Note Sheets: A Reliable Predictor of Success?

Correlating Students' Note Sheets and Exam Performance

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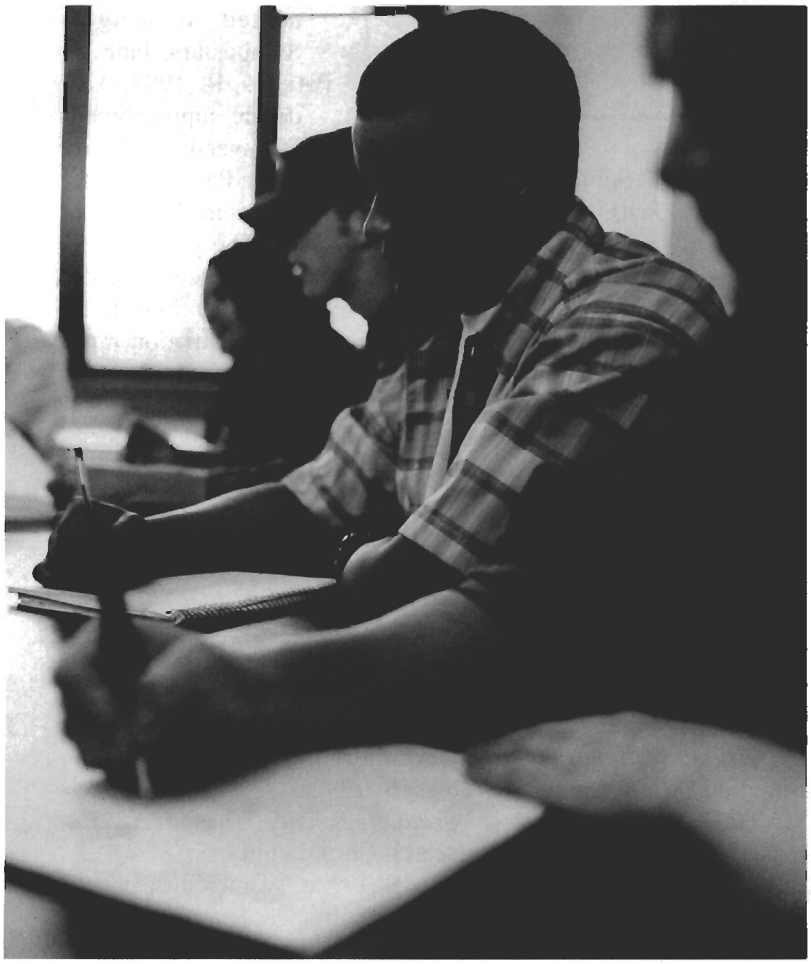
Students in a large introductory-level biology course brought one page of notes to their exams. The authors scored these note sheets for their format and content. Student performance on exams showed a very limited correlation with the format or content of note sheets. Results suggest that, for some students, preparing note sheets is not an effective study method.



When it comes to exams, there is no better predictor of good performance than thorough and effective preparation. To do so, students should review lecture notes and readings and prepare a few pages of notes that summarize the material. Whether or not students should be allowed to use any of these supplementary materials during the exam, however, has been the subject of extensive debate and research.

Most studies of students' use of notes or other supplementary materials during exams have compared closed-book exams, where no outside materials are allowed, and open-book exams, where students may consult textbooks and all of their own notes during the exam. Several studies of students' perceptions of open-book exams (Feldheusen 1961; Boniface 1985) found that "open-book examinations reduce counterproductive anxiety in some candidates" (Boniface, 201). In addition, these exams "reduce the unnecessary 'rote' memorization of facts" (Boniface, 201). Theophilides and Dionysiou (1996, 162) reported that students felt open-book exams promoted "creative use of the knowledge gained" and "encouraged mastery of course content."

While students are enthusiastic about open-book exams, the effects on student exam performance are mixed. Krarup et al. (1974) and Jehu et al. (1970) found no effect on scores when either multiple-choice or essay exams were studied. Ioannidou (1997) observed improved scores with open-book exams when the questions involved terminology and problem-solving, but not when the questions involved argumentation. In a detailed study of students' activities during an open-book exam, Boniface (1985) found that time spent consulting books and notes was negatively correlated with exam performance. Taken together, these findings suggest that access to textbooks and lecture notes can improve exam performance for some students in some situations, although for others, it may lead to inadequate preparation and overdependence on notes and books, which then results in poor exam performance.

To help prevent the underpreparation that can result in the case of open-book exams, some educators allow students to use only a single page of highly condensed notes during the exam. Distilling the relevant information onto these note sheets is thought to

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"reinforce the material" (Clopton 1992, 110) and thus improve exam performance. In one study of this technique (Dorsel and Cundiff 1979), one half of a class of university students were allowed 10 minutes to prepare a small card of highly abbreviated notes immediately before an exam. When the scores of the groups were compared, there was no significant difference between students who made and used their notes and students who neither made nor used notes. While these results suggested that the note sheets would be of limited value in preparing for an exam, a study of more extensive note sheets was warranted.

In this study, students in a two-semester General Biology series were encouraged to prepare notes on both sides of a single 8.5″ x 11″ sheet of paper; all students were allowed to use their note sheets during the exams. After each exam, we collected these note sheets and compared each student's performance on the exam with the organizational style and content of his or her note sheet.

Research Methods

This study involves three exams from one semester of General Biology I (which covers genetics, biochemistry, molecular biology, and cell biology) and one semester of General Biology II (which covers evolution, phylogeny, physiology, and ecology) These are large lecture courses (roughly 225 students in General Biology I; 125 in General Biology II) with a substantial lab component. Both courses were conducted by one of the investigators (BW), who prepared the exams, lab manual, and lectures. Three exams were administered. The genetics exam, which consisted entirely of problem-solving questions, and the biochemistry exam, which mixed problem solving and factual recall, were given in General Biology I in the fall of 1997. The animal phylogeny question, which was entirely based on factual recall, was the second question of four on the third exam in General Biology II given in the spring of 1998.

Before each exam, we gave the students a detailed list of topics to be covered and told them that they could bring one 8.5″ x 11″ sheet of paper to the exam containing whatever notes they chose. At the end of each exam, students attached their note sheets to their exams with a paper clip; we reassociated note sheets that became separated from exams using the students' names, if present, or by comparing handwriting. Any note sheets that we could not match with exams were not included in the study. Table 1 shows the subset of all the exams that could be matched with note sheets. In all cases we measured, the mean score of the exams included in the study was not significantly different from the mean of the class as a whole.

We scored the notes using rubrics developed collaboratively by all three investigators. Each note sheet was scored by at least two of the investigators; all discrepancies found were then resolved.

Graduate teaching assistants (TAs) graded the exams under the supervision of the instructor (BW). First, the instructor provided the TAs with a draft grading rubric based on concepts the instructor had emphasized in addition to likely student mistakes. Each TA then read several answers and, based on these, made minor revisions to his or her rubric with the supervision of the instructor. For consistency, each TA was assigned to grade all the answers to a particular question. The instructor was present during the grading session to resolve any ambiguities in the rubric. (Sample questions from the genetics exam, the biochemistry exam, and the entire animal phylogeny question, along with their final grading rubrics, can be found on *JCST*'s website at *www.nsta.org*.)

We analyzed the data using StatView 5.0. The statistical conclusions described are identical to those found when the percentages were transformed to angles using the arcsin transformation $\theta = \arcsin[\sqrt{x/100}]$ or when untransformed data were analyzed using nonparametric methods.

Results

Correlation between Score and Note Sheet Content

The genetics exam included only problem-solving questions; we scored students' note sheets for the presence or absence of information relevant to each of the four exam questions. These scorings were then combined with the point values of each question to give the percent of relevant information on the note sheet. The animal phylogeny question emphasized factual recall; we scored the students' note sheets for presence, partial presence, and absence of relevant

Table 1. ***Fraction of exams with matching note sheets.***

This table compares the scores of the students we included in this study with the scores of the class as a whole. We found no significant differences

	Entire Class			Exams with Matching Note Sheets				
Exam	**n**	**Mean**	**sd.**	**n**	**Mean**	**sd**	**% Matched**	**p**
Genetics	226	63.21	22.49	170	63.36	22.25	75	>0.9
Biochemistry	194	65.56	20.20	129	66.03	18.27	66	0.08
Animal Phylogeny	116	not measured		89	84.41	15.72	76	—

Table 2. *Score vs. note sheet content: Genetics exam and animal phylogeny question.*

This table shows the regression coefficients (r^2) and slopes of the best-fit lines for data correlating exam score with note sheet content. The regression coefficients are small but significant. The differences between the correlation coefficients and between the slopes are not significant.

Exam	r^2	slope
Genetics	0.074	0.183
Animal Phylogeny	0.194	0.324

information. As shown in table 2, performance on both exams shows a significant correlation with content. Less than 20 percent of the variation in scores, however, is correlated with differences in note sheet content. The differences between the correlation coefficients and slopes are not statistically significant ($p = 0.1$ and $p > 0.75$, respectively).

The biochemistry exam contained both problem-solving and factual-recall questions; we scored the students' note sheets for the presence or absence of information in four major categories: basic chemical bonding; protein structure; free energy and enzymes; glycolysis, respiration, and photosynthesis. Figures 1a and 1b show sample sections of note sheets made by students who took the biochemistry exam. The portions shown include information from the basic chemical bonding and protein structure categories. The student whose note sheet is shown in figure 1a received 39/100 on the exam; the student whose sheet is shown in figure 1b received 90/100. Table 3, which lists the relationship between content and student performance on the exam, shows that none of the differences between the categories of students are statistically significant.

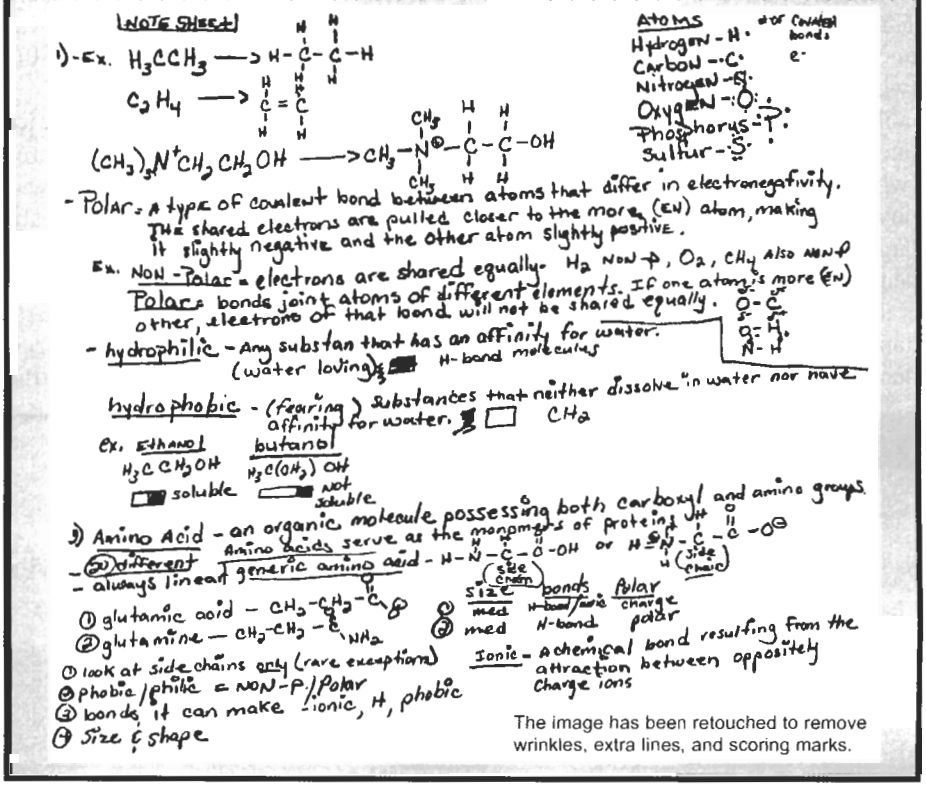
These results can also be analyzed as shown in table 4 by dividing a graph of points scored versus note sheet content into four quadrants. The four quadrants are formed by dividing the exam scores into high (score above class average) and low (score below class average) and dividing the note sheet content into poor (content below class average) or good (content above class average). These quadrants identify four types of students (table 4a). Tables 4b, 4c, and 4d present data from the genetics exam, the biochemistry exam, and the animal phylogeny question in this format. All four types of students are present in substantial numbers in each case. At least 50 percent of students have either good note sheets and high scores (type 4) or poor note sheets and low scores (type 1). Surprisingly, students with good note sheets but poor scores (type 2) represent a substantial fraction (15–30 percent) of the students in each case. Students with poor note sheets and good scores (type 3) represent a smaller fraction of the class (6–18 percent).

It is neither necessary nor sufficient for each student to prepare a comprehensive note sheet to do well on a given exam. We encourage students to regard preparing note sheets as a means of reviewing and organizing the material, not an end in itself.

Relationship Between Score and Note Sheet Style

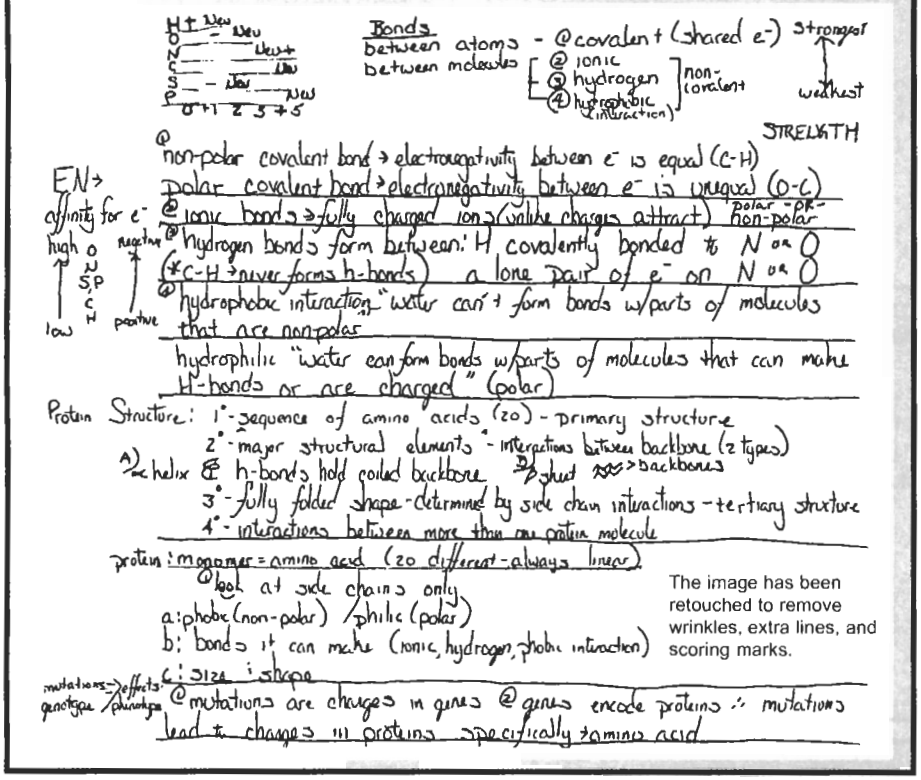
We sorted the notes relevant to the animal phylogeny question into three groups based on their organizational style. Those who used the "Table" style constructed a matrix where the rows corresponded to different animal groups and the columns corresponded to particular properties of the animals in the groups. Those who used the "List" style

Figure 1. *a. Portion of note used during the biochemistry exam. The student who wrote this received a 37/100 on the exam.*



The image has been retouched to remove wrinkles, extra lines, and scoring marks.

Figure 1. ***b. Portion of note sheet used during the biochemistry exam. The student who wrote this sheet received a 90/100 on the exam.***



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expressed the information as a list of animal groups with their properties enumerated as subtopics. The note sheets that could not be categorized into any of the above groups were typically quite unorganized; we scored these as "None." The distribution of students' scores for each of these groups are shown in table 5. Students who used the table or list styles did significantly better than those whose note sheets had no discernable organizational style.

We sorted the note sheets for the biochemistry exam into groups based on how well organized the notes were. The "Very Good" note sheets had clear headings and a logical layout and grouped related information together. Those labled "Average" had some of these features; those found "Poor" had none. The relationship between organizational style and overall exam score is shown in table 6. Surprisingly, students whose notes showed poor organization had significantly higher overall exam scores than either of the other styles. There was no significant difference in overall exam score between students whose notes were rated "Very Good" or "Average" for organization.

Students' Perceptions of Note Sheets

The students in General Biology II compared their experience with note sheets on two exams, one primarily factual recall and one primarily problem solving in an anonymous survey conducted in lecture several weeks after the second of the two exams; 61 out of 121 students (50 percent) responded. Note sheets from these exams were not analyzed as part of this study. The overwhelming majority (>95 percent) of the students made note sheets for both exams; more than 80 percent of the students reported that they used them during the exam.

The students rated how helpful making the note sheet was when studying for the exam as well as how helpful having the note sheet was when taking the exam. Their responses were on a scale of 0 (not at all helpful) to 3 (helped a lot) (table 7). The students felt that the note sheets were significantly more useful when taking the factual-recall exam than on the more problem-solving exam. In both cases, they felt that making the note sheet as they studied was significantly more valuable than using the notes while they took the exam.

Discussion

We had hoped to encourage more complete preparation by allowing students to make two-page note sheets as they studied for the exams in General Biology I and II. We felt that the act of condensing several weeks of class material into two sides of one page should help to solidify this material in the students' minds. This view was supported by the students' perceptions of the note sheets as shown in table 7, which shows that most students felt that making note sheets was useful preparation for the exam.

If preparing the note sheets were a valuable study aid, one would then expect that a more complete or

Table 3. ***Score vs. note sheet content: Biochemistry exam.***

Each group is compared to the group above it. None of the differences are significant.

Number of Subject Matter Categories	Score mean	sd	n	p*
0	—	—	0	—
1	65.9	24.7	8	—
2	65.7	18.4	40	0.98
3	68.5	18.9	41	0.49
4	63.7	16.3	40	0.22

Table 4. ***Students sorted into four types based on score and note sheet content.*** (The percent is listed of each type for each of the three exams studied.)

	a		b		c		d	
	Four types		Genetics		Biochemistry		Animal Phylogeny	
High	3	4	14	40	18	31	6	41
Low	1	2	31	15	19	32	24	29
	Poor	Good	Poor	Good	Poor	Good	Poor	Good
	Note Sheet		n=170		n=129		n=89	

Table 5. ***Score vs. note sheet organizational style: Animal phylogeny question.***

Each group is compared to the group above it in the table. The scores of the students who used the 'Table' style are significantly higher than those who used the 'List' style, which are significantly higher than those whose note sheets had no clear organizational style.

	Score			
Style	**mean**	**sd**	**n**	**p***
Table	90.4	10.2	31	—
List	84.2	15.6	51	0.03
None	65.5	18.9	7	0.04

Table 6. ***Score vs. note sheet organization: Biochemistry exam.***

Each group is compared to the group above it in the table. The scores of the students whose note sheets were classified as poorly organized were significantly higher than those of the other two groups.

	Score			
Organization	**mean**	**sd**	**n**	**p***
Very Good	57.2	13.6	17	—
Average	59.1	16.8	45	0.6
Poor	72.9	17.7	67	<0.001

well-organized note sheet would represent more thorough preparation on the part of the students. One would then expect that students with these more complete note sheets would perform better on the exam. Conversely, the students who had prepared poorly for the exam would have incomplete or disorganized note sheets; this poor preparation would then lead to poor performance. One would therefore expect a strong correlation between note sheet quality and score.

The data correlating performance with note sheet content reveal a more complex pattern. In all cases, the distribution of scores of students with little or no relevant information on their note sheets overlapped substantially with the distribution of those whose note sheets contained all the relevant information. The effects of note sheet content on exam performance were small (in the cases of the genetics exam and the animal phylogeny question) to nonexistent (in the case of the biochemistry exam); the size of this effect was independent of whether the questions emphasized factual recall or problem solving.

Our data can be further explored by considering the implications of each of the four types of students shown in table 4. The naive model described previously predicts that we should only find students with poor notes and poor scores (type 1) and students with good notes and good scores (type 4). The distributions we observed demonstrate the existence of two unexpected additional types of students: those with good notes but poor scores (type 2) and those with poor notes but good scores (type 3). For students in these groups, making detailed note sheets was not an effective method of preparation for the exam. The smallest unexpected group of students in each case, those who were able to do well on the exams even with incomplete notes (type 3), presumably know the material well enough that notes were unnecessary. Their notes are likely to represent the few details they could not be sure to remember. These students presumably found other more effective methods of exam preparation that were not documented in their note sheets.

Most surprising are students with complete and well-organized notes who did quite poorly on the exams (type 2). These students, who represent 15–30 percent of the class, were able to identify the relevant material, select the most important portions, and condense this material into two pages. However, these students were unable to apply this material successfully to either factual-recall or problem-solving questions on the exams.

Although the note sheets of type 2 students are very similar to those of type 4 students, their differing exam scores show that this similar content corresponds to very different levels of understanding. For example, the statement "autosomal dominant diseases show affected individuals in every generation" was one of several tips for starting pedigree problems that the instructor put on the blackboard during a genetics lecture. That phrase, verbatim, was present on the note sheets of many students who took the genetics exam; the genetics exam scores of these students ranged

from 2/100 to 95/100. Based on their performance on the exam, the type 4 students used that statement as a guideline and were not misled by exceptional situations. The answers given by the type 2s reveal that they did not understand the limitations of the statement and applied it too generally, and were thus often unable to answer relevant questions correctly.

Another example is shown in figures 1a and 1b. Figure 1a shows part of the note sheet of a student who received a 39/100 on the biochemistry exam. Figure 1b is the comparable portion of a note sheet of a student who received a 90/100. Both contain essentially the same material in roughly the same format, thus both students studied this material in detail. However, based on their exam scores, the student from figure 1b was able to apply this information to the questions correctly while the student from figure 1a was not.

In contrast, our data show a strong correlation between note sheet quality and exam performance. Not surprisingly, better performance on the animal phylogeny question, which emphasized comparisons between different phyla, was correlated with having the properties of different organisms organized by phylum in matrix or list format for rapid access. In this case, there was a clear match between the format of the notes and the cognitive activities required to answer the question. In contrast, this effect was reversed on the biochemistry exam, which emphasized problem solving to a greater degree. Here, the students whose notes were most organized did significantly poorer than those whose notes appeared disorganized. With a greater emphasis on problem solving, the cognitive activities required to answer these questions were not clearly reflected in any particular organizational style.

This probably represents a phenomenon similar to the one observed in the analyses of note sheet content. In this case, the well-organized note sheets are the result of type 2 students who invested substantial effort in recopying their notes without understanding what they were writing. For this group of students, their notes looked more useful to the teachers who sorted them than they were to the students who wrote them.

Implications for Teaching

Our findings show that preparing detailed note sheets has only a small positive effect on student performance. However, it is clear from our survey (table 7) and others' research that students prefer to have notes available during the exam because it reduces the amount of memorization required and their level of anxiety. As a result, students are allowed to bring note sheets to exams in General Biology I and II. In these courses, we use the results of this study to help the students to prepare and use note sheets effectively. As the students found, preparing a note sheet is more useful as a study aid than actually having a note sheet while taking the exam.

We encourage students to regard preparing note sheets as a means of reviewing and organizing the material, not an end in itself. Ideally, the process of preparing a note sheet should make using the note sheet unnecessary, except in the case of certain specific details. By encouraging the students to reflect on their study processes in this way, we will help them to develop the metacognitive skill needed to prepare for exams more successfully.

Table 7. *Students' evaluation of note sheets.*

Students' responses were on a scale of 0 (not at all) to 3 (helped a lot). In both cases, making a note sheet was found to be significantly more useful than using it during the exam. Preparing a note sheet was found to be significantly more useful during an exam that emphasized factual recall than during an exam which emphasized problem solving.

	How helpful was **making** the note sheet in preparation for the exam?	How helpful was **using** the note sheet during the exam?	
Exam Type	**Mean ± sd. (n)**	**Mean ± sd. (n)**	
Factual recall	2.47 ± 0.66 (56)	1.89 ± 0.86 (58)	p<0.001
Problem solving	2.22 ± 0.89 (59)	1.54 ± 0.90 (59)	p<0.001
	NS	p=0.03	

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