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The Analysis of a Murder, a Case Study

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Instruction in chemistry has begun to shift away from the traditional lecture approach toward more student-centered, active-learning methods. Peer-led instruction *(1),* problem-based learning *(2),* guided-inquiry learning *(3),* team learning *(4),* and case-study teaching *(5)* are prominent among these pedagogies. Case study-based instruction is commonplace in fields such as business, law, and medicine but it is relatively rare in the physical sciences, particularly chemistry. Recently, however, the NSF-supported, web-based, National Center for Case Study Teaching in Science *(6)* has been created as a vehicle for the dissemination of science-based case studies. The Center has greatly enhanced the use of case-based instruction in the sciences.

At this college, case-based experiments are being used in our teaching laboratories to make laboratory instruction more interesting, challenging, and relevant to our students. Case studies are stories designed to engage students and convey a pedagogical message. They are useful to teach course content in an interesting manner and to clearly demonstrate the real-world significance of the content that the students learn. A well-written case requires the use of higher-order thinking skills than those required by conventional laboratory approaches.

The Analysis of a Murder case study was originally developed for an analytical chemistry course and has been extended to teach data handling and analysis in a non-laboratory context. When using the case in the latter manner, students are given pre-prepared dry-lab data and asked to properly analyze and apply the results. A data set designed for use this way is included in the Supplemental Material.[W] In this latter form, The Analysis of a Murder case study is suitable for use in general chemistry or nonscience major chemistry courses.

Summary of The Analysis of a Murder Case Study

A worker discovers the nude, limbless, headless torso of a dark-skinned, young boy floating in London's River Thames. Signs indicate that the boy, named Adam by the police, apparently was the victim of a ritual sacrifice. Two Scotland Yard detectives immediately begin a search for Adam's identity and his place of origin. Expert analysis of pollens found in Adam's stomach indicates that they are not of local origin, and the fact that the pollens have not been completely digested indicates that he had only been in London for a short time prior to his death. One of the detectives knows of a University of London professor whose research focuses on the distribution of strontium in soils, worldwide. He speculates that the professor's worldwide strontium concentration data base may be able to help them identify Adam's region of origin. The police contact him and ask whether he could aid them in locating Adam's region of origin. Working together, the team uses a synergistic combination of solid analytical chemistry and creative detective work to pin down Adam's country of origin to Nigeria. After gathering an assortment of Nigerian bone samples and determining their strontium concentration, the team further narrows Adam's region of origin to a specific, small area of that country.

At this point in the case, the students are told that it is their turn to take over the investigation. They are provided with a map of Nigeria *(7),* strontium-doped artificial bone samples "collected from specified regions of Nigeria", and a sample of "Adam's bone material" and are asked to determine its strontium concentration. After using their experimental data to determine Adam's region of origin, the students assume the role of detectives and formulate a strategy to use these data to identify the persons responsible for Adam's murder. At the conclusion of their study, the students write a detailed account of their investigation to the chief inspector of Scotland Yard.

The full text of the fictional case study that is based on the events described above, The Analysis of a Murder, is provided in the Supplemental Material.[W]

An account of the real-life crime that inspired this fictional case study appeared in the recent literature *(8).* The events in the real-life case are closely paralleled by those described in this case study. The samples that Scotland Yard provided to a University of London professor for strontium isotope determination led him to conclude that Adam's home was in Nigeria, and the pollens found in Adam's stomach indicated that he had been in London for only a short time. Two detectives traveled to Nigeria and collected samples that allowed the professor to narrow the likely area of Adam's origin to a 50 by 100 mile wide strip of land between Benin City and Ibaden. The detectives then launched a publicity campaign using the local media to make the residents of the area aware of the details of the case and asking their assistance in obtaining information about any young boy who had recently gone missing. This led to the identification of a woman who had taken her seven-year-old son to London just prior to Adam's murder and returned without the boy. The investigation is still underway at this writing, but extradition hearings are ongoing, and London police remain "interested in her".

The Laboratory Experiment

Prior to their investigation each student is given a copy of The Analysis of a Murder case study that provides them with a detailed account of Adam's murder. The case requires the class to act as analytical chemists who will play a key role in determining Adam's region of origin. They do so by comparing strontium concentration distribution data from "bones collected in regions of Nigeria" to the strontium concentration determined in "a bone from Adam's body" that are given. Advanced students who do experimental work (see below) use inductively coupled plasma atomic (ICP) emission spectroscopy (AES) to determine the strontium-to-calcium ratios present in the artificial bone samples. The samples are composed of calcium hydroxyapatite that has been doped with strontium nitrate and precipitated from solution. Drying of the doped, artificial bone samples affords material that closely resembles natural bone ash.

Digestion of a weighed quantity of the artificial bone sample in nitric acid followed by quantitative dilution affords a solution that can be analyzed using an ICP spectrometer. Calcium and strontium lines at 370.603 nm and 421.552 nm are relatively free from spectral interference and exhibit dramatically different sensitivities allowing the simultaneous determination of both calcium and strontium. A useful discussion of the ICP–AES technique suitable for the undergraduate level may be found in the instrumental analysis text by D. A. Skoog et. al. *(9).*

The laboratory procedure provided to the students for the determination of strontium in the artificial bone samples is given in the Supplemental Material.[W]

Case Management

Analytical chemistry classes in liberal arts colleges are generally small relative to those in a university environment. We have, therefore, developed two different case management procedures, either of which may be selected depending on the class size. Both procedures require the students to think carefully about the data that they obtain or are provided and to make critical decisions about its use if they are to make the best possible judgment about Adam's region of origin. The two procedures are described in detail in the Supplemental Material.[W] Whichever procedure is used, once the students have decided upon Adam's origin, they must then change hats, think as detectives, and formulate a strategy that will allow them to apprehend those responsible for his murder.

As their final task, the students are asked to write a detailed report to "Scotland Yard's Chief Inspector Warner" specifying the procedures they used, the data they acquired, how the data were analyzed, and the strategy they used to apprehend Adam's suspected murderers. This affords the students practice in writing reports similar to those they will soon be charged with writing in the "real world". If the report is not complete, is poorly written, or does not have a professional appearance, the "Chief Inspector" can return it to the students with a notation that it is to be redrafted.

Our experience suggests that this case is effectively taught to students working in two-person teams. The teams are encouraged to meet together frequently during the course of their investigation to decide each of the following questions: whether any data should be omitted from their data pool; exactly how the data they have acquired should be used to decide Adam's most likely region of origin; and, after this decision is made, what strategy they should use to find the person(s) responsible for Adam's abduction and murder.

Each two-person team is required to write its own report to Chief Inspector Warner. Having more than two persons responsible for the preparation of a report is generally not an effective strategy. It often leads to unequal sharing of the burden of the report's preparation.

Conclusion

The premise of case-study teaching is that students will respond to material that is placed in the context of an appealing story with more interest and enthusiasm than would result if the same material were presented in a conventional, dispassionate, academic manner. Ample empirical evidence supports this view *(10).* The popularity of many science-based mystery stories as well as such forensic crime shows as *CSI: Miami* demonstrate the appeal that such crime investigations hold for the public. This led us to believe that the "Adam" case would provide an interesting and challenging context for our student's work in analytical chemistry. The positive response the case has evoked indicates that we were correct in this judgment.

[W]Supplemental Material

Case study, experimental procedures, dry-lab data and procedures for the instructor and students are available in this issue of *JCE Online*.

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