

**PERFORMANCE TASKS: EFFICIENT TOOLS FOR ENHANCING
STUDENTS' PROBLEM SOLVING SKILLS IN CHEMISTRY**

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by

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Performance Tasks:

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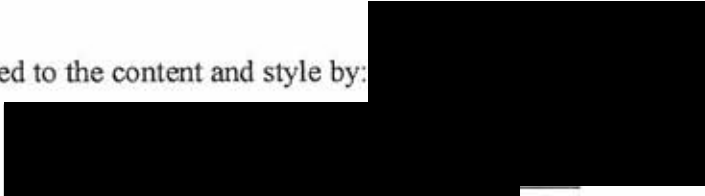
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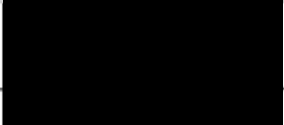
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I learnt about Performance Tasks at I.C.

DEDICATION

I dedicate this work
To my small family
Whose prayers opened
Many closed doors.

CONTENTS

	Page
ACKNOWLEDGEMENTS	iii
DEDICATION	iv
ABSTRACT	vii
Chapter	
I. INTRODUCTION	1
A. Problem solving in science education	1
B. Performance tasks	2
C. Rationale and purpose of the study	2
II. REVIEW OF LITERATURE	4
A. Teaching practices and students' perspectives	4
B. Laboratory work and problem solving	5
C. Teaching for understanding	6
D. Performance based assessment (PA)	8
III. CONSTRUCTION OF A PERFORMANCE TASK	14
A. Just before writing a PT: Determining a focus	14
B. Creating a context for the task	15
C. Procedure	15
D. Scoring guide	15
E. After writing a PT	16
IV. SAMPLES OF PERFORMANCE TASKS	17
A. Introduction	17

B. Task I: Hot and Cold Packs	18
C. Task I: Comments and Recommendations	21
D. Task II: Gases in Colored Tanks	26
E. Task II: Comments and Recommendations	29
F. Task III: Getting Rid of a Harmful By-product	33
G. Task III: Comments and Recommendations	37
H. Task IV: Should We Memorize All Those Catalysts?	41
I. Task IV: Comments and Recommendations	44
J. Task V: Quality of Vinegar	48
K. Task V: Comments and Recommendations	51
L. Task VI: What's Wrong with the School's Environment	55
M. Task VI: Comments and Recommendations	58
N. Task VII: An Article about Superconductivity	61
O. Task VII: Comments and Recommendations	64
P. Conclusion	67
REFERENCES	70

ABSTRACT

The purpose of this project is to acquaint the chemistry teachers with performance tasks as efficient tools for engaging students in constructive learning of chemistry and for promoting their problem solving skills. A performance task is an assignment designed in a special way to provide students with the practice, rehearsal, and appropriate challenge to evidence competency in the skills and knowledge considered important by the curriculum (Area Education Agency 267, 2004). They require active student engagement, balanced teacher intervention, and authentic problem situations that enable students to make connections between what is taught in school and the real world (Area Education Agency 267, 2004; Hibbard, 2004).

This project will explain, discuss, and illustrate the construction of meaningful performance tasks addressing different branches of chemistry i.e. analytical, organic, physical, and applied chemistry. Since the association between school chemistry and the surrounding world is strongly emphasized in the Lebanese new curriculum, the project is intended to have fruitful pedagogical implications on chemical education in Lebanon. Performance tasks are expected to particularly serve the currently implemented competency- based evaluation system.

Descriptors: Problem solving, teaching for understanding, authentic assessment, performance tasks, meaningful lab work

CHAPTER I

INTRODUCTION

Problem-solving in science education

Problem solving is a major issue in science education. Its importance springs from its substantial role in enriching students' abilities to cope with diverse and novel situations (Reif, 1983; American Association for the Advancement of Science, 1989). From a wider perspective, problem-solving seems to be a major educational challenge in modern societies, where an urgent commitment emerges to create a scientifically literate generation capable of making choices, engaging in public debates involving science and technology, understanding the phenomena of natural world, meeting the increasing demands of the modern work place, and participating in national decision making (Zoller, 1987; Saskatchewan schools, 1992). In Lebanon, the recent educational reform (National Center for Educational Research and Development [NCERD], 1997) addresses the need for development of an informed society empowered to identify, analyze and surmount different obstacles associated with environment, natural resources, and public health. Unfortunately, many studies in Lebanon and around the world show that the use of problems in science teaching does not seem to help students become competent problem solvers (Hobden, 1998; Boujaoude & Barakat, 2000; Salloum, 2000). While real world problems are ill-defined requiring powerful ideas and generalizable mechanisms, academic problems are closed emphasizing specific procedures and algorithmic manipulation leading to one correct answer (Mestre, 2001; Reid & Yang, 2002). This alienation of academic problems from the authentic context has a serious negative impact on students' conception of science. Students are misled to believe that since solutions to all scientific problems are unique, their personal contribution is not essential (Wood, 2006).

Performance Task

A performance task, as meant in this project, is an authentic assignment or project engaging students in real world applications or scenario-based problem-solving (Brighton et. al., 2002). In such an assignment, students can practice, rehearse, and develop competency in the skills and knowledge deemed important by the curriculum (Area Education Agency 267, 2004). The primary traits of good performance tasks include individual or collaborative active student engagement, motivational and authentic learning climate, and addressing multiple intelligences to allow greater success for a wider variety of students (Hibbard, 2004).

Rationale and purpose of the project

The goals of the new Lebanese science curriculum call for enhancing learners' involvement in independent and cooperative problem-solving, where they "use scientific knowledge and skills in novel situations especially in everyday life" (NCERD, 1997, p.459). A performance task internalizes the traits that make it a fertile medium for teaching conceptual and authentic problem-solving.

The major purpose of this project is to explain, discuss, and illustrate the construction of meaningful performance tasks addressing different branches of chemistry i.e. analytical, organic, physical, and applied chemistry. Since the association between school chemistry and the surrounding world is strongly emphasized in the new curriculum (NCERD, 1997), the project is intended to have fruitful pedagogical implications on chemical education in Lebanon. Performance tasks are expected to particularly serve the currently implemented competency- based evaluation system (NCERD, 2000). The fourth chapter includes suggested samples of performance tasks. Chemistry teachers, who decide to appropriate this technology, may either directly use

the samples provided, or adapt them to make the tasks more responsive to their instructional plans and students' needs.

CHAPTER II

REVIEW OF LITERATURE

Teaching practices and students perspective

Chemistry courses constitute an ideal field to enhance student problem-solving skills (Bodner & McMillen, 1986), but students perceive chemistry as a difficult subject. On the one hand, there is an inherent complexity of the subject which requires approaching the chemical concepts at the microscopic, macroscopic, and symbolic levels (Johnstone, 1991; Gabel, 1999). On the other hand, teachers do not facilitate students' understanding of the subject, since their prevailing teaching practices rely primarily on rote instructional methods and algorithmic problem-solving rather than conceptual understanding. Such practices deprive the students from active involvement in their learning process (Pickering, 1990; Sawrey, 1990; Mason et al., 1997; Gabel, 1999; Boujaoude & Barakat, 2000; Boujaoude & Tamim, 2000; Nakhleh, 1992; Francisco, Nicol, & Trautmann, 1998; Mestre, 2001; Chiu & Lin, 2004). According to Reif (1983) and Mestre (2001), instructional trends rely predominantly on the following pattern: presenting scientific information, showing examples of solved problems presented in a linear sequence of detailed steps, and indulging the students in solving similar problems by following the same linear sequential model. Gabel (1998) argues that such patterns are dysfunctional and pernicious, since they emphasize formal knowledge and mathematical descriptions at the expense of qualitative reasoning skills that are essential for conceptual understanding. Furthermore, by emphasizing the numerical aspect of problem-solving, teachers seem to delineate the subject matter from real world applications or problems that are not solvable by a mechanical performance (Hobden, 1998; Mestre, 2001; Chiu & Lin, 2004)

Students suffer from a narrow scope of problem tasks, as they expect all problems to be “familiar, well-defined, solvable within a short time, specific to a topic, and have one correct answer” (Hobden, 1998, p. 224). Many students are inclined to store information in a compartmentalized manner which hinders them from recognizing the links between the theme of a conceptual problem and their knowledge structures (Chiu & Lin, 2004; Reid & Yang, 2002). Studies conducted by Nakhleh (1992) reveal that students’ conceptual problem-solving abilities lag behind their algorithmic problem-solving potentials. Many learners, who fail in acquiring a sound understanding of scientific concepts, feel safe with rote memorization and algorithmic approaches, and alarmed when needing to cope with novel situations. These students might become competent algorithmic problem solvers with noticeable ability to apply and manipulate science formulas, but they do not succeed to solve ill-defined problems or problems dealing with daily life situations. (Novak, 1998; Niaz, 1991; Bodner & McMillan, 1986; Reif, 1983; Hobden, 1998; Salloum, 2000). Even when these students can solve routine numerical problems, they do not necessarily understand the underlying strategies, algorithms, and scientific concepts (Nurembern & Pickering, 1987; Reif, 1983). Indeed, no scientific literacy can be achieved through this trend on the long run (Salloum, 2000)

Laboratory work and Problem solving

Science laboratories, that are supposed to promote essential skills of inquiry and problem solving, seem to fail in developing the required conceptual understanding (Zineddin, 2000). Unlike authentic scientific research, most laboratory experiments are used to verify known phenomena and support the lecture portion of science courses (Zineddin, 2000; Mestre, 2001; Reid & Yang, 2002). Consequently, many students tend to apply the procedures provided by manuals without necessarily understanding the

correlation between experimental observations and underlying concepts of the experiment (Zineddin, 2000). In Lebanese textbooks, the experimental activities are included in the most barren style; procedures are always followed by results, interpretations, and conclusions (Safa et. al., 2002) hence negating the basic aim of any practical work. Suits (2004) contends that many chemistry educators are skeptical about the benefits of the traditional lab experiences on chemistry instruction, especially that research studies confirm that practical work solely reinforcing theory does little beyond what students acquire during lectures (Mestre, 2001). It is true that “recipe” experiments ameliorate students’ manipulative skills and data handling, but they also veil investigative skill development and inquiry based approaches. Moreover, such experiments cultivate within students “a rule-governed behavior” which dilutes the spirit of creativity and accomplishment (Mestre, 2001; Suits, 2004).

Teaching for understanding

For learners to realize the long term payoffs of problem-solving in science education, teachers ought to teach for understanding. The rationale for this instructional approach is that acquisition of knowledge and routine skills does not insure understanding of their basis (Perkins, 1993). This suggestion seems to match with research findings regarding algorithmic problem solving. It is found that students might succeed in using and manipulating algorithms without necessarily understanding them (Salloum, 2000). Teaching for understanding dictates the engagement of students in a variety of performances where they spend considerable time in thought demanding and appropriately difficult activities like explaining, predicting, generalizing, applying, making connections, representing in an original way, and constructing new products (Perkins, 1993). Real world and other open-ended problem situations, when carefully crafted within science curricula, constitute the best educational contexts of such

performances (Reid & Yang, 2002; Sungar & Tekkaya, 2006; Wood, 2006). In such contexts, a culture of scientific inquiry and problem solving is created motivating all learners to practice and develop processes leading to knowledge construction. Classrooms and laboratories transform into safe and collaborative environments for raising questions, taking risks, exchanging ideas, making/testing hypotheses, designing experiments, and exploring connections between school knowledge and personal experiences. Students in such environments would actively engage in deeper interaction with the scientific concepts and physical phenomena, an interaction that is expected to lead to conceptual understanding (Cardellini, 2006; Germann & Odom, 1996; Baxter & Shavelson, 1996; Barton & Fusco, 2001; Harlen, 2003; Exploratorium Institute for Inquiry Resources, 1996; Hofstein, 2004; Mestre, 2001; Zineddin, 2000). Teaching science through inquiry strengthens learners' comprehension of the nature of science. Students, who erroneously perceive science as representing the ultimate reality, realize the tentative, testable, and developmental features of scientific knowledge. Pupils would appreciate the indispensable role of science in explaining phenomena and solving problems; at the same time, they critically interpret scientific data in the light of plausible limitations. Understanding the nature of science is a vital component in science education. It assists students to understand the curricular content at a higher cognitive level, and it helps them in maturing into scientifically literate individuals and life long learners (Eick, 2000; BouJaoude, 2002)

The extensive implementation of inquiry and conceptual problem-solving approaches may require radical curricular changes that trigger teachers' concerns regarding issues like magnitude of work load, scheduling and preparing lab experiments, and classroom management. These concerns are legitimate. Teachers, however, do not have to employ inquiry practices in all their classes. At an initial stage,

they may resort to alternatives that balance between verification and inquiry experiments, and between algorithmic and authentic problems (Suits, 2004; Mestre, 2001). In fact, neither algorithms nor traditional labs should be thoroughly abandoned, for several merits can be associated with both instructional instruments. Numerical and dimensional analyses are essential to students known to be concrete reasoners, and they are helpful during standardized examinations where speed in obtaining results is important (Cohen & Toomey, 2000). Furthermore, “recipe” experiments, as mentioned earlier, train students on the basic experimental techniques and procedures.

Performance- based assessment (PA)

Performance assessment, PA, refers to the testing methods that mainly request students to perform, construct, demonstrate, and develop a product that reveals their knowledge or skills under well articulated standards (Elliott, 1995; Office of Educational Research and Improvement & U.S. Department of Education- history (1997); Ferra & McTighe, 1996). Products sought for by this assessment strategy represent a continuum of formats that range from simple student constructed responses to more complicated tasks including extended essays, models, hands-on performances, portfolios, open-ended problems, and real world simulations (Elliott, 1995; Stiggins, 1996; Perkins & Winograd, 1996 ; Office of Educational Research and Improvement & U.S. Department of Education- format, 1997). Research findings, however, reveal that the more advanced formats result in the highest gains on teaching and learning (Office of Educational Research and Improvement & U.S. Department of Education- analysis, 1997). The heart of any performance assessment task is its scoring rubrics as they embody the teachers’ vision of success for their students (Arter, 1996). A rubric is a mechanism used to assess a student’s performance according to a set of guidelines bearing the key features for a highly valued response or demonstration. These

guidelines are communication instruments that enable an examiner to distinguish between performances of different quality (Wiggins, 1996; Area Education Agency 267-Rubrics, 2004; Baker & Condelli, 2002). Rubrics might be either generic or task-specific. The generic type is applicable to a wide range of assignments because it elicits general knowledge or skills. The task-specific type, on the other hand, is customized to address specific tasks (Baker & Condelli, 2002). Rubrics, when well constructed, are powerful tools for teachers and students to organize teaching and learning around a clearly defined set of outcomes (Office of Educational Research and Improvement & U.S. Department of Education- reform, 1997). Consequently, teachers orient their instruction towards improving students' achievement, while pupils become empowered to judge and monitor their work towards meeting or exceeding expectations (Lazzaro, 1996; Woytek, 2005).

In general, PA provides effective means for promoting the processes of teaching and learning, but research findings report appreciable challenges facing its comprehensive implementation. So, what are these benefits and challenges?

Benefits of performance-based assessment

For pedagogy and teachers. PA may be regarded as the lever for reform at instructional and curricular levels (Office of Educational Research and Improvement & U.S. Department of Education- history, 1997). It has a strong potential to shift the focus in science education from abstract facts to real-life problems (Barton & Fusco, 2001; Arter, 1996; Woytek, 2005). Because PA admits a supportive relationship between instruction and assessment, it permits the collection of fair, valid, and reliable information about students' learning (Ferra & McTighe, 1996; Brighton et. al., 2002). Eventually, higher order skills, profound comprehension, and thoughtful adaptation of knowledge to solve problems may be achieved (Daz-lefebvre, 2004;

Teague & Wygoda, 1995; Field-tested Learning Assessment Guide, 1993). When adopting PA approaches, science teachers decide to make a substantial change in their instructional strategies, for they become mediators in a student-centered learning environment. Teachers make creative initiatives in planning lessons, establishing assessment tools, and organizing classroom settings to stimulate inquiry, personal growth, and cooperative learning (Costa & Kallick, 1996; Baxter & Shavelson, 1996; Office of Educational Research and Improvement & U.S. Department of Education-analysis, 1997; Palmer, 1996; Vogler, 2002). PA is a paved road to professional growth. Teachers, who assiduously supervise students' work and provide them with feedback to ensure improvement, would also examine and analyze pupils' progress mistakes and conditions of elicited performance (Bergen, 1993; Wisconsin Education Association Council, 1996; Woytek, 2005). In this way, teachers become more aware of their students' methods of thinking, knowledgeable about pedagogy, and confident of their professional judgments about learners (Perkins & Winograd, 1996; Palmer, 1996; Office of Educational Research and Improvement & U.S. Department of Education-analysis, 1997; Kentucky Department of Education, 1996).

For students. With performance assessment, students become in charge of their own learning, as they engage in meaningful tasks where they plan procedures, construct knowledge, and solve problems (Costa & Kallick, 1996; Baxter & Shavelson, 1996). Students understand the link between evaluation and achievement and improve their performance, as they make use of the scoring rubrics to self-assess their work and clarify outcomes for themselves (Costa & Kallick, 1996; Woytek, 2005). When involved in cooperative work, learners are trained to enhance their social competencies through consulting with one another and respecting each other's unique contribution (Baxter & Shavelson, 1996; Wisconsin Education Association Council, 1996; Office of

Educational Research and Improvement & U.S. Department of Education- format, 1997). At an advanced stage of PA implementation, pupils might be given the chance to participate in originating task problems and establishing the corresponding evaluation criteria (Baxter & Shavelson, 1996).

Challenges of performance-based assessment

Time constraints and Classroom settings. Implementation of PA technology is time consuming and resource demanding. Teachers need to devote an appreciable amount of their time and effort to plan, apply, and evaluate performance-based tasks (Office of Educational Research and Improvement & U.S. Department of Education- reform, 1997; Baker & Condelli, 2002). Appropriation of these tasks might come at the expense of content coverage. So teachers preparing their students for standardized exams, tend to go back to traditional instruction to finish the programs (Baker & Condelli, 2002; Office of Educational Research and Improvement & U.S. Department of Education- analysis, reform, 1997). Moreover, classroom setting ought to be changed in terms of facilities and rules. Necessary equipment, materials, and computers must be supplied, and discipline rules should become more flexible to accommodate students' interaction during team work (Baxter & Shavelson, 1996).

Authenticity. The best performance-based tasks are the most authentic ones, since they capture students' interest. So, teachers have to commit themselves to develop real-life situations and challenging open-ended problems, in which students apply their knowledge and skills. However, not all students feel comfortable with the challenge offered through authentic experiences (Office of Educational Research and Improvement & U.S. Department of Education- technical features, 1997; Wisconsin Education Association Council, 1996). Arrasmith, Kushman, & Olsen (1996) suggest the use of PA strategies "in concert with traditional instruction to shift the balance from

assessing only prerequisite skills to assessing higher order skills that prepare students for careers and responsible citizenship” (p. VII-1:3).

Multiple intelligences and learning styles. In order to insure extended students’ involvement in PA activities, different learning styles must be addressed. Students do not learn in similar patterns, and they can not be assessed in the same way. Focusing on one kind of learning pushes uninterested students towards rote memorization and poor performance (Brualdi, 1996; Daz-lefevre, 2004; Office of Educational Research and Improvement & U.S. Department of Education- students performance, 1997). Cluck & Hess (2004) contend that the implementation of multiple intelligences is associated with improved intrinsic motivation, learners’ engagement, and assignment completion. So for performance-assessment tasks to be fruitful to a maximum number of students, they should include experiences targeting a wide variety of skills and competencies (Office of Educational Research and Improvement & U.S. Department of Education- students performance, 1997).

Reliability and Validity. Teachers, adopting PA strategies, show a principal concern about the quality of their assessment (Office of Educational Research and Improvement & U.S. Department of Education- case study, 1997). This concern seems legitimate since establishing a reliable and valid scoring guide is the most critical part of a task. If the scoring criteria are inconsistent or ambiguous the evaluation loses its credibility, and the whole purpose of the task is defeated (Arter-performance criteria, 1996). Validity of assessment is insured through the alignment between the task’s purpose, body, and performance criteria. In this way, the scoring guide accurately measures the outcomes called for in the task (Arter-introduction, 1996). For teachers to achieve the demanded validity, they should proficiently plan for the format of the task and the domain of competencies that are worth assessing (Office of Educational

Research and Improvement & U.S. Department of Education- technical features, 1997). Reliability, on the other hand, has been always regarded as a problematic issue, especially that studies show that performance on one task weakly predicts performance on a future related task. However, reliability can be improved through a variety of measures some of which are: standardization of task administration, increasing the number of administered tasks, establishing clear scoring criteria, and efficient training of scorers (Office of Educational Research and Improvement & U.S. Department of Education- reform, technical features, 1997)

Rubrics and creativity. Depending on how are they are constructed, rubrics may either enhance performers' accomplishments or constrain their creativity. Rubrics that are written in a way to encourage novel and unorthodox methods to achieve a task's end product are expected to stimulate learners' imagination and innovation. On the other hand, rubrics built to call for traditional characteristics and formal behaviors encourage mimicry and stifle originality (Wiggins, 1996)

Performance tasks

As mentioned earlier, performance-based assessment refers to a full array of testing procedures that range between simple and extensive tasks. In this project performance tasks (PT) belong to the extensive category. They are assignments designed in a special way to provide students with the practice, rehearsal, and appropriate challenge to evidence competency in the skills and knowledge considered important by the curriculum. They require active student engagement, balanced teacher intervention, and authentic problem situations that enable students to make connections between what is taught in school and the real world. The proper technique for writing all the sections will be thoroughly discussed in the following chapter (Area Education Agency 267, 2004; Hibbard, 2004)

CHAPTER III

CONSTRUCTION OF A PERFORMANCE TASK

The format of a performance task that must be presented to students is composed of five sections: “Situation”, “Purpose”, “Audience”, “Procedure”, and “Scoring guide. In this chapter, teachers (task writers) are acquainted with the significance of each section and the proper way of writing it.

Just before writing a PT: Determining a focus

This stage is the initial yet the most fundamental stage of the writing plan, on which depends the efficiency of the sections of the task. Here the teacher has to make a wise instructional decision addressing the following focus questions:

- What substantial content objective(s) and learning skills are to be targeted? Is the number of objectives and skills manageable?
- What is the outline of the task’s scenario? Would this scenario constitute an authentic, challenging, and motivating experience to the learners? Does it reflect different learning styles and multiple intelligences?
- Are the resources, facilities, and materials needed to perform the task available for the students?

- Are the students equipped by the necessary prior knowledge and craft skills to create the desired final product?
- What changes (if necessary) are to be made on class meetings and lab sessions?
- Is the task intended for group or individual work?
- Does any part of the task necessitate the instructor’s direct supervision?
- What is a sufficient time for completion of the task? (Kentucky Department of Education, 1996; Hibbard, 2004; Area Education Agency 267, 2004; Perlman, 2003).

Creating a context for the task

The context of the task is composed of a “situation”, “purpose”, and “audience”. The “Situation” is a paragraph that explains the setting or the problem situation; it constitutes a background for the task that reflects its authenticity. When reading this section, students must feel engaged in an issue that is worth studying, and motivated to roll up their sleeves and work hard. The “purpose” is a statement specifying the role to be assumed by the students to develop the final product. What is expected from pupils ought to be challenging but feasible. The “audience” is a statement that identifies the side to which students should communicate the final report (Kentucky Department of Education, 1996; Hibbard, 2004; Perlman, 2003). Although it is recommended that students address an authentic audience, this might not be always plausible. At many times, classmates or the teacher may constitute an appropriate simulated audience that role-play one person or a group of people (Kentucky Department of Education, 1996).

Procedure

Unlike traditional experiments in which a procedure refers to the step-by- step description of the experimental technique, the “procedure” in this context is a list of general guidelines that assist the pupils organizing their work plans. The “procedure” should be detailed enough to give students the guidance they need. More mature students need less guidance (Hibbard, 2004). A teacher might even choose to disregard this section when students acquire high levels of proficiency in performance tasks.

Scoring guide

The quality of the information offered by any rubric relies on the validity and reliability of the measures (Baker & Condelli, 2002). What specific features should the writer of a task observe to promote validity and reliability of a scoring guide?

Validity. The assessment measures what is intended to be measured if two main factors are respected. The first factor is the thorough alignment between the task's focus and the scoring guide. This alignment is insured once the items of the scoring guide address each and every content objective and learning skill. The second factor is centered around distribution of points among the rubric items. Validity is enhanced if the distribution reflects the importance of showing profound understanding of the content and learning objectives (Hibbard, 2004; Office of Educational Research and Improvement & U.S. Department of Education- reform, 1997; Wiggins, 1996).

Reliability. The assessment is likely to produce consistent scores over time when the elements of clarity and conciseness of the scoring criteria are emphasized. When the items are conveniently concise, clearly worded, and logically scored, students have more chance to understand what is expected from them; moreover, an examiner or a group of examiners (at the same or different times) could accurately estimate the depth of students' understanding (Hibbard, 2004; Wiggins, 1996; Baker & Condelli, 2002; Perlman, 2003).

After writing a PT

Once the writing of a task is accomplished, the task writer (teacher) ought to make a final review of the complete format to ensure clarity, consistency, and alignment among all sections. It is advisable that the writer seek the opinion of a second or third and fourth readers. The most successful performance tasks are those that are produced by collaborative efforts of all chemistry department members. If the task employs a multidisciplinary approach, then it will be tremendously enriched by views of teachers from different disciplines at school.

CHAPTER IV

SAMPLES OF PERFORMANCE TASKS

Introduction

In this chapter, seven complete samples of performance tasks are included. The tasks were written for some units of the Lebanese chemistry program of first, second and third secondary classes. Comments and recommendations are given to help teachers in the appropriation of the tasks, and suggestions for purposeful modifications are also provided. In some tasks, the “situation” is derived from exercises, documents, and lab experiments in textbooks or lab manuals. So, original references are cited when necessary.

As mentioned earlier, the format of the task that should be presented to pupils is composed of: “Situation”, “Purpose”, “Audience”, “Procedure”, and “Scoring guide”. The comments and recommendations are only for teacher’s use.

Task I

Hot and Cold Packs

Situation

A commercial company manufactures hot and cold packs that are used as first-aid devices to treat injuries. These devices, consisting of a pouch of water and a dry chemical, are user-friendly. Striking the pack causes the pouch to break and the temperature of the pack to rise or to decrease, depending on whether the dissolution process is exothermic or endothermic. The company has been using calcium chloride in their hot packs and ammonium nitrate in the cold packs for a long time; however, a new employee has recommended the use of magnesium sulfate instead of calcium chloride in the hot packs (Chang, 1994, Jaegar & Weisker, 1999)

Purpose

You have been hired by the company to evaluate the use of magnesium sulfate in the hot packs. Your task is to conduct an experimental study to determine the heat given off per one gram and the cost effectiveness of each salt. Procedures, data, observations, calculations, results and conclusions of the study should be thoroughly recorded in a well-organized report.

Audience

Your audience is composed of the quality control manager, marketing manager and chief accountant.

Procedure

1. Review the assessment list (scoring guide)
2. Plan a safe experimental procedure and decide on all the equipment, materials and references you will need in your study.
3. Present the plan to your instructor for approval and/or suggestions.

4. Pay a visit to the chemistry lab and check with the lab technician for the availability of materials.
5. During the assigned lab session, perform your procedure several times until you obtain consistent results.
6. Show a detailed description of your work, observations, calculations and conclusions in a report addressed to the company's general manager.

Scoring Guide

Element	Possible points	Self evaluation	Teacher evaluation
1- Experimental Work:	36%		
a) The experimental design (procedure) serves the purpose of the task	10pts		
b) Correct techniques are used in manipulating equipment and chemicals.	7pts		
c) Safety precautions are respected.	7pts		
d) Scientific investigation is approached with self- motivation and perseverance	5pts		
e) Authenticity of data is respected.	7pts		
2. The report	60%		
a) The procedure is clearly described in steps.	5pts		
b)The material list is complete	5ps		
c) Raw data (qualitative & quantitative)			

is recorded accurately allowing for easy interpretation	10pts		
d) Raw data is processed correctly	10pts		
e) Connections are made between the observations and the underlying theoretical concepts.	10pts		
f) Analysis, interpretation and conclusion items are clear, concise, and accurate.	10pts		
g) The report is well organized, presentable, and written with proper scientific vocabulary.	6pts		
h) References consulted are clearly cited according to APA style	4pts		
3. Time management	4%		
The report is submitted on time.			

Task I

Comments and Recommendations

Focus

- a. The content objective of this task is given by the focus question: How can the quantity of heat be determined experimentally through calorimetry?
- b. Learning Skills:

Skills	Items
Thinking	Making observations, making comparisons, and making inferences & deductions
Problem-solving & decision making	Conducting experiments, proposing solutions, using sources of information, and collecting & organizing data
Psychomotor	Manipulating materials & equipment
Communication	Writing scientific report
Mathematical	Computing
Intrapersonal skills	Attending details and accuracy, managing time & organizing work, committing to neatness & presentability, and accurate self-assessment

Class and unit

This task is suitable for the class of second secondary. It is an application on the first unit: Thermochemistry (physical chemistry)

Role of the learner

In this task the learner is playing the role of a chemist

Prerequisite knowledge and skills

a. Before attempting this task:

- Students must be introduced to “Calorimetry”
- Teachers make sure that students are aware of the essentials of lab work (manipulation of equipment and materials, safety measures, collecting data, writing a report) and basic research, organizational, and time management skills.

b. Preparing for the lab: Teachers are advised to agree with their students and the lab technician on a date for an extended lab session for students to implement their approved procedures. Probably the teacher should arrange for that session with the administration and his/her colleagues for changes in schedules might be necessary. Teachers should supervise students’ work in the lab to assess their performance.

Individual vs. collaborative work

This task requires individual work, since the theoretical concepts and the experimental work must be within the reach of most students, provided that the task is assigned at the right time. If there is no sufficient space in the lab, teachers might resort to group work but they are urged to add to the scoring guide one or more items assessing collaborative skills

Procedure

a. Reading the assessment list: The first step in the procedure is exceedingly essential. Instructors must draw their students’ attention to the importance of the assessment list as an eligible road-map towards the final product. Students

should understand that the quality of their performance depends on how well they understand each and every item of the scoring guide.

- b. Students' plans: When checking students' experimental plans, teachers are recommended to check them for safety and overall feasibility and not to correct each of the minor errors in the technique. Students are supposed to discover their mistakes and evaluate/ improve their procedures themselves as they implement their plans.

Assessment

- a. Self- evaluation: Self-evaluation is a fundamental part of the scoring rubric, since it plays an indispensable role in ameliorating students' abilities to monitor their performance. At initial stages of using performance tasks, teachers must expect an appreciable variance between their scores and the pupils' scores because learners usually tend to overestimate the quality of their product. With time and experience, the gap between instructors' and students' scores ought to become narrower indicating an improvement in students' evaluative potentials and, eventually, in their performance. So the magnitude of the difference between instructors' and students' scores is a good indicator for students' progress and achievement. At a certain stage, it is advisable to encourage students to suggest some elements of the scoring guide. This instructional initiative would have an appreciable motivational revenue on students.
- b. Type of assessment list: This assessment list is of the generic type that is the items might be applied to other similar tasks. Although some experts theorize that task-specific rubrics produce more valid results (Wiggins, 1996), giving too many details within the assessment elements might render the task less challenging to the student. One thing to remember here is that students who will

perform this task are around sixteen years old, so they should be mature enough to handle scoring guides with little information.

- c. Overall grade: The overall grade is determined by the teacher's evaluation.
- d. Distribution of scores: This distribution reflects the author's emphasis on the lab work (36%) and the report content (60%).
- e. Tasks' scores and students' averages: Performance tasks in general are quite demanding. For this reason, the way tasks' scores are considered in students' averages for a certain grading period must be proportional to the effort and time spent to accomplish the required work.

Recommended time for students to complete the task

One week after the lab session.

Learning styles and Interdisciplinarity

- a. Learning styles: In this task, three learning styles are addressed, namely visual (experimental observations), kinesthetic (manipulation of equipment and materials), and read/write (scientific report)
- b. Interdisciplinary aspects: The features of interdisciplinarity are quite weak but not totally absent. The use of APA style is a good opportunity for consultation with the English language instructor or the librarian. Moreover, the element of cost-effectiveness is a humble attempt to reveal the interdependence between the fields of science and economics.

Modifications

In schools that do not have lab facilities, instructors might eliminate the lab part and make the essential modifications to change the task into a planning activity. In such an activity the focus would be on identifying variables (independent, dependent, and

controlled), making hypotheses, and planning a procedure. (Consult task IV in this chapter)

Task II

Gases in Colored Tanks

Situation

A small company provides gases to customers in colored steel tanks. To prevent any confusion between the gases, each tank is always filled with the same gas, and different colors are used for the different tanks. At the company's factory, a painter accidentally painted several tanks with the same color. The painter believes that the tanks contained nitrogen, N_2 , and methane, CH_4 , but he isn't sure. Both gases are odorless and colorless, so they are hard to distinguish (Jaegar & Weisker, 1999)

Purpose

You and two of your colleagues are a group of the company's best chemists and the manager selects you to determine the identity of the gases in the tanks. Since the company is small and sophisticated instrumentation is not available, you ought to conduct a simple experimental procedure to perform the task. Your manager insists that you prepare a well organized and detailed report about your experimental work and conclusion.

Audience

Your audience is the company's manager.

Procedure

- 1- Review the assessment list.
- 2- Choose your two partners in the group.
- 3- Consult relevant references (lab manuals, books ... etc) and plan a safe experimental procedure. Decide on all the materials needed.
- 4- Present the plan to your instructor for approval and/or suggestions.
- 5- Check with the lab technician for the availability of materials

- 6- Implement your planned procedure. Repeat it to obtain consistent results.
- 7- Write a final report and organize it taking into consideration the items in the assessment list.

Scoring guide

Element	Maximum points	Self evaluation	Teacher's evaluation
1- The introduction clarifies the conceptual / theoretical background of the experimental design.	12 %		
2-The procedure is clearly described in steps.	10 %		
3- A fully labeled diagram of the experimental set-up is drawn	10 %		
4- Qualitative data is clearly presented and quantitative data is tabulated	5 % 5 %		
5- Calculations are worked out correctly with correct units.	10 %		
6- Sources of error are reported and their influence on the accuracy of results is discussed	6 % 6 %		
7- A concise and clear conclusion addressing the purpose of the task is made.	5 %		
8-The report is well organized,	3 %		

presentable and written in proper scientific language	3 % 5 %		
9-References are cited according to APA style	5 %		
10- The report is submitted on time	5 %		
11- While working in the lab, each student approaches the investigation with self- motivation and perseverance	5 %		
12- While working in the lab, group members exchange ideas with each other, integrating them into the task	5 %		

Task II

Comments and Recommendations

Focus

- a. Content objective: How do relations between moles, volume, pressure, and temperature determine the behavior of ideal gases?
- b. Learning skills:

Skills	Items
Thinking	Making observations, making comparisons, making inferences & deductions
Problem-solving & decision making	Conducting experiments, proposing solutions, analyzing consequences , using sources of information, and collecting & organizing data
Communication	Writing scientific report
Reading skills	Reading scoring guide carefully
Mathematical	Computing
Intrapersonal	Attending details and accuracy ,managing time & organizing work, committing to neatness & presentability, and accurate self-assessment
Interpersonal	Working cooperatively with others and developing group discussion

Class and unit

- a. Class: Third secondary
- b. Unit: The gaseous state (physical chemistry)

Role of the learner

Chemist

Prerequisite knowledge and skills

- a. Prerequisite knowledge : Gas laws
- b. Prerequisite skills: Essentials of lab procedures and techniques; basic research, team work, organizational, and time management skills.
- c. Preparing for the lab: Teachers are advised to agree with their students and the lab technician on the date for an extended lab session for students to implement their approved procedures. Probably the teacher should arrange for that session with the administration and his/her colleagues for changes in schedules might be necessary. Teachers should supervise students' work in the lab to assess their performance

Individual vs. collaborative

This task requires group work. All anticipated experiments that may be employed to satisfy the purpose are quite demanding and collaboration among students will make the mission safer and more efficient. Teachers are advised to assess interpersonal skills rather than manipulative skills, because they might find themselves obliged to interfere in many situations to help students assembling apparatus or managing certain parts of the experiments.

Procedure

- a. Reading the assessment list: The first step in the procedure is exceedingly essential. Instructors must draw their students' attention to the importance of the

assessment list as an eligible road-map towards the final product. Students should understand that the quality of their performance depends on how well they understand each and every item of the scoring guide.

- b. Students' plans: When checking students' experimental plans, teachers are recommended to check them for safety and overall feasibility and not to correct each of the minor errors in the technique. Students are supposed to discover their mistakes and evaluate/ improve their procedures themselves as they implement their plans.

Assessment

- a. Self- evaluation: Self-evaluation is a fundamental part of the scoring rubric, since it plays an indispensable role in ameliorating students' abilities to monitor their performance.
- b. Type of assessment list: This assessment list is of the generic type that is the items might be applied to other similar tasks.
- c. Format of assessment list: Here it is a bit different from that of task I. A teacher might use any format as long as clarity is respected in the statements used.
- d. Overall score: It is determined by the teacher's evaluation.
- e. Distribution of partial scores: Obviously, the partial scores are distributed evenly on the items.
- f. Task's score and student's average: The way the task's score is considered in students' averages for a certain grading period must be proportional to the effort and time spent to accomplish the required work.

Recommended time for students to complete the task

One week after the lab session.

Learning styles and interdisciplinarity

- a. Learning styles: In this task, three learning styles are addressed, namely visual (experimental observations), kinesthetic (manipulation of equipment and materials), and read/write (scientific report). Manipulative skills here are practiced but not assessed.
- b. Interdisciplinary features: The use of APA style is a good opportunity for consultation with the English language instructor or the librarian

Modifications

In schools that do not have lab facilities, instructors might eliminate the lab part and make the essential modifications to change the task into a planning activity. In such an activity the focus would be on identifying variables (independent, dependent, and controlled), making hypotheses, and planning a procedure. (Consult task IV in this chapter)

Task III

Getting Rid of a Harmful Byproduct

Situation

ChemLebanon is a reputable national company specialized in the synthesis of many products. Recently, the company has been receiving complains from active environmental communities. The complains are centered around one of the company's products, whose synthesis is accompanied by the production of H_2O_2 , a byproduct that is harmful to wild life. The manager, who is worried about his company's reputation but also determined to resume synthesizing the valuable product, is seriously considering the catalytic decomposition of H_2O_2 as a suitable alternative. The three catalysts $FeCl_3$, MnO_2 , and yeast are recommended to the manager, but he is seeking the most effective and economical method. So, the manager decides to hire ChemResearch Labs, Inc. to investigate the catalysts and recommend the most cost-effective one. (Jaegar & Weisker, 1999)

Purpose

You are the director of material testing at ChemResearch Labs, Inc. and you are in charge of conducting the investigation. So you select two of your best assistants to help in planning and implementing an experimental procedure to identify the cost-effective catalyst. PowerPoint must be used as a tool for presenting the work and conclusions to ChemLebanon's manager and heads of departments.

Audience

Your audience in this task is the manager and heads of departments of chemLenanon

Procedure

- 1- Review the assessment list
- 2- Make sure that you master the essentials of PowerPoint presentations.
- 3- Plan and develop a 40-minutes presentation taking into consideration the items of the scoring guide.
- 4- Prepare a formal invoice for costs (to be circulated to audience) of materials and services. You may need to consult with the lab technician for appropriate format and reasonable prices.

Scoring guide

Element	Points Possible	Self evaluation	Teacher evaluation	Audience Evaluation
1. Introduction: A concept map introduces the theoretical background (rationale) of the investigation plan, such that: a. Main concepts are easily identified and sub- concepts	12%			
branch appropriately from the main concepts	6 pts			
b. Linking lines connect related terms in correct direction, linking words accurately, and describing relationships correctly.	6 pts			

<p>2. Experimental Section:</p> <p>a. The procedure followed is safe, efficient, and clearly summarized.</p> <p>b. Qualitative data is clearly presented and quantitative data is tabulated.</p>	<p>24%</p> <p>12 pts</p> <p>12 pts</p>			
<p>3. Results:</p> <p>a. The graphs corresponding to the three catalysts can be compared and interpreted accurately</p> <p>b. The conclusion addressing the purpose is supported by necessary calculations, and a comprehensive discussion and evaluation of data and results</p>	<p>35%</p> <p>15 pts</p> <p>20 pts</p>			
<p>4. PowerPoint presentation:</p> <p>a. The presentation uses between 20 and 25 slides</p> <p>b. Layout of the slides is organized, clear, and easy to follow. All text is easily readable</p>	<p>12%</p> <p>3 pts</p> <p>3 pts</p>			

<p>c. Sound effects and animations are appropriate to the topic and help in efficient communication with the audience</p> <p>d. The presentation has a title page and a correctly cited bibliography.</p>	<p>3 pts</p> <p>3 pts</p>			
<p>5. Invoice:</p> <p>The format of the invoice is authentic and the prices are reasonable</p>	<p>5%</p>			
<p>6. Group work:</p> <p>a. During the experimental work group members exchange ideas with each other, integrating them into the task</p>	<p>12%</p> <p>6 pts</p>			
<p>b. All group members participate in the PowerPoint presentation in an assorted manner.</p>	<p>6 pts</p>			

Task III

Comments and Recommendations

Focus

- a. Content objective: How are rates of chemical reactions influenced by catalysts of different natures?
- b. Learning skills:

Skills	Items
Thinking	Making observations, making comparisons, making inferences, and webbing concepts.
Problem-solving & decision making	Conducting experiments, proposing solutions, analyzing consequences , using sources of information, and collecting & organizing data
Communication	PowerPoint presentation
Mathematical	Computing and graphing data.
Interpersonal	Work cooperatively with others and developing group discussion

Class and unit

- a. Class: Third secondary- Lebanese program
- b. Unit : Chemical Kinetics (Physical Chemistry)

Role of the learner

Director of material testing/chemist

Prerequisite knowledge and skills

- a. Prerequisite knowledge: Catalysis and kinetic curves

- b. Prerequisite skills: Basic lab techniques and procedures, basic research, organizational and time management skills, PowerPoint presentations, team work, and concept mapping. Teachers are strongly advised to use concept maps as learning and assessment tools. Researchers think that the hierarchical construction of the map helps students to organize concepts , prioritize information, and discover relationships that make their learning meaningful (Novak, Brezt & Pendley, 1994)
- c. Preparing for the lab: Teachers are recommended to arrange for an extended lab session with students, other teachers, and the administration for any necessary changes in schedules. For efficient supervision and assessment of students in the lab, teachers are encouraged to seek the assistance of other chemistry teachers and/or the lab technicians. This would be especially compulsory when the number of students, following different experimental procedures, is large. As indicated earlier, performance tasks are most successful when they become a departmental project.

Individual vs. collaborative work

The author task has chosen group work for this task, since it is quite demanding at the investigation and presentation levels.

Procedure

The procedure here is quite reduced. Obviously, the guidelines about the preparation of lab investigations (see tasks I and II) are eliminated, whereas guidelines concerning the presentation are emphasized. The writer might choose to do so, if he/she presumes that at certain point some guidelines become redundant and unnecessary.

Audience

Most probably securing an authentic audience in this case might be difficult for most schools. A simulated audience will be satisfactory. Students and/or invited chemistry teachers could be the constituents of the simulated audience.

Assessment

- a. Self evaluation: Self-evaluation is a fundamental part of the scoring rubric, since it plays an indispensable role in ameliorating students' abilities to monitor their performance.
- b. Type of assessment list: It is mainly generic. Item 3a, however, is task-specific since it dictates a lab procedure that produces quantitative data suitable for graphing. Graphical analysis is a requested skill in the Lebanese chemistry program and it is highly emphasized in chemical kinetics, so it is highly recommended in this context.
- c. Overall score: Since the task requires a presentation, some teachers might want to add an extra column of assessment list to incorporate the audience's evaluation. Hence the overall grade for the task would be synthesized from teacher's and audience's scores

- d. Distribution of scores: Almost 60% is given for experimental section and results and 40% is allocated for the presentation and team work. This distribution reflects the author's intention to spread the grade on the achievement and demonstration. Note that in this task the manipulative skills are not assessed.
- e. Task's score and student's average: The way the task's score is considered in students' averages for a certain grading period must be proportional to the effort and time spent to accomplish the required work.

Recommended time for students to complete the task

One week after the lab session

Learning styles and interdisciplinarity

- a. Learning styles: In this task, three learning styles are addressed, namely visual (experimental observations, PowerPoint), kinesthetic (manipulation of equipment and materials, presentation), and read/write (presentation)
- b. Interdisciplinary aspects: The fields of chemistry, information technology, and economics are integrated in this task.

Modifications

In schools that do not have lab facilities, instructors might eliminate the lab part and make the essential modifications to change the task into a planning activity. In such an activity the focus would be on identifying variables (independent, dependent, and controlled), making hypotheses, and planning a procedure. (Consult task IV in this chapter)

Task IV

Should We Memorize All Those Catalysts?!

Situation

The following dialogue occurred in a chemistry class between Mr. Karam, the chemistry instructor, and Mazen, one of his students:

Mr. Karam: esterification reactions are very slow and they need a long time before achieving their equilibrium state; however they could be appreciably enhanced by heating along with catalysts like concentrated H_2SO_4 & H_3PO_4 , and

Mazen (in a low voice): Oh no, another catalyst. Why not platinum here! How are we supposed to remember all these catalysts?

Mr. Karam: Excuse me. Would you say that again; I did not hear you!

Mazen: Sir, we studied that platinum is good for the Haber process, why can't we use it for esterification? Also, I can still remember that FeCl_3 worked fine for the reaction between $\text{S}_2\text{O}_8^{2-}$ and Γ I mean, why not here?!

Mr. Karam smiled and was about to explain the situation to his student when a very good idea came to his mind.

Mr. Karam: Mazen, I think you are a lucky person. You have just found an excellent topic for this term's planning experiment.... Remember?! Why don't you figure out the answers yourself? I can not wait to read your report next month!

Mazen: Oh, my God! What have I done to myself?

Mr. Karam: Is anything bothering you, Mazen?!

Mazen: Me! Not at all, sir. I feel just great!

Purpose

Put yourself in Mazen's shoes and try to come up with the answers!

You are required to plan an experiment to investigate the effect of Pt or FeCl_3 on esterification reactions. Your plan should include a clear identification of the research question, a hypothesis based on theoretical background, and a complete description of the experimental design (variables, material list and procedure). The experimental work ought to be implemented in the lab and the results should be recorded and discussed.

The plan and experimental outcomes must be written in a well organized report.

Audience

Your audience will be Mr. Karam, the Chemistry instructor.

Procedure

1. Read carefully the purpose and the assessment list of the task
2. Plan an experimental investigation, implement it, and write your scientific report

Scoring guide

Element	Points Possible	Self evaluation	Average Teachers' evaluation
1. The research question is clearly identified	6%		
3. The formulated hypothesis is based on relevant theoretical background (7pts) and is directly related to the research question (5pts).	12%		
3. Dependent, independent and controlled variables are selected	10%		
4. The materials list is complete.	5%		

5. The procedure is safe and described in steps.	10%		
6. Qualitative and quantitative raw data are authentic and clearly tabulated.	10%		
7. Data processing leading to decisions concerning the catalyst is done correctly.	14%		
8. Conclusions are based on experimental outcomes (4pts). Explanations, evaluations and comments on the sources of errors are presented (10pts).	14%		
9. The report is organized (3pts). References are clearly cited according to APA style (4pts)	7%		
10. During the lab session : Correct techniques are used to safely manipulate equipment and materials, and to build up set-ups (8pts).	12%		
Investigation is approached with self-motivation and perseverance(4pts)			

Task V

Comments and Recommendations

Focus

- a. Content objective: How can reaction mechanisms explain the role of a catalyst in reversible reaction? How does a catalyst affect the equilibrium position?
- b. Learning skills:

Skills	Items
Thinking	Making observations, making comparisons, and making inferences
Problem-solving & decision making	Conducting experiments, proposing solutions, analyzing consequences , using sources of information, and collecting & organizing data
Communication	Scientific report
Mathematical	Computing and estimating quantities
Interpersonal	Attending details and accuracy, managing time & organizing work, committing to neatness & presentability, and accurate self-assessment

Situation

The dialogue is derived from a real experience in one of the author's classes. Students should be regarded as a prosperous source of authentic situations. Actually, teachers might want to ask their students to propose situations that they are curious about for some performance tasks.

Class and Unit

- a. Class: Third secondary
- b. Unit: Chemical equilibrium (physical chemistry)

Role of learner

Student – researcher

Prerequisite knowledge and skills

- a. Prerequisite knowledge : Basic concepts of chemical equilibrium
- b. Prerequisite skills: Basic lab procedures and techniques, and basic research, organizational, and time management skills. Prior to assigning this task, teacher ought to explain the essentials of planning experiments emphasizing the significance of the research question, hypothesis, and variables (dependent, independent and controlled). This task is meant to be a special one because it is an excellent exercise for an authentic planning investigation in chemistry. After this task, students are expected to have developed many basic skills of scientific design, especially those related to defining a research question, formulating the hypotheses, and selecting variables.
- c. Preparing for the lab: For efficient supervision of students in the lab, teachers are encouraged to seek the assistance of other chemistry teachers and /or the lab technicians.

Individual vs. Collaborative work

This task requires individual work

Procedure

The procedure here is very brief since the author is assuming that students have acquired acceptable experience in performance tasks.

Assessment

- a. Self evaluation: Self-evaluation is a fundamental part of the scoring rubric, since it plays an indispensable role in ameliorating students' abilities to monitor their performance.
 - b. Type of assessment: mainly generic
 - c. Overall grade: It is recommended that reports are graded by more than one teacher in the chemistry department. The reports in this case are expected to be quite extensive and detailed. Reliability of assessment could be enhanced by "group marking". The overall grade would be the average of the individual grades given by instructors.
 - d. Distribution of scores: Around 80% is allocated to the experimental design, data collection, data processing and presentation, and conclusion and evaluation, indicating the author's particular concern about the learning benefits of these parts of the task.
 - e. Task's score and student's average: The way tasks' scores are considered in students' averages for a certain grading period must be proportional to the effort and time spent to accomplish the required work.
-

Recommended time for students to complete the task

10 days after the lab session.

Learning styles and interdisciplinarity

Learning style: In this task, three learning styles are addressed, namely visual (experimental observations), kinesthetic (manipulation of equipment and materials), and read/write (scientific report)

Modifications

Teachers might want, for various reasons, to restrict this task on the planning part i.e. to eliminate the practical part. This will need corresponding changes in the scoring guide.

Task V

Quality of Vinegar

Situation

A company manufactures vinegar by the bacterial fermentation of alcohol. This process produces vinegar containing 12% acetic acid by mass. The company dilutes the vinegar to 5% by mass so that it becomes suitable for food products.

Recently, the manager has been receiving reports from the marketing department saying that the consumers are unhappy with the company's commercialized vinegar. People presume that the concentrations on the bottles' labels are incorrect. At the same time, rumors are spreading in the company about some workers who are violating the rules and tampering with dilution equipment.

The manager asks the chemistry lab in the company's quality control department to evaluate the vinegar from the production line. (Jaegar & Weisker, 1999; Safa et. al., 2002).

Purpose

You are in charge of the chemistry lab in the company and you are supposed to perform the investigation. Your task involves planning and implementing an experimental procedure to evaluate the vinegar, and then writing a short report to the manager about your experimental work and conclusions.

Audience

The company's manager

Scoring guide

Element	Points Possible	Self evaluation	Teacher evaluation
<p>1. Introduction of Report</p> <p>a. In no more than 10 lines, the experimental technique is introduced and its eligibility for the task is explained.</p> <p>b. Principal chemical reaction(s) is(are) included</p>	<p>14%</p> <p>10 pts</p> <p>4 pts</p>		
<p>2. Body of report</p> <p>a. A safe and valid procedure is described step by step</p> <p>b. A fully labeled diagram of the set-up is drawn</p> <p>c. Raw data (quantitative and/or qualitative) are accurately recorded</p> <p>d. Raw data is processed correctly</p> <p>e. The conclusion is valid based on: correct</p>	<p>50%</p> <p>6 pts</p> <p>6 pts</p> <p>10 pts</p> <p>12 pts</p>		
<p>interpretation of results and critical evaluation of the reliability of the technique.</p> <p>f. The report is organized and proper scientific language is used</p>	<p>12 pts</p> <p>4 pts</p>		
<p>3. Time management</p> <p>Report is submitted on time</p>	<p>5%</p>		

3. Lab work	31%		
a. Correct techniques are used to safely manipulate equipment and materials, and build up set-ups	12 pts		
b. The data collected is authentic.	12 pts		
c. The investigation is approached with self-motivation and perseverance	7 pts		

Task V

Comments and Recommendations

Focus

- a. Content objective: How can the technique of titration be used to verify information on a product's label?
- b. Learning skills:

Skills	Items
Thinking	Making observations, making comparisons, and making inferences
Problem-solving & decision making	Conducting experiments, proposing solutions, analyzing consequences, and collecting & organizing data
Communication	Scientific report
Reading skills	Reading the assessment list carefully
Psychomotor	Manipulate equipment and materials for experiments
Mathematical	Computing
Interpersonal	Attending details and accuracy, managing time & organizing work, committing to neatness & presentability, and accurate self-assessment

Class and unit

- a. Class: First and third secondary
- b. Unit: Acids and bases (analytical chemistry)

Role of the learner

Chemist

Prerequisite knowledge and skills

- a. Prerequisite knowledge: Acids and bases
- b. Prerequisite skills: Basic lab techniques and procedures, especially titration; basic organizational and time management skills.
- c. Preparing for the lab session: Teachers are advised to agree with their students and the lab technician on the date for an extended lab session for students to implement their approved procedures. Probably the teacher should arrange for that session with the administration and his/her colleagues for changes in schedules might be necessary. The commercial vinegar on which the students are supposed to experiment should be supplied by the lab technician. Teachers should supervise students' work in the lab to assess their performance.

Individual vs. collaborative work

This task requires individual work whether it is applied in the first or third secondary. The titration technique should be easy for third secondary students, however for younger students it might be demanding. This fact should be taken into consideration in the planning phase and while preparing for the lab.

Procedure

There is no need for a procedure if this task is to be implemented with graduating students. However, with younger students just moving into the secondary school, a teacher is advised to write a procedure similar to that in tasks I and II.

Assessment

- a. Self evaluation: Self-evaluation is a fundamental part of the scoring rubric, since it plays an indispensable role in ameliorating students' abilities to monitor their performance.
- b. Type of assessment list: Generic. The terms used in the assessment list might be difficult or not clear for young children (for example: data processed, evaluation of reliability of results ...). So if task is to be used in first secondary, teachers are recommended to use more specific terms.
- c. Overall grade: Should be determined by teacher's evaluation
- d. Distribution of scores: 31% is allocated for students' personal skills in the lab, and this means that these skills are emphasized. Teachers might decide to reduce this percentage; it all depends on their perception of what is fair to their pupils, especially when it comes to young children.
- e. The task is not very challenging to students of the graduating students since it does not bear many alternatives. There are two ways to satisfy the purpose, either simple titration (using an indicator) or pH-metric titration. Students are expected to choose the first since it might be easier. If teachers wish to force their students to go through pH-metric titration and graphical analysis, probably they should insinuate that through appropriate items in the assessment list. First secondary students are not familiar except with simple titration. At any rate, the task is still a good exercise on manipulative and organizational skills.

Task's score and student average

The way the task's score is considered in students' averages for a certain grading period must be proportional to the effort and time spent to accomplish the required work.

Time required for students to complete the task

- a. Third secondary students: 2 days after the lab session
- b. First secondary students: one week after the lab session

Learning style and interdisciplinarity

Learning style: In this task, three learning styles are addressed, namely visual (experimental observations), kinesthetic (manipulation of equipment and materials), and read/write (scientific report)

Task VI

What's wrong with the School's Environment?

Situation

The administration of Happy Generation High School have noticed that many students in the school always seem to have runny eyes, sinus problems, and asthma-like symptoms. Students claimed that these symptoms worsen as the school day progresses. The director and his assistants wondered if there is something in the school environment that was causing these problems. One of the assistants suspected the presence of harmful chemicals in school that may cause these symptoms. The director consulted with the chemistry teachers about his assistant's suspicion, and asked them to prepare an appropriate plan to investigate the matter.

Purpose

Imagine that some of your friends at your school are suffering from the symptoms noticed at Happy Generation High School. Your chemistry instructor thinks that this issue constitutes an excellent opportunity to enhance the students' understanding of properties of organic compounds and their impact on environment. So, she divides the class into small groups, and asks them to work as research teams to investigate the potential link between students' health and the chemicals. The results of the investigation should be presented to the school administration in a report form.

Audience

The school administration

Procedure

- a. Read the assessment list
- b. Prepare an inventory of the ingredients of products found in the school, and check which organic molecules are believed to be harmful.

- c. Search the internet for common studies done to determine the effect of school environment on students' health.
- d. Select the studies that you regard as suitable for your school setting.
- e. Write a report incorporating all your work, taking into consideration the items in the assessment list.

Scoring guide

Element	Possible points	Students' evaluation	Teacher's evaluation
1. Introduction of report A brief introduction includes: <ol style="list-style-type: none"> a) An overview on the issue of school safety and environmental illness. b) A well defined purpose of the report that demonstrates student's understanding of the task. 	16% 8 pts 8 pts		
2- The body of the report <ol style="list-style-type: none"> a) <i>Harmful organic chemicals:</i> displayed in charts along with their correct IUPAC or common names, structures, properties, and their locations in the school. b) <i>Discussion:</i> demonstrates a substantial understanding of why these chemicals cause health problems. 	60% 20 pts 15 pts		

<p>c) <i>Hypothesis</i>: suggesting, in the light of the discussion and in clear terms, whether there is a link between the symptoms and the chemicals at school.</p> <p>d) <i>Proposal for testing the hypothesis</i> : creative and takes into consideration the appropriateness to your school setting (convenience, feasibility, cost, and duration)</p>	<p>5 pts</p> <p>20 pts</p>		
<p>3- Communications</p> <p>a) The report is well organized and written in away that is appropriate for the audience</p> <p>b) The information is communicated clearly with logical progression of ideas and using accurate scientific terms.</p> <p>c) The reference list is complete are reference citations follow the APA style</p>	<p>24%</p> <p>7 pts</p> <p>10 pts</p> <p>7 pts</p>		

Task VI

Comments and Recommendations

Focus

- a. Content objective: What is the effect of chemicals on humans and environment?
- b. Learning skills:

Skills	Items
Thinking	Classifying and making inferences
Problem-solving & decision making	Research using sources of information analyzing consequences , hypothesize cause and effect, and collecting & organizing data
Communication	Scientific report
Reading skills	Reading the scoring guide carefully
Interpersonal	Attending details and accuracy ,managing time & organizing work, committing to neatness & presentability, and accurate self-assessment

Class and unit

- a. Class: Third secondary
- b. Unit : Organic chemistry

Role of learner

Researcher

Prerequisite knowledge and skills

- a. Prerequisite knowledge: Basics of organic chemistry; functional groups

- b. Prerequisite skills : Basic research ,organizational , time management, and team work skills

Individual vs. Collaborative work

Collaborative work

Audience

The audience here could be more or less authentic where one or more member of the administrative team could be part of the assessment

Time needed for students to complete the task

Around 10 days

Assessment

- a. Self evaluation: Self-evaluation is a fundamental part of the scoring rubric, since it plays an indispensable role in ameliorating students' abilities to monitor their performance.
- b. Type of assessment list: Mainly task specific especially sections 1 and 2
- c. Overall grade: Determined by the teacher's evaluation
- d. Distribution of scores: 60% is allocated for content of the report reflecting an emphasis on the analysis of the effects of chemicals on human health
- e. Task's score and student's average: The way tasks' scores are considered in students' averages for a certain grading period must be proportional to the effort and time spent to accomplish the required work.

Learning styles and interdisciplinarity

Learning styles: mainly visual and read/write

Modifications

The format of the final product might be changed from a report to an oral presentation attended by all the administrative team, where they can participate in the

assessment. This is a good opportunity for the audience to be totally authentic. Who knows, after these presentations, the school might take strict measures to make the school a safer place.

Other potential products of this task might be articles for the school magazine (see the next task) or brochures enhancing the community awareness' of risks of some chemicals.

Task VII

An Article about Superconductivity

Situation

Mr. Kadi, the owner of “Science for All” magazine, is unhappy with his magazine’s position. He has been receiving many reports indicating serious decline in the magazine’s sales. Readers were complaining about the recurrence of themes in many articles, and the complexity of terminology used in some texts. Mr. Kadi calls the board of editors for a meeting in his office and conveys to them the readers’ complains, then he elaborates: “I have to remind you that our magazine does not address solely specialized people or scientists. We aim to spread scientific literacy among all segments of our society, so please take that into consideration in your writing styles. Moreover, I would like you to be creative and up-to-date when selecting topics for your articles. Despite its diverse and important applications, an interesting phenomenon like superconductivity is not dealt with in our magazine, and frankly, I cannot understand why. You all agree with me that we have worked hard to earn our good reputation, we do not want to lose it now”

Purpose

You are an editor in “Science for All”. After the meeting in Mr. Kadi’s office, the editor-in-chief asks you to write an article on superconductivity. The article, consisting of no more than five pages, is meant to expose the applications of superconductivity in the fields of transportation and medicine.

Audience

The magazine readers

Procedure

- a. Read the assessment list
- b. Pay a visit to your school library and use its facilities to conduct a comprehensive research
- c. Ask your English teacher to check your article for any language errors (sentence structure, spelling mistakes, punctuation)
- d. Self evaluate your work.

Scoring guide

Element	Possible Points		
<p>1- Introduction</p> <p>A brief introduction serves the following purposes:</p> <p>a) Defining and explaining(concisely) the phenomenon of superconductivity</p> <p>b) Formulating a clear, purposeful, and informative statement to introduce the article body</p>	<p>15%</p> <p>10 pts</p> <p>5 pts</p>		
<p>2- Content (article body)</p> <p>When exposing and explaining the applications, the writer:</p> <p>a) Focuses on the topic, and avoids extraneous or loosely related ideas.</p> <p>b) Shows mature understanding of the phenomenon and explains accurately its</p>	<p>40%</p> <p>10 pts</p>		

employment in applications	20 pts		
c) Includes clearly labeled explanatory figures and/or schematic diagrams.	10 pts		
3- Closure	25%		
The writer concludes his article by :			
a) Outlining the benefits and limitations of using superconductivity in medicine and transportation	15 pts		
b) Outlining the areas that should be researched further to enhance the benefits.	10 pts		
4- Writing style & article format	11%		
a) The writer uses simple but scientifically acceptable language.	6 pts		
b) The article is consistent with the following format: (font 12, space 1.5, 1 inch margins and figures on the same page of corresponding texts). Maximum of 5 pages (excluding reference page)	5 pts		
5- Reference page	5%		
The list of references is written according to APA style.			
6- Time management	4 %		
Articles are submitted on time			

Task VII

Comments and Recommendations

Focus

- a. Content objective: What are the properties and applications of superconductors?
- b. Learning Skills:

Skills	Items
Problem-solving & decision making	Research using sources of information
Communication	Writing an article (creative writing and drawings/illustrations)
Reading skills	Follow written directions (scoring guide)
Intrapersonal	Attending details and accuracy , managing time & organizing work, committing to neatness & presentability, and accurate self-assessment

Class and unit

- a. Class: Third secondary
- b. Unit: New materials (Applied chemistry). High educational gains are more plausible if this task is assigned before explaining the lesson to the students. One good decision is to use students' work on the task to emphasize the unit's main objectives.

Role of the learner

Editor

Prerequisite knowledge and skills

- a. Prerequisite knowledge: Conductors of electricity; metallic conductors
- b. Prerequisite skills: Basic research , writing, time management, and organizational skills

Individual vs. Collaborative work

This task requires individual work

Time needed for students to complete the task

One week

Audience

Here the recommended simulated audience could be composed of the teacher, students, English teacher, and physics teacher.

Assessment

- a. Self evaluation; Self-evaluation is a fundamental part of the scoring rubric, since it plays an indispensable role in ameliorating students' abilities to monitor their performance.
- b. Type of assessment list: mainly task specific
- c. Overall grade: average teachers' score
- d. Distribution of scores on the elements: 85% is allocated to scientific content
- e. Task's score and student's average: The way tasks' scores are considered in students' averages for a certain grading period must be proportional to the effort and time spent to accomplish the required work.

Modification

The task could be developed into an excellent interdisciplinary physics- chemistry- English project, provided that the requirements concerning the scientific content

become deeper and more advanced. Physics and chemistry teachers have to plan the appropriate depth of scientific content.

Another alternative end product for this task is a lesson plan prepared by the students. A teacher divides the class into groups and asks each group to prepare a lesson plan about New Materials, the last unit in the chemistry program for life science section. Students are given the instructional objectives of the unit, so that the plan addresses every single objective. The instructor might require the plan to be of the extended type involving thorough description of the scientific information, illustrations, explanatory exercises, and assessment. The instructor might also insist that students use graphic organizers and Power Point as tools for presenting the lesson. Electronic copies of the lesson plans could be submitted to the Chemistry teachers in the school for evaluation, and the best plan is presented in class.

Conclusion

Advantages of performance tasks

In general, the tasks belong to the “guided inquiry” category. They may not accede to the rank of open-ended problems, but they constitute a leap towards teaching for understanding. The author took into consideration to offer a learning tool that is feasible within the Lebanese school contexts and aligned with the essentials of the system of evaluation in the Lebanese curricula. Performance tasks provide students with appropriate practice and rehearsal to promote their competencies in the domains of applying knowledge, designing experiments, and communication.

“Teaching by problem solving” is a pedagogical approach that is strongly advocated by the new Lebanese curricula (NCERD, 1998). This approach, which is based on the essentials of the scientific method, aims at guiding “the student to lead an explanatory investigation procedure which allows him to construct his knowledge in an active and progressive manner” (NCERD, 1998, p. 29). Performance tasks may be regarded as powerful instruments for this approach. On the one hand, such assignments are expected to help pupils to develop a deeper perspective of the discipline of chemistry by providing students with ample opportunities to apply chemical concepts, understand the nature of chemistry and its methods, and comprehend the relations of chemistry to other disciplines and its relevance to daily life issues. On the other hand, appropriation of performance tasks should also have a positive influence on students’ problem solving abilities, as they learn to analyze a problem, formulate plans for relevant and feasible solutions, support their suggestions by accurate explanations and justifications, make connections between different parts of a complex problem, and evaluate efficiency of techniques and reasonability of answers.

When to use performance tasks?

Performance tasks are complex, time-consuming and resource-demanding requiring students to employ several skills and strategies to develop a real product or complete a demonstration of their learning. This is why such projects should be reserved for assessing the competencies not easily measured by regular tests and quizzes (Area Education Agency, 2004; Brighton et. al., 2002; Hibbard, 2004). These tasks are not meant to replace traditional examination instruments (tests, quizzes) which are also necessary to prepare students for official and external exams.

Performance tasks are designed to promote the learning skills for a wider segment of students and hence to increase their chances of success. The sought for educational gains are more probable once the following substantial factors are respected when writing a task:

- 1- Authenticity which is ensured through real life situations and open ended problems.
- 2- Validity that is promoted thorough alignment between the content and learning objectives and the items of the scoring guide.
- 3- Reliability which is enhanced by clarity and conciseness of the scoring criteria.
- 4- Fairness that is achieved if the task is challenging but feasible.

Investigating the authentic relationship

The primary traits of performance tasks lead us to anticipate a favorable influence of performance tasks on students' problem solving potentials. This anticipation, however, cannot be confirmed except through a valid research plan. Action research is a method of choice to explore the authentic relationship. The "teacher- researcher" formula dictated by action research should help in arriving at more reliable inferences.

One preliminary suggestion for a research question could be to study the effect of performance tasks on students' ability to:

- a. understand a problem and express their understanding clearly
- b. formulate a plan for a relevant and feasible solution for a problem in the light of chemical concepts discussed in class
- c. answer qualitative questions by using correct scientific vocabulary and supporting the answers by accurate explanations and justifications
- d. perform mathematical operations correctly and evaluate reasonability of answers.

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