Pedagogy and andragogy are models of education based, respectively, on passive and active learning. This project compared two balanced sections of an undergraduate course in physiology. Both sections used the pedagogical method of didactic lectures to present basic material. Students in section 01 were given multiple-choice examinations, a pedagogical procedure, over the lecture content for the purpose of performance evaluation. In section 02 the lectures were used as an information source, which students combined with other information researched in the library to draft essays on assigned topics, i.e., an andragogical approach. Grading of the essays constituted 75% of a student's performance evaluation, with participation in class discussions making up the remaining 25%. There was no significant difference in overall performance outcome between the two sections ($P > 0.47$). Students from both sections valued the lectures, even though they served a different purpose in each section. However, overall the student rating of section 02 was significantly higher than that of section 01 ($P < 0.05$). This reflected different teaching methods rather than different teachers, because the ratings of the two instructors were virtually identical ($P > 0.98$). These results suggest that a combined pedagogical and andragogical approach is an acceptable model for teaching introductory physiology.


Key words: pedagogy; andragogy; active learning

As originally used, the term andragogy implied the art and science of helping adults learn, whereas pedagogy pertained to the art and science of teaching children (7). However, in considering the whole scope of learning, Knowles (7) has suggested that andragogy and pedagogy should not be viewed as dichotomous models but rather as two ends of an educational spectrum. A reasonable implication from this suggestion is that educators should consider both andragogical and pedagogical characteristics in designing a course of study at any academic level. In this regard, some universities have successfully applied andragogical and pedagogical principles in a single program (e.g., Social Work education at the University of Georgia) (5).

The salient characteristics of andragogical learners are that they tend to be self-directed, have a variety of life experiences that serve as resources for their own learning, are motivated by internal incentives, and have a problem-centered orientation to learning (6). Educational methods that fit the andrago-
cal learner are quite varied but, in general, can be classed as active learning, which has been broadly defined by one of us as any process by which students become directly involved in their own education and, in part, the source of their own learning (12).

In contrast, pedagogical learners are externally motivated and dependent on the teacher for decisions regarding what should be learned, how it should be learned, and whether it has been learned (7). Accordingly, the pedagogical model is a teacher-centered process focused on the transmission of information through lectures and assigned readings (8). The students in this model are to a large measure passive recipients of the information transmitted by the teacher, and their success in learning is judged by the degree to which they are capable of recalling and sometimes integrating information in standardized examinations. Thus, in broad terms, pedagogy and andragogy are respectively characterized by passive and active learning.

As exemplified by the “McMaster Philosophy” (10), the active learning methods in health care education that have been developed over the past 20 years have, for the most part, used andragogical tenets (1, 9). In contrast, college level undergraduate courses in the basic medical sciences primarily use passive learning (i.e., pedagogical) methods, even though active learning has been successfully applied at this level (11). Furthermore, to the best of our knowledge, there have been no reports of pedagogical and andragogical methods being combined in an undergraduate life science course.

The purpose of the project described here was to introduce andragogical methods into an undergraduate level course in elementary physiology and to compare student perceptions and learning outcomes with those of a separate section of the same course taught in accordance with pedagogical principles. Because a large portion of students who take the course are in pre-health care profession programs, a long-range objective of the project is to better prepare students for the emerging active learning tracts in health care education.

**METHODS**

**Nature of the physiology course.** The educational setting for this project was a one-semester 3-credit-hour lecture-based (i.e., no laboratory) undergraduate-level course entitled “Elementary Physiology” (PGY 206), which is offered by the Department of Physiology at the University of Kentucky. This course is taken primarily by 2nd- and 3rd-year undergraduate students in a variety of college programs. The course is offered in one or two sections per semester, and the enrollment ranges from 60 to 100 students per section, with one instructor assigned to each section. Thus PGY 206 is a large-class single-instructor setting.

**Course sections and educational methods of the study.** This study compared two sections of PGY 206, both of which were offered at the same time of day during the Spring term of 1993. Each section adhered to the same class schedule (two 75-min class periods per week), used the same text (*Human Physiology* by Stuart Ira Fox), and followed the same general sequence of topic presentations.

The description of the course in the University catalog was the same for each section: “An introductory survey course in basic human physiology.” No indication was made as to how the two courses were to be taught. However, the nature of each section (described below) was explained to the students on the 1st day of class, and they were given the opportunity to switch sections. Less than 10 students, of a total of 148, selected this option, and there was no net gain or loss for either section.

**Section 01** was taught by traditional pedagogical methods: didactic lectures, with performance evaluations based on multiple-choice examinations.

**Section 02** incorporated components of both pedagogical and andragogical models of teaching. Approximately 75% of the scheduled class time was used to present the basic framework of the various physiological systems in a didactic teacher-centered lecture format (i.e., a pedagogical approach). The remaining 25% of the class time consisted of discussing problem-oriented applications of the lecture
material in a Socratic format. The discussion topics were either of instructor origin or derived from a variety of sources, including the course text (Fox) and texts of physiological problems (2). In a relatively few cases, ~8% of the discussion topics, the students first individually worked on an applied problem, e.g., construction of a graph; then, after these were handed in, they were discussed with the class. All other discussion topics were presented to the students in narrative form at the beginning of the class period. This process helped to keep the Socratic dialogues on task. The following is an example of a discussion topic.

A common recovery room phenomenon after extensive surgery is that the patient feels quite cold upon waking up. Discuss reasons for this as related to possible effects of anesthesia on temperature regulatory mechanisms.

The major active learning (i.e., andragogical) component of section 02 consisted of a series of open book essays, which were researched and written by the students outside of scheduled class time. To assist students in this effort, the Department of English at the University of Kentucky maintains a Writing Center in which students can receive assistance in developing writing skills. There is no charge for the service, and students make their own arrangements with the center for assistance. Information on the Writing Center was given to the students in section 02 with encouragement to use this service. However, it was stressed that this was optional and that use of the Writing Center was to be at the student's discretion.

There were a total of seven mandatory and four optional essays. Students were required to submit the mandatory essays for instructor evaluation, whereas the optional essays were used for the purpose of extra credit (see Performance evaluations).

Five of the mandatory and all of the optional essays were problems applicable to material presented in lecture, whereas the remaining two mandatory essays required the students to write a synopsis of material that was not presented in class, the gastrointestinal (GI) system. The following is an example of one of the mandatory problems.

*Kwashiorkor is a form of severe protein deficiency malnutrition usually affecting children between the ages of 1 and 3 years but may extend to 5 or 6 years of age* (*McLaren and Burman, 1982*).

A puzzling characteristic is this disease is that in spite of marked growth retardation, kwashiorkor patients have a substantial increase in plasma levels of growth hormone (*Pimstone, 1968*). Describe possible connections between kwashiorkor and elevated plasma growth hormone.

Note that in the above example students were given references to get them started in the process of library research. The two essay topics on the GI system read as follows:

1) **Follow a protein molecule from its ingestion, digestion, and absorption. State what tissues or organs of the GI system are involved at each step, what the functions of each tissue or organ are, how these functions are carried out, and how the functions are regulated (e.g., what exocrine products are involved and what are their neural/hormonal regulatory mechanisms).**

2) **Do the same as #1 for a molecule of fat (i.e., a triglyceride). In addition, describe how the fat molecules are transported in the blood, and, in this context, describe the connection between lipoproteins and atherosclerosis.**

The students had been exposed briefly to atherosclerosis in conjunction with the cardiovascular lectures, but otherwise the GI material had not been presented in class. Furthermore, there were no class periods scheduled during the time in which the GI system would normally be covered. Thus, of the seven mandatory essays, five required solving problems related to material presented in a didactic lecture format, whereas the remaining two essays gave students an opportunity to assemble basic information on their own with minimal guidance from the instructor.
The class was given 2 weeks to write up and hand in the problem-oriented mandatory essays and 3 weeks to complete collectively the essays on the GI system. The optional essays could be handed in anytime during the course of the semester. There were no specific requirements as to length of the essays, but guidelines of two to five pages were given, depending on the nature of the topic. Students were encouraged to discuss the essay topics among themselves (some formed study groups for this purpose) and to do library research before writing a given essay. However, the essays themselves had to be individual efforts. The students were further instructed that all referenced material had to be cited at the end of the essay, but they could use any citation format they chose (examples of several styles were given).

The instructor of section 02 evaluated the essays and provided feedback primarily in the form of written comments. In addition, the mandatory essays were briefly discussed with the class as a whole when they were returned to the students.

Performance evaluation: assigning of grades. Grade assignments for section 01 were based on the cumulative score from four multiple-choice examinations, collectively totaling 190 points. The examinations were evenly spaced throughout the semester, each covering a specific section of the course. All were administered during scheduled class time and were not comprehensive in nature. The examinations were machine graded by the University of Kentucky Computing Service. In addition to providing individual and group scores, this service provided a Kuder-Richardson reliability index and an average discriminating power for each examination.

Performance evaluation and grade assignment for section 02 were more complex. Instructor evaluation of the essays comprised 75% of a student’s final grade. Each particular essay was graded across the entire class before assignment of the next essay, and the essays were evaluated on the following points: 1) Was each component of the question or problem addressed? 2) Was the student’s response to each component correct in terms of the underlying physiological mechanisms or phenomena? 3) Was the essay written in a clear and succinct manner?

Each essay was given a letter grade ranging from E (failure) to A+ (performance above expectation). Failure (E) occurred when a particular problem was only partially addressed and the information presented was incorrect. Performance above expectation (A+) occurred when all three of the above evaluation points were satisfactorily met and the student added additional relevant information. In grading the essays, instructors placed emphasis on scientific content. That is, a student presented correct responses to all components of the question or problem but the writing style was poor, his/her grade would probably have been an A- or B+, whereas, if the writing was eloquent but the response was both incomplete and incorrect, then the grade would probably have been a D or E.

For quantitative purposes, letter grades were translated into point scores ranging from 0 (E) to 4.5 (A+). The point scores were used to obtain an average grade for the essay component of the course.

The essay average (as described above) was based on six of the highest seven mandatory essays. That is, the lowest grade was dropped. Subsequent to obtaining an average grade for the mandatory essays, the optional essays were considered. If the score on a particular optional essay was greater than a student’s average score on the mandatory essays, then it was included and the average score was recalculated.

Because approximately one fourth of the class time was used for in-class discussions and other activities, such as graphing data or interpreting graphed data, 25% of a student’s grade was based on his or her participation in such activities. The central objective for the in-class participation component of section 02 was for the students to discuss ideas openly, without fear of being wrong or not properly articulating their views. Accordingly, the responses were not graded as to content. A student’s grade for this section of the course was based only on the number of times he or she voluntarily responded. For those
situations in which the class performed an activity, such as completing a graph, students signed their work sheets, and their participation was recorded as a voluntary response. However, because these were subsequently discussed with the class, any misconceptions a student may have had about the material were addressed.

The instructor’s responsibility in the class performance process was to buffer the aggressive students’ tendency to dominate and to encourage the shy students. Both of these tasks were performed to a very limited extent so as to allow internal motivation, a central tenet of andragogy, to come to the fore. However, for those students who were not responding, a pedagogical approach was taken in which they were reminded in private and advised as to the possible consequences of this behavior on their course grade.

A grade for the class participation component of the course was determined from a class distribution of the number of voluntary responses. This distribution was translated into a grade distribution ranging from 0 (E) to 4.5 (A+) and then incorporated with the essay grade to arrive at a course grade, as:

\[
\text{Course Grade} = 0.75 \times \text{(Essay Grade)} + 0.25 \times \text{(Participation Grade)}
\]

**Data analysis.** Unpaired \(t\)-tests were used when values of a single variable were compared between the two sections, whereas paired \(t\)-tests were used when two treatments of a given variable were compared within a section. A one-way analysis of variance (ANOVA) was used to compare statistically more than two treatments of a given variable between the sections, whereas a repeated-measures ANOVA was used when multiple treatments within a section were analyzed. The \(F\) ratio was used to determine overall significance with the ANOVA tests, and if significance was found, then the Fisher least significant difference test was used to determine which means were significantly different. In all tests the 0.05 probability level was used to indicate significance.

**RESULTS**

**Class profiles.** Table 1 presents the profiles of the two sections of the PGY 206 class. Other than there being more students in section 01, the two sections were well balanced. The second column (year postmatriculation) shows that section 02 had a broader distribution of 1st-, 2nd-, 3rd-, and 4th-year students, as indicated by the larger SD, but overall the average number of years in college was statistically the same for both sections (\(P > 0.84\)). The last four columns of Table 1 show that the distribution of students with regard to degree programs was similar between the two sections. Note that both sections were dominated by students in pre-health care profession programs. Students in these programs are in 4-year tracks within the College of Arts and

![Table 1: Class profile of sections](image)

<table>
<thead>
<tr>
<th>Section</th>
<th>No. of Students</th>
<th>Yr Postmatriculation</th>
<th>Degree Program, % of Students</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Pre-health care</td>
</tr>
<tr>
<td>01</td>
<td>89</td>
<td>2.91 ± 0.77</td>
<td>47</td>
</tr>
<tr>
<td>02</td>
<td>58</td>
<td>2.95 ± 0.95</td>
<td>45</td>
</tr>
</tbody>
</table>

Postmatriculation yr values are means ± SD.
Sciences leading to BA or BS degrees in natural sciences, social studies, or humanities. The pre-health care programs ensure that the students obtain the necessary prerequisites for admission into the degree program of their choice. Some health care programs, e.g., physical therapy, can be entered after 2 years of undergraduate courses, whereas others, e.g., medicine, require a full 4 years of undergraduate studies. Because we were not always able to determine which particular pre-health care program a student was in, programs were pooled into one category.

Performance evaluations. Table 2 summarizes the performance evaluations for both sections. The average cumulative examination score for section 01 and the average total point score for section 02 were not significantly different when expressed as percentage of maximum (P > 0.47).

The two methods of evaluation used in section 02, essays and class performance, were reasonably well correlated (r = 0.713), and differences were not significant (P > 0.30). The class average for the essays included both the mandatory and optional papers. However, because only 21 students turned in a collective total of 29 optional essays for evaluation, of a possible total of 232 (4 optional essays x 58 students), inclusion of the optional essays did not have a significant effect on the overall class average (3.41 without vs. 3.45 with optional essays included). Furthermore, the optional essays had very little effect on the essay grades of the 21 students who turned them in for evaluation (3.40 without vs. 3.46 with optional essays included), and the difference for any one student was not sufficient to improve his/her overall course grade.

The information presented in Table 3 lists the average class scores for the seven mandatory essays, along with the subject matter of each essay in the order in which they were assigned during the semester. The essays dealing with homeostasis and the cardiovascular system were significantly below the mean of all essays combined (P ≤ 0.05).

Student evaluation of the course and instructors. The results of this analysis are presented in Table 4. The student ratings of the instructors for sections 01 and 02 were similar. The course itself

### TABLE 2
Performance evaluations

<table>
<thead>
<tr>
<th>Section</th>
<th>Essay Score</th>
<th>Class Performance Score</th>
<th>Total Points</th>
<th>Maximum Possible Points</th>
<th>Total Points as % of Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>—</td>
<td>—</td>
<td>144 ± 25</td>
<td>190</td>
<td>75.9 ± 13.5</td>
</tr>
<tr>
<td>02</td>
<td>3.45 ± 0.51</td>
<td>3.53 ± 0.86</td>
<td>3.49 ± 0.58*</td>
<td>4.5</td>
<td>77.5 ± 13.1</td>
</tr>
</tbody>
</table>

Values are means ± SD. *Total points = (0.75 x essay score) + (0.25 x class performance score).

### TABLE 3
Point scores on mandatory essays (section 02)

<table>
<thead>
<tr>
<th>Subject</th>
<th>Class Mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homeostasis: negative feedback</td>
<td>3.1 ± 1.1*</td>
</tr>
<tr>
<td>Higher CNS function</td>
<td>3.3 ± 0.7</td>
</tr>
<tr>
<td>Growth hormone</td>
<td>3.4 ± 0.7</td>
</tr>
<tr>
<td>Cardiac stroke volume; systemic blood volume</td>
<td>3.0 ± 0.8*</td>
</tr>
<tr>
<td>Digestion and absorption of protein</td>
<td>3.4 ± 0.6</td>
</tr>
<tr>
<td>Digestion and absorption of fat</td>
<td>3.5 ± 0.6</td>
</tr>
<tr>
<td>Spermatogenesis and regulation of pregnancy</td>
<td>3.5 ± 0.5</td>
</tr>
<tr>
<td>Overall mean</td>
<td>3.45 ± 0.54</td>
</tr>
</tbody>
</table>

CNS, central nervous system. *Significantly different from overall mean.

### TABLE 4
Overall course and instructor ratings

<table>
<thead>
<tr>
<th>Section 01</th>
<th>Section 02</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instructor</td>
<td>3.60 ± 0.56</td>
<td>3.65 ± 0.54</td>
</tr>
<tr>
<td>Course</td>
<td>3.33 ± 0.62</td>
<td>3.63 ± 0.55</td>
</tr>
</tbody>
</table>

Values are means ± SD. Students rated the course and their instructor separately using the following scale: 4, Excellent; 3, Good; 2, Fair; 1, Poor.
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was well received in both sections, as indicated by ratings in the good-to-excellent category. However, the average rating for section 02 was significantly higher than that for section 01.

The common characteristic of both sections was the presentation of basic information in didactic lecture format. For a comparison of perceptions of the lectures in sections 01 and 02, the evaluation documents contained a set of questions related to this component of the course. Students were asked to rank from 1 to 4 whether the lectures 1) developed basic concepts, 2) used appropriate examples, 3) summarized and emphasized major points, and 4) aroused their interest. Respective mean (± SD) rankings for sections 01 and 02 were 3.4 ± 0.1 and 3.6 ± 0.1 (P > 0.13).

DISCUSSION

The salient finding of this study was that an undergraduate introductory course in physiology can be effectively taught by using didactic lectures, a pedagogical method, to present basic information along with problem-centered self-directed essays, an andragogical procedure, to evaluate performance. Furthermore, students seem to prefer this combined approach over the traditional pedagogical format of didactic lectures followed by multiple-choice examinations.

The data for this study were acquired by comparing two sections of an undergraduate introductory course in physiology. The sections were well balanced in terms of student profiles (Table 1), and student perceptions of the two instructors were similar (Table 4). Furthermore, other possible confounding factors, such as the duration of the class periods, the time of day the class was offered, and the course text, were standardized. Thus these two sections offered a reasonable base for comparison of different educational methodologies.

Section 01 used teacher-centered didactic lectures to transmit a core of factual and conceptual information to students in a pedagogical manner. Performance evaluation in this section was based on multiple-choice examinations.

The central framework of section 02 was also teacher-centered didactic lectures, and these constituted the main pedagogical component of this section. However, the purpose of lectures in this section was to serve as a reference source of basic information, which the students could use along with information researched in the library to draft essays on topics and applied problems in physiology. Construction of essays was the major andragogical activity of section 02. Student performance on these essays was reasonably consistent, with the exception of significantly lower scores on essays dealing with homeostasis and the cardiovascular system (Table 3). We have no explanation for the lower score on the homeostasis essay. The cardiovascular problem dealt with control of blood volume and required the students to describe and integrate renal and cardiovascular components of volume control in their essays. However, the tendency among the students was to describe only one of these systems. This suggests that more effort should be given to discussing examples of how the various organ systems of the body interact.

We could find no substantial difference in overall performance outcome between the two sections (Table 2). Many of the procedures used in section 02, e.g., a more lenient grading policy, may have given the students of this section at least a psychological advantage over those of section 01. However, if this was the case, it did not affect performance outcome in terms of grades. This point indicates that providing students with a relatively stress-free environment, as was the attempt in section 02, within which they could operate in accordance with each individual's desire to learn, does not necessarily lead to grade inflation.

Although performance outcomes were similar between the two sections of our course, this experience does not predict that students taught in the manner of section 02 would score the same on standardized examinations [e.g., the Medical College Admission Test (MCAT)] as those taught by the more traditional methods of section 01. In this regard, comparisons of medical students taught by passive and active methods tend to show lower scores for the active learners on Part 1 of the
National Board of Medical Examiners (NBME), but for the most part differences are not statistically significant (1, 3). However, as students progress through medical school, those taught by active methods tend to score as well (3) or better (1) than their traditionally taught counterparts on Part II of the NBME examinations. A tenable explanation for this observation is that, because premedical students are primarily taught in a passive pedagogical mode, it may take the duration of a student’s basic science years in medical school to become adapted to active andragogical methods of teaching. This notion is consistent with the results of an undergraduate problem-based course in pharmacology at McMaster University, which showed that the students’ “comfort level” to the active learning approach tended to increase as the course progressed (11). In this context, the long-range objective of the present project, to better prepare undergraduate students for the active learning tracts in health care education, seems reasonable.

Student evaluations of the course were in the good-to-excellent range for both sections (Table 4); however, the course rating for section 02 was significantly higher than that of section 01. This seemed to reflect the different teaching methods as opposed to different teachers, inasmuch as the ratings of the two instructors were essentially the same (Table 4).

Because the salient difference between sections 01 and 02 was that section 02 incorporated andragogical methods, the higher rating given to this section suggests that undergraduate students in the basic health sciences have a tendency to prefer an andragogical approach to their education. Undergraduate pharmacology students at McMaster University gave high ratings to their problem-based course, but these results were not compared with ratings from students taught by traditional methods (11).

Although the students in section 02 seemed to have appreciated the andragogical approach, they also valued the lecture component of the course, a salient pedagogical method. As mentioned in results, students from both sections gave high ratings to questions related to the value of lectures. This finding supports cognitive theories of education, which suggest that teacher-centered organization (e.g., a lecture) is necessary so that progress from simple to complex concepts does not occur in an arbitrary manner (4).

Evaluation of the students in section 02 was based on the andragogical activities of essays and participation in classroom discussions. The observation that these two components were reasonably well correlated ($r = 0.713$) suggests that students who do well in learning material on their own outside of class are also comfortable with Socratic dialogue in a classroom setting. Conversely, noticing students who tend to be shy in class could make it possible for an instructor to identify those who may need extra guidance in outside assignments.

In summary, the results of the present study suggest that an effective model for teaching an introductory-level course in the basic health sciences would be to provide a framework of teacher-centered lectures from which the students could obtain a base of knowledge in an organized manner. However, instead of memorizing this knowledge for subsequent recall on an examination, a student would integrate it into his/her pool of resources available for more active learning of the subject in a problem-oriented, self-directed manner. Such a procedure is consistent with the suggestion of Knowles (7) that pedagogy and andragogy are not age-specific methods for the respective teaching of children and adults, but rather that they are different educational models, each of which has merit and purpose in all stages of the learning process.

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