computer Science and Information Systems Education, with the necessary expertise and interest in subjects relevant to the theme of the conference. The program committee had 53 members, of which 30 were international members. Each paper was reviewed by 3 reviewers in a rigorous double-blind peer review process. The programme chairs solicited additional expert reviews in cases where further clarity was warranted. We accepted 40 papers of high quality for presentation at SACLA 2017. Before publishing a paper, authors had to include the corrections as stated by the peer reviewers. Of the 40 presented papers, 22 papers will be published in the Springer publication: Communications in Computer and Information Sciences and therefore, only the titles and short abstracts of these papers are included in this publication.

Thank you again to all our reviewers and authors. I am looking forward to meeting all of you at the conference.

Janet Liebenberg
SACLA 2017 PC Chair
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Authorized Cheat-sheets as an Educational Tool in Computer Science Examinations

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Abstract. Authorized cheat-sheets in formal assessment provide some of the advantages of open-book examinations, such as reduced student anxiety, without the disadvantages, such as the time used by students to look up information during examinations. The use of authorized cheat-sheets has the potential added benefit of students spending more time consolidating the course concepts in order to summarize the most important aspects while preparing their cheat-sheets. This paper describes an investigation into the use of authorized cheat-sheets in the final examination of a second year computer science module on computer architecture and assembly programming. The volume and type of content as well as the quality of student-constructed cheat-sheets were analysed. The impact of these different aspects on student performance was investigated. It was found that the quality of the cheat-sheets created by the students was positively correlated with improvement in individual performance, but that the general performance decreased when cheat sheets were introduced.

Keywords: authorized cheat-sheets, quality content analysis.

1 Introduction

On the spectrum of examination formats from closed-book to take-home examinations, the use of cheat-sheets falls between these two extremes. Authorized cheat-sheets refer to the practice of allowing students the opportunity to compile limited notes in preparation for the formal assessment and to use these notes during the assessment.

One disadvantage of closed-book examinations is that students may spend valuable study time memorizing facts, rather than trying to understand concepts. Complete open-book examinations, on the other hand, have the disadvantage that students may spend less time studying the material in preparation for the examination [2]. Students may prepare less, knowing that they will be able to look up information during the examination. This is usually a false sense of security, however, because if a student does not have a proper understanding of the concepts beforehand, they usually do not benefit from having the information on hand during the assessment.

An added advantage of cheat-sheets over closed-book and open-book formats is that it offers an opportunity for the students to consolidate their thinking in order to create the cheat-sheet. This can help to structure study time since it involves a concrete task that must be completed before the assessment. When using authorized cheat-sheets a limitation on the quantity and format of allowable notes during the examination is specified to level the playing field in the sense of allowing students equal opportunity to choose the content they want to access. Original handwritten format was chosen to not advantage students with wider access to resources than others and to discourage copying.

Other than access to course materials, aspects to be considered in the design of tests and examinations also include the time allowed, level of permitted assistance / collaboration, and scope. The form of assessment investigated in this study was time-restricted (3 hour examination), without any assistance or collaboration and of clearly specified scope. In a series of formative tests a closed-book format was used, while in the examination, authorized cheat-sheets were allowed. The aspect that is investigated in this study is therefore the level of access to course materials while writing a test or exam.

The remainder of the paper is organised as follows: Section 2 discusses some related work on the use and evaluation of authorized cheat-sheets, while Section 3 describes our investigation in the use of cheat-sheets in a
Related Work

The use of authorized cheat-sheets is not a new idea and a number of studies have argued for the benefits of this approach, although results on whether their use is beneficial to learning have been mixed. This section discusses some of the related work in more detail.

2.1 The Impact of the Use of Authorized Cheat-sheets on Student Performance

Many studies advocate for the use of cheat-sheets in examinations. Some of the arguments for the use of cheat-sheets include the following:

1. reduced student anxiety as a result of students having some information on hand to consult during the examination [5, 7, 13];
2. increased learning as a side-effect of the actual cheat-sheet construction (the coding hypothesis [6]);
3. promotion of higher-level thinking skills such as problem solving and reasoning [1, 11];
4. improved performance over closed-book [10] and over open-book [9] formats by students during examinations; and
5. less time wastage for students during examination (compared with open-book examinations) [13].

Some studies argue that the use of authorized cheat-sheets does not enhance learning [5]. This could be because students rely on their cheat-sheets and so are less inclined to learn the material [8] (the dependency hypothesis [6]). In contradiction to the dependency hypothesis, Mathew [10] found that there were no differences in the reported study time between students studying for open-book, closed-book and cheat-sheet exams. Song and Thuente [12] found that the use of cheat-sheets helped the weaker students to improve more than it helped the stronger students. The context of all of these studies [5, 6, 8, 10] was the teaching of psychology. It may be possible that the effects of authorized cheat-sheets could differ in the context of different fields of instruction, such as computer science.

In a study of the use of cheat-sheets in an introductory programming module, De Raadt [4] found that the use and compilation of cheat-sheets had a positive impact on student performance. He also found that students who used cheat-sheets (as opposed to those who chose not to use them) showed a larger improvement in marks relative to the mean mark from one assessment to the next. In our study, we wanted to see whether cheat-sheets, similarly, had a positive impact on student performance in a second-year computer science module.

2.2 Content Attributes of Authorized Cheat-sheets

As an extension to investigations related to the impact of using cheat-sheets on the performance of students, researchers have analyzed the contents in student-compiled cheat-sheets. De Raadt [4] rated cheat-sheets in an introductory programming course on two main aspects: layout and content. The analysis of the layout refers to quality aspects of the cheat-sheets. These are discussed in Section 2.3. De Raadt categorized the content of student created cheat-sheets using four binary features: (1) whether code examples were present or not, (2) whether abstract representations were present or not, (3) whether sample answers to examination questions were included or not, and (4) whether the student included unnecessary language references (provided in the examination paper). He found that the inclusion of sample exam answers was negatively related to student performance.

Song and Thuente [12] extended De Raadt’s binary classification, by quantifying the number of sample answers, formulae and graph representations on the cheat-sheets. The context was a senior-level computer science networking course. They found that the quality of cheat-sheets was highly related to students’ grades.

In this study, we similarly analysed the content of the student cheat-sheets in terms of the quantity of information and the type of information (facts, diagrams, examples or code). We used a density measurement to quantify the content in each of the categories. The aim was to investigate whether a link could be found between these characteristics and student performance.

2.3 Quality Attributes of Authorized Cheat-sheets

Other than the actual content of cheat-sheets, the quality could also relate to student performance.
When rating cheat-sheets in an introductory programming course, De Raadt [4] included quality aspects related to the layout of the cheat-sheets. He categorized the cheat-sheets using three binary features: (1) dense/not dense, (2) organised / not organised, and (3) whether the order on the cheat-sheet matched the course content order or not. De Raadt found that higher performance was positively related to cheat-sheets where the order on the sheet matched the order of the course content and positively related to cheat-sheets that included abstract representations. Song and Thuente [12] extended De Raadt’s binary classification, by quantifying different levels of density and organisation on the cheat-sheets.

In the context of psychology and statistics courses, Mathew [10] rated cheat-sheets on two aspects, namely, richness of detail and the level of organization, but no analysis was conducted based on these ratings. In a medical context, Burke et al. [3] developed a computerized system called QNOTE to evaluate the quality of clinical notes. Apart from identifying the elements that should be part of a clinical note, they identified seven quality aspects to evaluate these notes namely clarity, completeness, conciseness, currency, organization, prioritization, and sufficiency of information.

Inspired by these studies, we evaluated the quality of computer science cheat-sheets on five aspects, namely, abstraction, discretion, coverage, structure and legibility and analysed the impact on students’ performance.

3 Gathering Data

3.1 The Context of our Investigation

The context of this study was a second year module called “Computer Organisation and Architecture” at the University of Pretoria. The module involved a theoretical aspect and a practical programming aspect. Theory topics included representation of data on the machine-level; organisation of the machine on the assembly level; the architecture and organisation of memory; inter- and intra-component interfacing and communication; data paths and control; and parallelism. The practical aspect covered assembly programming, in particular 64-bit Intel assembler for Linux.

The module was introduced in 2014 and student performance was not good. The pass rate after the examination (before the supplementary examination) was 58%. Students expressed high anxiety around the examination, possibly due to the wide range of different concepts and levels of thinking required by the students, from high-level understanding of instruction set design to intricate knowledge of assembly programming on a byte-level.

To assist the students, the use of authorized cheat-sheets in the examination was introduced in 2015. The students were instructed to compile a single A4 hand-written page of notes. The reason for specifying hand-written notes was to ensure that students spent individual effort compiling the notes, rather than simply photocopying from the textbook or from other students’ notes.

During the semester, students wrote closed-book tests. This provided us with an opportunity to compare the performance of the students when using authorized cheat-sheets in the examination with how they performed in closed-book tests. Of the 87 students who participated in the exam, 75 students submitted their notes. We analysed all the submitted notes.

3.2 Analysing Content

When scanning the pile of submitted cheat-sheets, one of the most obvious distinguishing features between sheets was the volume of content. Some sheets had all possible white space on both sides crammed with minutely written content, while others contained only a few lines of content sparsely filling only half of one side of the permitted A4 sheet. Another distinguishing characteristic was the type of content on the sheets. Some sheets comprised only code listings, some only written facts, while others also included diagrams and worked out examples. To analyse the content of the cheat-sheets, five categories of content were defined as follows:

1. Empty: Blank portion with no text or annotations.
2. Facts: Textual facts such as definitions or descriptions of advantages/disadvantages of approaches. Figure 1 and Figure 2 show two examples of factual content.
3. Diagrams: Graphical representations such as flow diagrams or circuit symbols. Figure 4 shows examples of diagrams.
4. Examples: Worked examples such as the calculation of a sample problem or a table of numbers with their binary and hexadecimal values. Figure 3 shows some specimens of content of type ‘Examples’.
5. **Code**: The syntax of assembly commands or the code for the implementation of an algorithm. Figure 5 shows two examples of code content.

![Figure 1](image1.png)  
**Fig. 1.** Content showing facts – dense.

![Figure 2](image2.png)  
**Fig. 2.** Content showing facts – sparse.

![Figure 3](image3.png)  
**Fig. 3.** Content showing examples.

![Figure 4](image4.png)  
**Fig. 4.** Content showing diagrams.
To estimate the quantity of each type of content on each sheet, the number of words in a $2.5\text{cm} \times 2.5\text{cm}$ unit area containing representative written content was counted (using a cutout cardboard template). This number of words was used as a measure of density for the sheet. The number of $2.5\text{cm} \times 2.5\text{cm}$ blocks containing facts, diagrams, examples and code on both sides of the sheet were then multiplied by the density measure to quantify the volume for the whole sheet.

No evidence of copying among students was observed during the analysis of cheat sheets. It seemed as if the restriction of having original handwritten cheat sheets did have the desired effect of students compiling their own notes.

### 3.3 Analysing Quality

The quality of the student notes was assessed using five aspects of quality: (i) Abstraction, (ii) Discretion, (iii) Coverage, (iv) Structure and (v) Legibility. The meaning these aspects is defined by the rubric used to rate each aspect, given in Table 1.

Figure 6 shows an example of content with low and high abstraction of the hamming code algorithm. The top figure shows a worked out example with detail down to the bit level (low abstraction), while the lower figure gives a high-level description of the same algorithm.

![Fig. 6. Sample extracts showing low (top figure: worked example) and high abstraction (lower figure: description of algorithm) content of the hamming code algorithm.](image)
Each cheat-sheet was assigned a value from 0 to 2 for each aspect of quality as defined in Table 1. A total measure of quality out of 10 was then calculated as the sum of the five aspects of quality.

<table>
<thead>
<tr>
<th>Aspect of Quality</th>
<th>0</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstraction</td>
<td>Too much detail, either full sentences or long code listings</td>
<td>Some summaries or categorisation</td>
<td>Good abstraction of concepts, high level algorithms in place of detailed code</td>
</tr>
<tr>
<td>Discretion</td>
<td>Includes many unimportant facts/aspects of the content</td>
<td>Some important facts/aspects, but some not important</td>
<td>Notes reflect the essential concepts</td>
</tr>
<tr>
<td>Coverage</td>
<td>Only a few aspects of the course are covered in the notes</td>
<td>Notes partially cover the breadth of the course</td>
<td>Notes cover the full breadth of course topics</td>
</tr>
<tr>
<td>Structure</td>
<td>Almost no structure in notes</td>
<td>Some structure in notes</td>
<td>Notes are well structured allowing concepts to be found easily</td>
</tr>
<tr>
<td>Legibility</td>
<td>Notes barely legible, messy</td>
<td>Notes are fairly legible</td>
<td>Notes are highly legible</td>
</tr>
</tbody>
</table>

### 4 Results

#### 4.1 The Impact of Introducing Cheat-sheets on Overall Performance

Our first investigation involved determining if the introduction of authorized cheat-sheets had an impact on exam performance for the students who were required to use cheat-sheets compared with the performance of students who wrote a closed book exam. We compared the marks of the students in the exam of 2014 and the exam of 2015. In 2014, the exam was closed book while in 2015 the students were authorized to use their notes. The summary statistics of the two exams are shown in Table 2. Although the average did not change from 2014 to 2015, the distribution of marks changed slightly with a lower maximum, a lower minimum and a larger standard deviation.

<table>
<thead>
<tr>
<th></th>
<th>2014</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of students</td>
<td>66</td>
<td>83</td>
</tr>
<tr>
<td>Average exam mark</td>
<td>48</td>
<td>48</td>
</tr>
<tr>
<td>Median exam mark</td>
<td>48</td>
<td>48</td>
</tr>
<tr>
<td>Maximum exam mark</td>
<td>86</td>
<td>83</td>
</tr>
<tr>
<td>Minimum exam mark</td>
<td>21</td>
<td>10</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>16.3</td>
<td>17.0</td>
</tr>
</tbody>
</table>

Figure 7 shows the distribution of the examination marks in the two years. Since the total number of participants in these events are different, the values are normalised to percentages for comparison. The graph and the table in Figure 7 show the percentage of students in ten performance classes: 0 – 10%, 11 – 20%, ... 91 – 100%. The distribution of marks for the exam with authorized notes seems to be closer to a normal distribution compared with the distribution of marks for the closed book exam.

More students who participated in the exam with cheat-sheets were in the lowest two classes (0 – 20%) than students who participated in the closed book exam. This supports the notion that poor students may fare worse with the use of cheat-sheets than in closed book exams. This could be attributed to students’ inability to compile useful notes or to reduced preparation time due to false confidence based on the availability of notes.

Although the poorer students fared worse in 2015, the total percentage of students failing the examination (with marks under 50%) was slightly lower in 2015 (57%) than in 2014 (59%). This supports the notion that borderline
students may fare better when they have access to notes. It is possible that borderline students are likely to fail closed book exams due to failed short-term memory, while the availability of notes contributes to reduced anxiety leading to better performance. The overall pass rate in the COS284 module improved from 58% in 2014 to 62% in 2015.

![Graph showing distribution of exam marks for COS284 in 2014 and 2015]

**Fig. 7. Distribution of the exam marks of COS284 in 2014 and 2015**

### 4.2 The Impact of Using Cheat-sheets on Individual Student Performance

Our second analysis involved comparing how the performance of the same cohort of students differed when using cheat-sheets or not. In our sample of 75 students, 57.3% of the students performed worse in the examination using cheat-sheets than in the closed book summative assessment tests, which is contrary to Mathew [10] who observed overall improved performance when using cheat-sheets. This decrease in performance could be due to factors other than the cheat-sheets, such as increased content in the summative assessment. It is, however, interesting to analyse which students performed worse and which performed better.

Figure 8 plots the performance of students in closed-book tests compared with the written examination, showing the averages of groups of five students sorted by final mark. For example, for the group of five students who had the lowest final marks (with an average of 31%), the average mark obtained by these five students for the closed book tests was 34%, whereas the average mark obtained for the examination was 16%. Similarly, the other students with low final marks (below the 50% pass mark) performed worse when using cheat-sheets. A number of the middle achieving groups, however, achieved higher marks when using cheat-sheets. These findings are the opposite of Song and Thuente [12] who found that the use of cheat-sheets helped their weaker students to improve.
The impact of the type of content and the quality of the cheat-sheets on the improvement in student performance are investigated in the following sections.

4.3 Cheat-sheet Content and Student Performance

The horizontal axis of Figure 9 plots the average change in mark from closed book tests to examination (using cheat-sheets) of five consecutive students after sorting all the students by the value of this change. For each of these groups the bar shows the average number content-units (where one content unit is equivalent to 1000 words of written text) filled with each of the types of content. For example, the five students with the largest decrease in marks (an average of -22%) from tests to examination are plotted as the first column in the figure.

There is no apparent trend in Figure 9. The two groups of five students who provided the most content on average on their cheat-sheets achieved a decrease of 13% and an increase of 12%. In addition, there is no pattern in the type of content across the performance classes. We conclude that there is no relation between the volume or type of content on the cheat-sheets and the change in student performance.

4.4 Cheat-sheet Quality and Student Performance

Figure 10 shows the average quality per aspect for the same student groups as in Figure 9. Here it seems that there is a positive correlation between higher quality of the cheat-sheets and the improvement in performance of the students. Higher values associated with better discretion and abstraction is evident on the high side of the graph, i.e. for the students who showed greater improvement. This points to a possible future intervention strategy.
whereby students should be guided to create cheat-sheets of higher quality. Song and Thuente [12] found that in a class of engineering students, when students were able to improve the quality of their cheat-sheets between examinations, their grades improved. A possible intervention strategy could therefore be to assist low-performing students in the compilation of high quality cheat-sheets, with the hope that examination preparation and performance can be improved.

Fig. 10. Change in mark plotted against cheat sheet quality.

5 Conclusion

In this paper, we investigated the use of authorized cheat-sheets in the final examination of a second year computer science module on computer architecture and assembly programming. We described how we evaluated and classified these sheets. Our classification of content types as well as the rubric we used for quality assessment could be useful in other contexts.

Results show that the use of authorized cheat-sheets did not have a significant overall impact on student performance. For most students, especially the weakest ones, it had a negative impact. We have, however, seen that some students improved their marks significantly when using cheat-sheets and that the sheets created by these students were generally of a higher quality than the other students, especially when considering discretion and abstraction.

We conclude that the use of authorized cheat-sheets is beneficial to students who are willing and able to produce quality cheat-sheets. The introduction of cheat-sheets does not improve student performance by default, but it has the potential to be used as an educational tool to assist students to prepare better for examinations.

We believe that students can benefit more when required to compile such cheat-sheets if they are made aware of the learning opportunity imposed by the action and guided to put the correct kind of effort into creating these cheat-sheets.

References