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KIMIA DASAR: AN EVALUATION

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Kimia Dasar: An Evaluation

This report contains an evaluation of Kimia Dasar and II which was made during July and August, 1984. It has been compiled after discussions with staff and students and observations of lectures and laboratories. Our understanding of the courses are not perfect. We are not yet fluent in Bahasa Indonesia, nor have we stayed long enough in Indonesia to recognize the cultural influences upon the educational system.

In spite of these weaknesses, we hope that this report will be useful in two ways. First, it is a model of how to carry out a course evaluation for the purpose of improving a course. It is not to be used as a model for judging if a course is "good" or "bad." As new courses are developed at IPB, evaluations for course improvement should be made periodically. Such evaluations can be made by the staff of the jurusan who have developed the course or by people from outside the jurusan.

Secondly, this report can be used to plan improvement in Kimia Dasar I and II. The ultimate goal of such improvements is to decrease the number of students who fail these courses by improving student learning. These courses will also play an important role in encouraging students to major in chemistry or biochemistry.

We would like to thank Anwar Nur for all his help in this work. We thank also M. Sjachri, Elly Suradikusumuh, Sri Saeni, Norman Azwar, Tony Bird and W. Harjadi who gave generously of their time and opinions. We have tried to accurately record their concerns and opinions about Kimia Dasar.

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I. The Curriculum

Analysis

The material taught in Kimia Dasar I and II can be described as "traditional". Topics covered are similar to those taught in first level college chemistry courses world-wide. Much content is taught in a very short period of time. The course covers material rapidly, without much background information. There is little discussion about how to use the information. There appears to be much agreement among lecturers about what will be taught. There does not seem to be a current syllabus, although one was available in the past (1982).

The material taught is a mixture of facts, concepts, rules and problems. Problem-solving appears to have little emphasis in the curriculum compared to the US and Australia (the two educational systems with which we are familiar). This is indicated both in the amount of lecture time given to problem solving activities and also in the number of problems on the current exams.

Since students come to IPB with three years of high school chemistry, some parts of the Kimia Dasar curriculum must be repetition. We do not know how much or which parts of the curriculum are familiar to students before the beginning of Kimia Dasar I. The high school chemistry texts which we examined contain somewhat less information than American high school texts. At first analysis, the differences center around the number of examples and

the amount of quantitative problem solving illustrated or required. Many chemistry staff persons have spoken of the wide range of students who take chemistry at IPB and it is probable that student knowledge varies widely.

Comments

The number of topics taught is inversely proportional to the amount that can be learned about each one. Currently, the amount of information presented is so high that students can only learn superficially each topic. IPB students take chemistry because they need to use chemical processes and information in their major fields of study. The chemical topics which are taught should be only those which are important for agricultural students. The depth of information must be high enough so that students can learn to use the information which they learn in solving real chemical problems.

Possible Actions

The staff of Kimia Dasar should consider decreasing the number of topics taught. Omit from the curriculum topics of minor importance (e.g., historical developments) or abstract information with no practical use. Use common chemicals and processes to illustrate chemical principles.

Teach more problem solving in class and by assignments. Describe and illustrate how and.when chemical principles will be used in solving problems.

Identify which chemical information is already known by nearly all students from high school studies. Use analysis of the national

exams or develop a pretest to be given to IPB students at the beginning of Kimia Dasar 1. Develop alternative ways for students who begin the courses without the expected information to study it independently.

II. Teaching Methods

As in any school, lecturers have different characteristics from one another. However, there were some similarities. All lecturers which we observed were clear and well organized. Most followed the book closely. Examples used in lecture were often those from the text.

There was a moderate amount of teaching of comparisons and contrasts which is of great help t students who are learning concepts or processes. Some lecturers also summarized information at the end of a section of material. Mathematical formulas were given in class, sometimes with algebraic trans- formations of the formulas carefully worked out for students to follow. Some lecturers were observed to be using flexible wording in their presentations. Such presentations, if students are aware of this practice, would help students avoid parroting of definitions, and help them develop the precise meaning of chemical terms. That is, the teacher was showing by example how to put concepts into one's own words.

Except for comparisons and contrasts as noted above, there were not many examples of lecturers describing the relationships among parts of topics. However, this may be due to our inability to follow the subtitles of the lecture or because of the nature of the material which was being taught during our visit.

Although mathematical formulas were presented in class, few examples of problems were worked in class. Students were occasionally referred to examples of problems in the text or at times, were referred to problems which they should work on their own. One class was observed in which for 1 hour, students and the lecturer worked problems on the blackboard. Some students were observed to be working along with these problems. Other students were reading the textbook or were otherwise occupied.

Comments

Chemistry has a reputation for being a very difficult course. Part of this reputation comes from the large amount of information we expect them to learn. But part also comes from our failure to teach students what they will be expected to do with information that they learn.

It is possible to teach students how to think about chemistry properly and how to learn it efficiently. As noted above, the staff is already using some powerful teaching methods to assist students in this matter. These techniques should be used frequently and be made more direct. Each type of chemical knowledge (facts, concepts, rules, and problems) demands specific actions by students. For

example, in order to learn a concept, students must not only learn the meaning of the new term, but they must also develop criteria for recognizing all examples which belong to that concept class. Further, students must also learn to recognize the examples which are not members of the concept class.

As another example, for a student to learn to perform a chemical calculation, they must develop a general set of directions for solving any problem of that kind. They must also discover under what conditions that process should be used.

Many students will need instruction in how to perform such actions. If some instructions of this sort are included during lectures, this will decrease the amount of time available for presenting new information, but will help students be able to learn the presented material more completely and efficiently.

Possible Actions

Identify the learning demands of different kinds of chemical content (see the handout dated 3/8/84 on teaching methods). Given in this handout are some suggestions of teaching techniques for teaching students how to learn. Occasionally, during lectures, tell students why you are using a particular teaching technique.

Develop handouts of questions which students can use to direct their study outside of class. For example:

"How can you decide if a specific substance is an acid

-from its chemical formula
-from its reactivity?"

> "How do you solve a 'weight percent' problem, that is a problem which asks you to calculate the percent by weight of an element when given the chemical formula of a substance?"

These homework papers need not be collected. But students should be shown a direct connection between being able to answer these questions and their ability to answer questions on exams.

Determine more precisely what knowledge and skills you expect students to possess. For example, analyze some recent exams and ask for questions on these exams: "If I were a student, how would I go about answering these questions?" If you understand what knowledge and skills students must have to succeed on exams, you will be able to tell students more directly how to use the information presented in lecture.

III. Testing

The most obvious characteristic of the current chemistry exams is their length: 6 to 9 pages of closely typed material, with no work spaces on the paper. The format of the test contributes to its length. Multiple choice questions often contain multiple parts. Although the sum total of these questions for grading purposes was only approximately 60 to 70 questions, students actually needed to answer nearly 200 questions to produce the 60 or 70 answers. The need to develop such a large number of questions leads to repetition of some questions. There appeared to be more repeated questions on this current year's exams than on exams from two years ago.

The problems at the end of the exams were generally very hard. There were only a few simple problems, those which could be solved by following a model process which had been taught in lecture. Most of the problems combined two or more processes into one question, or disguised in some way what process was needed for solution to the problem. There was no partial credit for any problem; thus, if students did not put down the correct answer for a problem, staff were unable to tell if the student had made a trivial error, or if the student didn't know anything about the problem.

Test questions can ask students to recall or recognize information (facts, concepts, rules and problems), to classify examples into concept classes, to apply rules to familiar or new situations, as well as to solve problems. This list of question types is arranged according to difficulty (i.e., recognizing facts as correctly or incorrectly stated is the easiest skill; problem solving is the hardest). The majority of multiple choice type questions were on the very simple end. Few required application of rules or solution to simple problems. Some of these questions were of questionable importance (e.g., selecting the correct name of the person who first discovered a rule).

Comments

The number of questions on the exams leads to time pressure. Students must work very quickly, without much time for thinking or checking their work. Under these conditions, an advantage is given to students who can work the fastest, can decide well which questions to

spend their time answering and which to simply guess at an answer and those who can spot and exploit flaws in questions which give you the answer even if you do not know any chemistry. Thus, the exam grade may not accurately reflect the amount of chemistry which students have actually learned.

When more than one staff member teaches a course and yet common exams are given, there must be strong coordination among the staff to prepare well balanced exams. Staff must also cooperate with the coordinator by preparing questions in areas which are assigned to that person and getting the questions prepared in the specified time.

We believe that it should be possible for the Kimia Dasar staff to design a modified exam system which will give them better information about what their students have learned and simultaneously ease the burden of preparing and grading the exams. These issues are discussed more fully in the handout on testing methods (3/8/84).

Possible Actions

See the summary of recommendations for the above mentioned report.

IV. How Students Learn

In the US, successful students are those who study chemistry regularly (usually daily), can draw logical conclusions from information presented in class, test their own progress in learning the course content at regular intervals, are personally motivated so that they do the work even when their work is not checked by teachers, and can anticipate what types of questions will be asked on exams. We have not

been able to determine which of these actions and attitudes are essential for success in Kimia Dasar at IPB. The few students who we were able to talk with about their studying claimed to use strong studying methods as summarized above. Yet, staff of Kimia Dasar generally expressed dissatisfaction with the students' approach to studying.

Apparently, students do not receive regular feedback on the success of their studying process. The usual indication that a student is not learning appropriately is a failing grade on an exam. Students do not take quizzes or receive grades on their homework. Correct answers or solutions to assigned homework may not be available. Teachers are very busy and sometimes students are unable to find them to ask for help. Often, students seem not to seek help when they encounter difficulties with content, but seem to wait until shortly before exams before seeking help from instructors.

Some help by student instructors has been tried in various courses. Typically, few students attend the available question-answer sessions unless an exam is about to be given. Sessions before exams are often crowded so that students cannot always get the help they need.

Comments

Students at IPB are under heavy time pressure as they take simultaneously many courses. Students in first year also have the task of adjusting to the university system of education. It is clear that many staff members are dissatisfied with the amount and quality of studying that students do. We do not know if the optimal study

processes which the staff recommends now are possible for students or are the most efficient routes to learning for IPB students.

Staff can work in three areas to improve student study processes:

1) Increase students' knowledge of faculty expectations of the amount and quality of student work. This can include such actions as giving to students a syllabus, listing readings and homework assignments and learning objectives for each topic. Staff should use the Student Workload Summary prepared by Dr. Yayah Koswara as a guide for estimating the amount of work students can reasonably perform outside of class.

2) Increase student feedback about their progress prior to exams. Two types of feedback are possible: from teachers and by self-analysis by students. Teacher feedback (e.g., giving and grading quizzes) is expensive in teacher time. We hope that IPB will be able to finance more student contact with instructors (staff or student instructors) in the future. Ultimately, it will be desirable to teach students how to generate their own feedback on the success of their studying.

3) Develop incentives for students to work in the way that staff believe to be effective. Students must have reasons and encouragement to change their process of studying. It is not enough for staff to lecture students on what they should or should not do.

Possible Actions

Investigate and determine which study patterns are effective for Kimia Dasar students (student interviews). Develop a suggested study

approach for distribution to new students. For a model of such guidelines, see Chapter 10 in "A Survival Manual for General Chemistry", by Elizabeth Kean and Catherine Middlecamp.

Determine from the Study Workload survey how much study time is available for students outside of class. If study time is limited, consider using in class time for study activities (e.g., working on a set of problems or questions during class). Publicize to students the amount of work expected outside of class. Use the expected out-of-class workload as the basis for planning assignments in a semester long syllabus.

Generate student feedback devices such as the following. Give a short in-class quiz on material taught the previous week. Immediately afterward, give students the correct answers and refer them to sources where missing information can be found (text or lecture notes). Give performance criteria (e.g., if more than three errors, the student is in serious difficulty and must seek help immediately.)

Ask administration to develop funds for staff to prepare problem sets and study guides for course content. Such guides would outline what information and skills are needed for mastering the course content. After development, minimal staff time would be needed to update and revise the guides.

Begin staff discussions about incentives for students to change their study processes. Both "carrots" (rewards) and "sticks" (penalties) should be considered. For example, a student with a failing grade on an exam could be required to attend an office hour of an instructor as a condition for being able to take a retest or as a condition for being permitted to continue taking the course.

V. The Failure Rate

According to some staff members, approximately 25% of the Kimia Dasar students fail these courses. Apparently, more than one method has been used to determine how many students fail and what constitutes a passing grade. Staff have used either a set performance scale (all students below 50 percent on their exams fail) or student rankings (all students one standard deviation below the mean fail) to determine the pass line.

Staff have mentioned the following sources of student difficulties:

- not attending to the work (students must work at jobs to earn enough money to eat; thus, they don't have time to study)
- immaturity (students party too much and don't choose to study)
- the workload is too high (students haven't learned enough in high school so they have too much to learn now)
- students don't know how to study (poor study habits)

It is not well known who are the students who fail. Several of the staff have stated that the group of students admitted by recommendation rather than by examination fail at a higher rate. Other staff members have said the opposite. This year's group of students is heavily weighted on the side of admission by recommendation. Next year, this is expected to reverse. These changes will have an unknown effect on the knowledge and skill levels of the incoming students.

Comments

Educational standards for who should pass and who should fail are arbitrary. There are many ways to determine the pass/fail criteria. No one process is clearly superior to another. However, we believe that in a first course in chemistry, a preparation course for non-chemistry majors, that there is support for a mastery criteria (i.e., all students who can answer correctly "core" questions on exams should pass), rather than always failing some percentage of the lowest students.

The primary causes of failure should be ascertained because each different cause of failure can only be countered by certain remedies. No changes in the teaching system will help a student who has no time to study because he must work in order to eat.

We feel that the teaching system has the responsibility to actively work to increase student learning and thereby decrease the failure rate. The blame for failure cannot rest totally on students. Staff cannot control the quality or even the number of students in their courses. If they hope to improve the number of students who learn well, they must devise new ways to teach so that students are capable of learning sufficiently to pass. However, administrators should not expect staff to expend much time on these matters unless the staff has incentives for doing so. Staff will take aggressive action to improve learning and decrease failures only if it is in their interest to do so.

Possible Actions

Administrators or staff shouldundertake an examination of the causes of student failure. Data on student success, numbers of repeating students, etc. should be gathered and interpreted to identify high risk students and to identify the major causes of their poor performance.

Staff should continue to discuss how to develop educational standards or how to determine failure rates. All staff members of Kimia Dasar should participate in these discussions and ultimate decisions.

Administration should continue to involve staff in decisions about educational matters. Staff must be part of the decision-making process in most matters concerning their courses (e.g., decisions regarding texts, how to determine the pass rate). Administrators should seek appropriate incentives for involving staff in finding ways to increase student learning and success.

VI. Learning Aids

There seem to be several versions of textbooks for Kimia Dasar I and II in use. The 1982 version was a very sketchy book, with few learning examples. The 1984 version is a translation of "Chemical Principles" by Petrucci, with some few omissions of inappropriate content. The translation was done rapidly and there are some errors, which are being corrected. The translation has been true to the spirit (and syntax) of the Petrucci text. Only a few problems at the end of chapters have been translated into Bahasa Indonesia. Approximately 80 percent of the chapter end problems are not included in the text used by students.

Approximately one week before a chemistry exam, a discussion class is conducted by an upperclass student to answer questions and work problems. Students also are encouraged to seek help from their instructors. There seem to be few material resources for students to use to aid their studying.

Comments

The Petrucci text is written at a very high level. Most students at the University of Wisconsin were unable to read it well enough to learn from the book. Further, most of the problems at the ends of chapters are too difficult for US chemistry students. Thus, rarely are problems of this level of difficulty put on examinations. Thus, these problems are most often used as learning assignments which can teach students how to solve involved problems, rather than as the means of grading students.

The Petrucci text, like all US texts published nowadays, contains much more information than is possible to learn in one year. Thus, the lecturer must select out of the book the topics she or he wishes students to learn. These topics are taught in lecture. Students are told that they should not try to learn everything in the text, but to concentrate on the parts of the text which are discussed in class.

We recognize that resources are limited at IPB. Although it would be nice to have computer assisted instruction, audio-tape lessons and the like, more contact time between students and staff, smaller classes--these remain goals for the future. We have suggested elsewhere in this report, some possible inexpensive pencil and paper handouts which can direct student studying, or as feedback for their progress. These can be effective if students can be taught to use them.

Possible Actions

All staff members should be made aware of the limitations of the Petrucci textbook. Students should also be directed not to try to learn everything in the text. Staff should be cautious about using chapter-end problems (those translated as well as those which are not part of the student text) as test questions.

As the Jurusan of Chemistry becomes established, new resources may become available to aid student learning. As students begin to major in chemistry, they may be used as student instructors to some extent. Ties to the chemical industry may be sought as a source of funds for additional learning aids.

VII. The Laboratory

IPB has limited facilities for teaching the large numbers of Kimia Dasar students. Students take only one semester of lab, and this lab does not meet every week. The current lab book contains nine experiments:

- -2 experiments on lab techniques and equipment
- -3 quantitative experiments (2 on equilibrium constants; 1 on measuring end points of titrations)
- -1 experiment on qualitative factors in kinetics
- -1 chemical separation experiment (the chloride group)
- -2 qualitative analysis experiments (spot tests; specific tests for various ions in solutions)

Comments

Chemistry departments worldwide share the same problems about laboratory work. Labs are expensive not only in terms of facilities and chemicals, but in terms of student and staff time. Designing a laboratory experiment and writing the experiment so that students can learn from it is one of the most time consuming jobs for teaching staff.

Labs can serve many purposes. They can be used to confirm chemical principles learned in lecture. Lab experiences teach how to use technical equipment properly. Much of this equipment will be used later by students who work in agriculture. Labs train students to be precise in their scientific and technological work. The purposes of the laboratory as determined by the staff will influence the development of new experiments.

Possible Actions

Staff of Kimia Dasar should initiate discussions about the primary and secondary purposes of the laboratory associated with the courses. Development money should be sought for the writing and testing of new experiments. Ultimately, it is hoped that the laboratory could be expanded to include more experiments than currently available.

The experiments which introduce students to laboratory equipment should include actual work with the equipment. Some of the lab books which we have brought to the Kimia Dasar staff have examples of such experiments which might be adaptable for the labs here.

Staff should continue to strengthen the connection between work in the laboratory and chemical principles learned in the lecture. The number of quantitative labs might be increased or more calculations included in current labs.

Staff should discuss whether alternative scheduling of labs offer any advantages. For example, rather than schedule all labs during Kimia Dasar I, would there be advantages in use of facilities to assigning half the students to laboratory during Semester I and half during Semester II.

There should be a balance of laboratory experiments among the following types:

What is this? (labs to identify what chemicals are present)

How much do I have? (quantitative measurements of substances)

What is this substance like? (measurement of properties of pure substances, e.g., density, specific heat)

How can I transform this substance? (making new substances from old ones; percent of reactions)

How can I separate this mixture? (reactivities of substances and groups of substances)