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National curricula for advanced science classes in American high schools?

The influence of the College Board's Advanced Placement Program on science curricula

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Unlike many countries, the USA does not have a national system of education, and consequently there is tremendous variation in high school science curricula. Although there exist no federally sanctioned exit examinations, the College Board has partially filled this void through its Advanced Placement (AP) Program. This voluntary, non-governmental programme offers subject-specific examinations whereby students may earn college credit. To determine the influence of this nation-wide testing programme, the researcher performed within-subjects analysis of course curricula using information provided by educators experienced in teaching accelerated students both independently and within the AP Program. Although no assessment of quality was made, it was determined that teachers presented material in greater breadth, in greater depth, and with much greater speed when preparing students for the AP examination. The responsiveness of teachers to College Board recommendations demonstrates that nation-wide science curricula can be implemented through the use of credit-bearing examinations.

Introduction

The tenth amendment of the Constitution of the USA provides that those powers that are not delegated to the federal government by the Constitution nor prohibited to the states are reserved to the states or to the people. Since the Constitution is silent regarding the issue of education, the power to establish curricula rests at state and local levels. As a consequence of decentralized curricular decision making, there are tremendous variations in the science curricula implemented in American high schools. While some educators view such decentralization as a liability, others believe that it is an asset because it provides a large degree of curricular flexibility to meet the varied needs of a large and diverse nation.

Unlike the USA, many other industrialized countries co-ordinate curricula at the national level, and assess understanding of this information by content-specific exit examinations (Troost 1980, Stigler 1988, Klein 1985, Rutherford 1985, Dockrell 1984). Numerous researchers have suggested that education in America's secondary schools suffers due to the lack of accepted national standards by which student and school progress can be measured. Some have suggested that national curricular standards be established, but for this to take place it must occur through private channels since the federal government has no legal rights in this domain.

In reviewing the special projects and programme implemented in American schools, one nation-wide programme stands out, namely the Advanced Placement

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Program of the College Entrance Examination Board. The College Board, which represents numerous colleges and universities throughout the nation, established the Advanced Placement Program in the mid-1950s as a way to provide accelerated students the opportunity to earn advance standing and/or college credit for work performed in high school. The examinations employ multiple-choice and free-response questions that are designed to test basic knowledge as well as higher order reasoning skills (College Board 1990a, b, c). Following a year of instruction, students may sit for examinations in any of 19 subject areas, and based on their test performance and the standards established by the institutions to which they matriculate, may earn college credit. The Advanced Placement Program has been immensely successful, and has grown 175% in the past decade so that by 1990 more than 330,000 students were sitting for over 490,000 AP examinations (College Board 1990d).

Nation-wide, 71,219 AP science examinations were administered in 1990, making it the most widely implemented science curriculum in the country. Although the Advanced Placement Program is a popular option for advanced science courses, it is not universal since many schools have chosen to offer traditional 'honours' courses instead. As with most courses in American secondary schools, the curricula for honours courses are usually established by the teacher, department, school or district, and have no standard method of assessment. Given that honours classes serve similar students and are often taught by the same people who teach AP classes, they were selected to serve as a control when studying the perceived influence of the AP Program.

Despite the significant number of Advanced Placement and honours classes in American high schools, no prior studies have examined the influence of programme format on curriculum. The goal of this research was to examine this interaction and determine the extent of the Advanced Placement Program's influence in reshaping the curricula of advanced science classes in the USA. It was hypothesized that the AP Program, with its externally administered, nation-wide exam, would help establish a relatively uniform curriculum in a manner similar to that which has been achieved in those countries with national systems of education. Although it is not possible to generalize the findings of this study beyond the USA, it is hoped that the knowledge gained will help those in other nations understand the potential influence of nation-wide examinations on science curricula.

The study

A survey questionnaire was designed to elicit information about the curricula of advanced science classes. Potential questions were field tested in a series of interviews conducted with teachers of advanced science classes.

In the spring of 1989, the revised questionnaire was mailed to Advanced Placement and honours biology, chemistry and physics teachers in all 861 high schools in the state of California with graduating classes of 60 students or more. In addition, questionnaires were sent to 452 high schools in the state of New York. After a second mailing, a total of 847 teachers responded to the questionnaire. Based on information from the College Board (College Board 1988), we received responses from approximately 62% of all AP Chemistry teachers, 68% of all AP Physics teachers, and 68% of all AP Biology teachers in the state of California. Although the response rate among those who received questionnaires in New York was approximately the

same, this represented a smaller percentage of the total population since questionnaires were not sent to all high schools as was done in California. The results from the New York and California samples were indistinguishable for almost every variable analysed, suggesting that sampling biases were minimal.

Many high schools offer only AP or honours versions of biology, chemistry or physics, but not both. Thus, students desiring such advanced science instruction must take what is available, rather than choosing between honours and AP. Occasionally, schools decide to change formats, providing teachers an opportunity to teach similar students using the alternative format. Of the 847 teachers who responded to the questionnaire, 176 said they had such experience and had taught honours and AP to students with similar abilities and academic backgrounds. Within-subjects analyses were made using data from teachers belonging to this group. Since their students had no choice in the format of advanced instruction, self-selection biases were minimized. Where possible, these analyses were cross-checked by performing inter-group comparisons to contrast the responses of those who had taught only honours with those who had taught only AP, but no significant differences were found. In addition, the responses of teachers from different regions, disciplines, and academic and professional backgrounds were compared, and again no significant differences were found. The fact that similar responses were obtained using these subgroups further substantiated the findings of this study.

Textbooks

In many nations, a central agency of the national government is responsible for establishing curricular objectives and standards. Due to the decentralized nature of American education, such decisions are frequently made by the practitioners themselves. Not surprisingly, studies of science education in America by the National Science Foundation have demonstrated that the textbook is the most significant factor shaping course content, mode of instruction and evaluation (Hofwolt 1989). For this reason, one of the most important curricular decisions that an American science teacher, department, or district makes is the selection of a textbook.

The College Board does not endorse any textbooks, but it does publish lists of those most frequently used by the colleges which receive the most AP students (College Board 1990a, b, c). All of these texts are comprehensive, rigorous, and are designated as college texts by the publishers.

Table 1 lists the ten most widely used AP and honours biology texts. Those texts that are found in the AP Biology Course Description appear in boldface type (College Board 1990a). Although the data were collected from teachers experienced in teaching both AP and honours to students of similar grade level, ability and academic preparation, little similarity was seen in the textbooks employed in these programmes. Teachers reported that they used textbooks listed in the AP Biology Course Description 92% of the time when teaching AP classes, but only 18% of the time when teaching honours.

On further analysis, it was determined that 97% of AP Biology classes used texts classified by publishers as 'college level', while only 28% of honours biology classes used such texts. The four most popular textbooks accounted for three-quarters of those used in AP Biology classes. The most favoured text was *Biology* by Curtis and Barnes (used by 35% of AP classes), a comprehensive 1100+ page text. The other

Table 1. Ten most widely used texts in AP and honours biology.*

(%) AP *Biology texts*	(%) *Honours biology texts*
35 Curtis	20 BSCS Molecular Approach
15 Keeton & Gould	9 Oram
13 Arms & Camp	7 Schraer & Stoltze
13 Wallace, King *et al.*	**6 Curtis**
6 Vilee, Solomon & Davis	6 Otto & Towle
5 Campbell	5 Slownick
2 Raven & Johnson	**4 Keeton & Gould**
2 Mader	4 BSCS Ecological Approach
1 Davis & Solomon	4 Curtis
1 Purves	**3 Arms & Camp**
92% AP 'cited' books	**18% AP 'cited' books**

* Values indicate the percentages of all corresponding AP and honours classes which use these texts.

three texts, viz; *Biological Science* by Keeton and Gould, *Biology, the Science of Life* by Wallace, King and Sanders, and *Biology*, by Arms and Camp, are similar in length and coverage and are also commonly used at colleges throughout the nation. By contrast, the most popular text among honours biology classes was *Biological Science: Molecules to Man*, a product of the Biological Sciences Curriculum Study that is intended for advanced high school classes. While more comprehensive and challenging than standard high school biology texts, it is not as comprehensive as *any* of the ten most commonly used AP biology texts.

Eighty-one per cent of chemistry teachers used one of the texts mentioned in the AP Chemistry Course Description (College Board 1990b) for their AP classes, while only 23% used one of these texts for their corresponding honours courses. Ninety-eight per cent of all AP Chemistry classes used college level texts while only 33% of corresponding honours chemistry classes did so. Forty-one per cent of all AP Chemistry teachers used one of the two versions of *Chemical Principles* by Masterton, Slowinski and Stanitski and, although this text was also the single most frequently used honours text (17%), the vast majority (67%) used traditional high school chemistry texts such as *Chemistry, a Modern Course*, by Smoot, Price and Smith, or *Modern Chemistry* by Tzimopoulos.

The trend in physics was the same as for chemistry and biology, with 97% of all AP Physics classes using college level texts but only 32% of corresponding honours classes doing so. The most popular AP physics text was the classic college text *Physics* by Halliday and Resnick (32%), while the most popular text among honours physics teachers was the classic high school text *PSSC Physics*. While most of the texts used in AP physics classes employ calculus, none of the high school texts used by honours classes does. Eighty-two per cent of AP physics classes used texts mentioned in the AP Physics Course Description, while only 26% of honours classes used one of these texts.

In summary, only one-third of all honours science classes used the same rigorous college-level texts as their AP counterparts, while the remaining two-thirds used standard or accelerated high school texts. If textbook selection is a reflection of curriculum, then the curricula of AP classes are significantly more sophisticated than honours classes which serve similar students.

Curricular emphasis

Biology instructors were asked to compare the emphases given to specific curricular topics in their AP and honours courses (table 2). Half of the topics were selected to represent the traditional high school curriculum (Mendelian genetics and inheritance, human anatomy, classic embryology, plant anatomy, and qualitative, observational laboratories), while the other half were selected because they parallel these topics but are generally covered in college (molecular basis of genetics, comparative anatomy, gene control and induction, photosynthetic pathways, and quantitative, analytic laboratories). All topics were randomly arranged on the questionnaire. Differences in the ratings of honours and AP courses were classified as follows: 0·0–0·4, none to small; 0·5–0·9, moderate; 1·0–1·4, large; 1·5–3·0, very large.

With the exception of qualitative, observational laboratories, teachers emphasized *all* topics more in AP than in honours. The magnitude of the difference was greater for 'college' topics than for 'high school' topics. For example, the difference between AP and honours for Mendelian genetics and inheritance was moderate (1·1), while it was large (1·8) for the molecular basis of the gene, a topic usually reserved for college. An analysis of table 2 will show that this pattern held true for the other topic pairs as well. These data suggest that the AP format promotes a more rigorous approach to the entire curriculum, especially for advanced topics.

Table 2. The differences in emphasis (D) placed on specific topics in corresponding honours and AP classes.

High school curriculum	(D)	*College curriculum*	(D)	*Two-tailed probability*
Biology				
Qualitative labs	0·0	Quantitative labs	0·9	0·000
Classic embryology	1·2	Gene control	1·8	0·003
Plant anatomy	0·9	Photosynthetic pathways	1·7	0·006
Mendelian genetics	1·1	Molecular genetics	1·5	0·040
Human anatomy	0·8	Comparative anatomy	0·5	0·227
Chemistry				
Qualitative labs	−0·1	Quantitative labs	0·9	0·000
Le Chatelier's Principle	0·8	Equilibrium constants	2·0	0·000
Oxidation numbers	0·5	Nernst equation	2·3	0·000
Atomic structure	0·9	Quantum numbers	1·2	0·041
Reaction rate law	2·0	Arrhenius equation	2·1	0·800
Physics				
1-D kinematics	0·4	2-D kinematics	1·0	0·003
Qualitative labs	−1·1	Quantitative labs	−0·2	0·011
Rotational statics	1·8	Rotational dynamics	1·5	0·213
Electrostatics	0·3	Magnetostatics	0·6	0·305
Induction	1·3	Maxwell's equations	1·3	1·000

Positive values indicate greater emphasis was placed on a topic when teaching AP, with 0·0–0·4 indicating small or no difference; 1·5–3·0 a very large difference. While greater emphasis was placed on virtually all topics in AP, the increase was greatest among 'college' topics. The final column represents the two-tailed probability that the difference in emphasis between 'college' and 'high school' topics could have arisen by chance. ($N = 176$ teachers experienced teaching AP and honours to students of comparable academic ability and background.)

In the questionnaire sent to chemistry teachers the topics were: atomic structure and quantum numbers (atomic theory), reaction rate laws and the Arrhenius equation (kinetics), Le Chatelier's principle and equilibrium constants (equilibrium), oxidation number and Nernst equation (oxidation-reduction) and qualitative, observational labs and quantitative, analytical labs (laboratories). Those teachers who had taught comparable honours and AP chemistry classes reported greater emphasis in their AP classes for *all* of the curricular items except qualitative, observational labs. The column on the right in table 2 displays the two-tailed probability that the difference for 'high school' topics and 'college' topics was a result of chance. As with biology, there is a proportionately greater increase in emphasis on advanced topics relative to basic topics in AP, indicating that AP students are exposed to significantly greater breadth and depth.

With the exception of laboratories, physics teachers gave greater emphasis to all of the topics listed in table 2 when teaching AP. Once again, it seems as though the AP examination motivated teachers to present a more extensive and intensive academic programme.

To cross-check these data, between-subjects analyses were performed in which the responses of teachers experienced in only one advanced format were compared with each other. To provide a common reference point, teachers were asked to make comparisons relative to standard college preparatory classes in the same discipline. The indirect comparisons from this between-subjects analysis yielded results very similar to the within-subjects comparison, indicating the robustness of the findings.

To summarize, the key findings were as follows: (1) In AP there is significantly greater emphasis on nearly all topics, but (2) this enhanced emphasis is not uniform in that there is a proportionately greater increase in emphasis on 'college' level topics as opposed to 'high school' topics. In conclusion, AP classes place greater emphasis on virtually all topics, but particularly on those advanced topics generally reserved for the college curriculum.

Breadth, depth and pace

Teachers were asked to make direct comparisons of the breadth, depth and pace of comparable AP and honours science classes. Three and a half times as many believed that the breadth of the AP curriculum was greater than believed the reverse, and eleven and a half times as many believed the curriculum had greater depth. Given this information, it was not surprising to learn that nearly 60 times as many teachers rated the pace of their AP classes as greater.

These findings were cross-checked by asking teachers to compare the depth, breadth and pace of their AP and honours courses to their standard college preparatory courses. Indirect comparisons between AP and honours classes showed a moderate (0·66) difference in the breadth of coverage, while a large difference in depth (alpha = 0·000; difference = 1·36) and a very large difference in speed (alpha = 0·000; difference = 1·69). When statistical analyses were performed on the entire sample ($N = 847$), or on any subset, similar trends were found. Thus, both direct and indirect comparisons clearly indicate that teachers believe that the AP format has a profound influence on increasing the breadth, depth and pace of their curricula.

Although the depth and breadth of the curriculum is greater in AP than in honours, it does not necessarily follow that instruction and learning are also better.

Additional research by the author (Herr 1991a) has demonstrated that instructors rely much more heavily on lectures when teaching AP classes than honours classes, and spend proportionately less time with student-centred teaching techniques. Recent reform efforts in American science education suggest that greater emphasis be place on student involvement in learning, the development of ideas and the fostering of higher order thinking skills rather than on the acquisition of specialized knowledge (Ward 1989, AAAS 1989). Further research is needed to determine whether AP or honours is better at achieving these goals.

Laboratory

Many Asian and European nations have externally administered syllabus-based examination at key points in secondary education. Japan, for example, has a very centralized educational system that relies heavily on externally based examinations to guide the curriculum. The Mombusho (Ministry of Education, Science, and Culture) is not only responsible for establishing the college entrance examinations, but also the syllabi and textbooks to be used in primary and secondary school classrooms. Researchers have suggested that the excellent performance of Japanese students in basic mathematics (Stevenson *et al.* 1986, Stigler *et al.* 1982) is due in part to the structured, examination-driven curriculum. While the examination system provides an incentive for disciplined study, it also encourages rote learning. It has been noted that the Japanese curriculum shifts from an intuitive, hands-on emphasis in the early years, toward a rote-memorization, text-based approach in the years prior to the college entrance examinations. The curricula appear more constrained as students approach the college entrance examinations (Troost 1980).

Because the Advanced Placement Program is based on a nationally administered examination, it is conceivable that it might experience successes and problems similar to those found in countries like Japan which have examination-driven national educational systems. In particular, the researcher hypothesized that hands-on laboratory experiences would be sacrificed to provide more time for those activities which prepare students for the examination. Indeed, it was found that in those instances where AP examinations did not assess laboratory work, teachers allocated less time to such activities than in corresponding honours classes (Herr 1991a).

Although this phenomenon was not documented until recently, there had been concern about the laboratory component of AP classes for many years. To deal with this perceived problem, the AP Biology Test Development Committee decided to publish a series of laboratory exercises and to assess understanding of these exercises on the national examination (Walt MacDonald, personal communication). It was found that the implementation of this policy was accompanied by an immediate increase of 11% in the time allocated to laboratory work. Of greater significance, however, was the fact that 96% of the teachers adopted one or more of the original six recommended laboratories, and 76% adopted four or more of them. Twelve times as many teachers said their labs had become substantially more quantitative and analytical as claimed the opposite, and five times as many said their laboratory exercises were more experimental as a result of the policy change. Thus, it appears as though the laboratory-assessment policy stimulated a significant change in the laboratory component of AP Biology classes in American high schools.

Summary

It appears as though the College Board's Advanced Placement Program acts as a substitute for a national science curriculum in that it engenders a high degree of uniformity among participating schools. While the College Board is not a federal agency, and does not fund AP courses, it publishes recommended course outlines, suggests possible textbooks, presents training workshops for teachers and offers national examinations to test mastery of the subject-matter, all of which are common in a nationalized educational system.

Prior to the advent of the Advanced Placement Program, honours classes were the only option for accelerated science instruction, and many such classes still serve students of similar grade level, ability and academic preparation to their AP counterparts. By comparing the experiences of teachers who had taught both AP and honours to comparable students, we were able to examine the extent of the perceived influence of the AP Program on the science curriculum.

It was shown that there is a strong correlation between the type of class format and the curriculum taught. AP classes characteristically use much more sophisticated textbooks, and since research has shown that textbooks are the greatest factor in determining the science curriculum in American schools, it was not surprising to find that the curriculum covered in AP classes was also more sophisticated. Results showed that teachers covered a wider range of material and did so in greater depth when teaching AP than when teaching honours. Although the curricula of AP classes is more advanced, it does not necessarily mean that it is superior. Further studies are needed to assess the quality of the educational experience.

The most common mechanism to increase the breadth and depth of coverage was to increase the pace of instruction. For every individual who believed that their honours class moved at a faster pace, nearly 60 stated that their AP class moved faster. Such agreement demonstrates the nation-wide influence of the programme on instruction. This influence was seen particularly well when a very large percentage of AP teachers from across the country rapidly adopted a set of prescribed laboratory experiments in response to a policy change by the AP test development committee. Such examination-driven educational reforms are reminiscent of reforms which have occurred in countries with nationalized educational systems such as Scotland (Dockrell 1984) and Japan (Troost 1980).

In the drive to improve American education, two majors models have developed. Some reformers suggest that American schools can be improved by introducing accountability as measured through standardized examinations and quantifiable performance. Other reforms suggest that American education would not benefit from such 'technocratic control', but rather by increasing the autonomy of local schools and encouraging teacher participation in school management and the development of locally based curricular initiatives. Those who propose the second model suggest that 'unchecked positivist science... would lead to a total technocracy' (Wirth 1988). Such reformers argue that a system based on standardized examinations would work against the development of the democratic ideals on which American public education was founded. Although the Advanced Placement Program is not sponsored by the government, it does raise concerns for those opposed to centralization and the traditional, positivist, reductionist view of science.

The Advanced Placement curriculum imitates a national curriculum as AP classes across the country share many similarities with each other that appear to be dictated

by the nature of the nation-wide examination. Historically, Americans have limited the influence of the federal government and championed private enterprise. In this environment, it should not be surprising to find that an independent organization has inadvertently established what might be considered to be a 'national curriculum' for advanced science classes.

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