A Two-Year Study of Microscopic Urinalysis Competency Using the Urinalysis-Review Computer Program

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Background: The microscopic examination of urine sediment is one of the most commonly performed microscope-based laboratory tests, but despite its widespread use, there has been no detailed study of the competency of medical technologists in performing this test. One reason for this is the lack of an effective competency assessment tool that can be applied uniformly across an institution.

Methods: This study describes the development and implementation of a computer program, Urinalysis-Review™, which periodically tests competency in microscopic urinalysis and then summarizes individual and group test results. In this study, eight Urinalysis-Review exams were administered over 2 years to medical technologists (mean, 58 technologists per exam; range, 44–77) at our academic medical center. The eight exams contained 80 test questions, consisting of 72 structure identification questions and 8 quantification questions. The 72 structure questions required the identification of 134 urine sediment structures consisting of 63 examples of cells, 25 of casts, 18 of normal crystals, 8 of abnormal crystals, and 20 of organisms or artifacts.

Results: Overall, the medical technologists correctly identified 84% of cells, 72% of casts, 79% of normal crystals, 65% of abnormal crystals, and 81% of organisms and artifacts, and correctly answered 89% of the quantification questions. The results are probably a slight underestimate of competency because the images were analyzed without the knowledge of urine chemistry results.

Conclusions: The study shows the feasibility of using a computer program for competency assessment in the clinical laboratory. In addition, the study establishes baseline measurements of competency that other laboratories can use for comparison, and which we will use in future studies that measure the effect of continuing education efforts in microscopic urinalysis.

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The examination of urine sediment is one of the most commonly performed microscope-based tests in the clinical laboratory and in point-of-care settings. Therefore, the teaching of microscopic urinalysis is part of the education of medical technologists and other healthcare personnel. Manual microscopic urinalysis is associated with poor reproducibility (1, 2). This is likely the result of variability in the experience and education of personnel and variability in the procedures and equipment for performing the test (3, 4).

In the US, microscopic urinalysis is considered a moderate complexity task. Therefore, personnel who perform microscopic urinalysis must be assessed for competency. A competency assessment program for a moderate complexity test should have the following characteristics: (a) it should be performed and documented at least two times annually; (b) it should identify problem areas for individuals and provide remedial retraining in those areas; (c) it should be applied uniformly across the laboratory; and (d) it should be easy to administer, taking a minimal amount of technologist and supervisory time, at the same time providing a maximal amount of information regarding competency of both individuals and the entire laboratory.

The standard approaches to competency assessment for microscopic urinalysis are exams based on viewing urine specimens through a microscope or exams based on printed photos or projected slides. These traditional approaches have several drawbacks. The microscope-based approach is difficult because specimens that demonstrate...
the desired urine sediment structures are not always available, and when available, the specimens are difficult to preserve for use by a large group of technologists. In addition, the variability of microscope equipment can make it difficult to administer an exam uniformly across a large laboratory or group of laboratories.

An adequate collection of photos or slides can demonstrate all the relevant urine sediment structures. However, it is time-consuming to develop a photo or slide library and expensive to purchase one. In addition, it is difficult to obtain adequate brightfield photomicrographs of urine sediment structures that have low contrast, such as hyaline casts and bacteria. Finally, photos or slides cannot simulate microscope techniques that are sometimes necessary to identify urine sediment structures. These techniques include moving the microscope stage and using polarization or phase contrast microscopy.

Although clinical laboratories are required to assess the competency of their technologists in microscopic urinalysis, the results of these assessments are not published routinely. Therefore, the average competency of technologists who perform this test is unknown. Proficiency testing results are available, but it is difficult to derive general conclusions about technologist competency from these results.

For the last 6 years, the University of Washington Department of Laboratory Medicine has been developing computer programs that teach the interpretation of image-based laboratory tests and monitor the competency of individuals and laboratories that perform image-based laboratory tests [for an early review, see Ref. (5)]. The underlying premise of this work is that computers can overcome some of the problems associated with traditional methods of instruction and competency assessment. Our previous work covers a variety of image-based tasks including peripheral blood smears (6), gram stains (7,8), ova and parasite exams (9), identification of fungi (10), electrophoresis of serum and other body fluids (11), and immunofluorescence assays for anti-nuclear and other autoantibodies (12–15).³

Urinalysis-Tutor™ (distributed by the University of Washington, Seattle, WA and by Bayer Diagnostics, Tarrytown, NY) systematically teaches the microscopic examination of urine sediment, and its development, implementation, and educational effectiveness has been the subject of a previous publication (16). This study focuses on a complementary computer program, Urinalysis-Review℠ (University of Washington). Urinalysis-Review is a competency assessment program that tests the ability of laboratory personnel to identify and quantify urine sediment structures and keeps track of individual and laboratory performance over time. Here we describe the program and the results obtained when we used the program in our laboratory over a 2-year period. The study demonstrates the feasibility of using computer programs as an alternative to traditional methods for competency assessment, and it establishes baseline measurements of competency that other laboratories can use as a basis for comparison.

### Materials and Methods

#### Program Description

Urinalysis-Review administers competency assessment exams and displays the results of the exams. The exams were developed by a team of clinical laboratory science educators working with a computer programmer. Each exam consists of 10 image-based questions that test the user’s ability to identify and quantify urine sediment structures.

The images in the exams were collected from fresh urine sediments that were prepared in the clinical laboratories at the University of Washington Medical Center (Seattle, WA) and the Harborview Medical Center (Seattle, WA). The images were captured using a digital video microscopy system operated by Optimas image analysis software (Optimas). The hardware components of the system included a light microscope (Olympus model BH2; Olympus), a color CCD camera (Javelin Chromachip II model JE3462RGB; Javelin Electronics), an 80486 computer (Gateway 2000), a video imaging board (MVP-AT; Matrox Electronic Systems), and a 13-inch closed circuit television monitor (Sony) that was used to display the images. The imaging board converted the analog camera signal into a digital image that could then be saved and edited. When necessary, digital image editing was performed using Adobe Photoshop (Adobe Systems). Editing could include contrast and brightness adjustment, color correction, and noise reduction. The goal of image enhancement was to make the images appear nearly identical to images viewed through a high-quality microscope.

Urinalysis-Review is written in Microsoft Visual Basic for Windows® (Microsoft). The program runs under Windows 3.1, 95, 98, or NT, and the minimal computer requirements to run the program are an 80486 computer running at 33 megahertz, four megabytes of RAM, and two megabytes of hard disk storage per exam. The minimal display resolution is $640 \times 480$, 256 colors; the optimal display resolution is $800 \times 600$, 256 or more colors.

Urinalysis-Review is distributed to the laboratories in our academic medical center and to client laboratories. There are currently two modes of distribution of the program. The first is a subscription service (University of Washington, Seattle, WA) in which participating laboratories receive a new exam on a floppy disk every 3 months. The second mode of distribution is through a special release of Urinalysis-Tutor (Bayer Diagnostics),

³ Additional information about educational software from the University of Washington Department of Laboratory Medicine can be found on the World Wide Web at: http://www.labmed.washington.edu/Tutors.
which incorporates a version of Urinalysis-Review that has four exams.

A schematic diagram of Urinalysis-Review is shown in Fig. 1. Urinalysis-Review is designed for two general classes of users. The first class of users includes technologists or other individuals who are taking the exam. At the start of the exam, the examinee logs in his or her name and then is presented with 10 image-based, multiple-choice questions. There is no exit from the program until the exam is completed. The second class of users includes the laboratory supervisor who interacts with a control panel that displays results and program settings. The supervisor accesses the control panel using a password. The control panel can display the results of individuals and the entire laboratory for the current exam, any previous exam, or cumulatively on all exams to date. The control panel also has a program options menu that can change the password to the panel, back up the program's statistics file, or export the file for use by other programs, such as a spreadsheet, database, or statistics program.

For each exam, 9 of the 10 questions require the identification of one or more urine sediment structures. Each structure identification question has 34 possible answers, which are listed in Table 1. For an answer to a question to be scored as correct, the examinee must identify all structures that are present and must not select any structure that is absent. The large majority of the structure identification questions are on unstained urine. Some structure identification questions allow the examinee to change the microscope configuration from bright-field microscopy to polarization or phase contrast. After the examinee completes the question, the correct answer and a detailed explanation are presented.

An example of a structure identification question, with its associated answer, is shown in Fig. 2. The question (Fig. 2A) involves the identification of transitional epithelial cells, white blood cells, hyaline casts, and bacteria. The user navigates through the 34 possible answers using the “Next” button and selects the structures that are present using the mouse. The screen in Fig. 2A was captured when the display showed the cell types that can be selected. If the “Next” button were chosen from this screen, the list of possible casts would then be presented. After casts, the order of presentation is normal crystals, abnormal crystals, and organisms/artifacts. When a structure is selected, the name of the structure turns from white lettering to green, and it is then listed in the “Your answer(s)” field. In Fig. 2A, this field is blank, which indicates that no structures have been selected. After choosing the answers, the examinee selects the “Done” button, and a screen (not shown) in which a list of the correct answers is displayed next to the user’s answers. If these two lists are not identical, the user is told that the question was not answered correctly, and then a screen is presented in which the correct answers are demonstrated using text and arrows pointing into the image (Fig. 2B).

One of the 10 questions requires the quantification of a urine sediment structure. Each quantification question simulates the movement of the microscope stage so that multiple microscope fields can be viewed and counted. After the question is completed, the correct answer and an explanation are presented.

An example of a quantification question is presented in Fig. 3, which tests the examinee’s ability to quantify white blood cells. In Fig. 3A, the user is asked to quantify (on a scale of 1+ to 4+) the white blood cells present, assuming the microscope is set at high power (total magnification, ×400). The user simulates moving the microscope stage, using the arrows displayed below the image. The white square in the center of the arrows represents the entire microscope slide, and the movable gray box within the square represents the current field of view, which is shown in the image above the arrows. After an answer is selected, the user is told if the answer is correct (not shown) and then shown the explanation for the correct answer (Fig. 3B). The explanation for the correct answer

<table>
<thead>
<tr>
<th>Cells</th>
<th>Casts</th>
<th>Normal crystals</th>
<th>Abnormal crystals</th>
<th>Organisms and artifacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>White blood cells</td>
<td>Hyaline</td>
<td>Uric acid</td>
<td>Leucine</td>
<td>Yeast</td>
</tr>
<tr>
<td>Red blood cells</td>
<td>Granular</td>
<td>Hippuric acid</td>
<td>Tyrosine</td>
<td>Parasites</td>
</tr>
<tr>
<td>Squamous epithelial cells</td>
<td>Waxy</td>
<td>Calcium oxalate</td>
<td>Cystine</td>
<td>Spermatozoa</td>
</tr>
<tr>
<td>Transitional epithelial cells</td>
<td>Fatty</td>
<td>Triple phosphate</td>
<td>Bilirubin</td>
<td>Bacteria</td>
</tr>
<tr>
<td>Renal tubular epithelial cells</td>
<td>Red blood cell</td>
<td>Calcium carbonate</td>
<td>Cholesterol</td>
<td>Fibers</td>
</tr>
<tr>
<td>Oval fat bodies</td>
<td>White blood cell</td>
<td>Calcium phosphate</td>
<td>Sulfonamide</td>
<td>Starch</td>
</tr>
<tr>
<td></td>
<td>Renal cell</td>
<td>Ammonium blurate</td>
<td>Radiopaque dye</td>
<td>Air bubble</td>
</tr>
</tbody>
</table>

Table 1. List of the 34 possible answers to each structure identification question.
expresses the answer both on the semiquantitative scale and as cells per high power field.

STUDY POPULATION
The primary examinees in this study were medical technologists, all with a Bachelor of Science degree in medical technology, who work at the University of Washington Medical Center. The study was performed from May 1996 to May 1998. To ensure that there was no fragmentation of the database of exam results, Urinalysis-Review resided on only one of the several computers in the clinical chemistry laboratory. A new Urinalysis-Review exam was
Fig. 3. Screen captures showing a quantification question related to white blood cells (A) and part of its answer (B). See text for details.
installed on the computer every 3 months, and the study encompassed eight consecutive exams. The technologists were required minimally to take a Urinalysis-Review exam twice per year. However, the majority of technologists took all eight exams. Overall, a mean of 58 (range, 44–77) different technologists took each of the exams.

The official departmental policy regarding use of the program as a competency assessment tool is stated below:

Each technologist who is routinely scheduled on the urinalysis bench must complete a designated Urinalysis-Review exam twice each year. Results are recorded in five major areas: cells, casts, normal crystals, abnormal crystals, and organisms/artifacts. Quantification skill is also assessed. Each technologist is given a score for each area as well as a composite score for the entire exam. Acceptable performance on each exam will be an overall score of at least 70% and a score of at least 60% in each individual area. Any technologist who obtains a score below the stated criteria is required to complete the appropriate portion of the Urinalysis-Tutor as retraining. The date that retraining is completed is recorded on the exam performance summary log.

OVERVIEW OF EXAMS USED IN THE STUDY

The eight exams used in this study had a total of 80 questions consisting of 8 quantification questions (1 per exam) and 72 sediment structure questions (9 per exam), which required the identification of one or more structures. The eight quantification questions consisted of four questions about red blood cells, three about white blood cells, and one about granular casts. The 72 structure identification questions covered 134 structures (mean, 17 per exam) consisting of 63 examples of cells, 25 casts, 18 normal crystals, 8 abnormal crystals, and 20 organisms/artifacts. For the 72 sediment structure questions, 68 (94%) were on unstained urine, 4 (6%) were on urine stained with either the Kova variant of the Sternheimer-Malbin stain (3 of the 4 stained urines; Hycor Biomedical) or a Sudan IV fat stain (1 of the 4 stained urines; JT Baker). In addition, 8 (11%) of the 72 sediment structure questions allowed the examinee to switch back and forth from brightfield to polarization microscopy, and 1 (1%) allowed the user to switch back and forth from brightfield to phase contrast microscopy. The structure identification questions encompassed the majority of microscopic findings in urine, and many structures, especially each specific cell type, were covered multiple times.

Results

GROUP PERFORMANCE: SPECIFIC EXAMS

December 1996. The group performance (n = 53) for a single exam (December 1996) is presented in Fig. 4. For this exam, the quantification question was about granular casts. The nine structure identification questions had a total of 19 urine sediment structures to identify, consisting of 9 cells (3 questions containing white blood cells, 2 containing renal tubular cells, 2 containing squamous epithelial cells, 1 containing red blood cells, 1 containing transitional epithelial cells), 2 casts (1 hyaline, 1 renal cell), 2 normal crystals (1 calcium oxalate, 1 triple phosphate), 2

![Fig. 4. Group performance (n = 53) for the December 1996 exam. See text for details.](image-url)
abnormal crystals (1 bilirubin, 1 cystine), and 4 organisms/artifacts (3 bacteria, 1 yeast).

Like all the figures presented in this section, Fig. 4 is a computer screen captured from the exam results section of the program. The text at the top of the screen in Fig. 4 shows that the exam date is December 1996 and 53 examinees took the exam. For the 53 people to correctly identify the 19 structures in the exam, they would need to make a total of $53 \times 19 = 1007$ correct responses. Of the 1007 possible correct responses for sediment structures, the group scored 809 (80%) correct responses. There were $53 \times 9 = 477$ possible correct cell responses, and the group scored 341 (71%; blue column in graph, first column from left) correctly. The group had 86 missed cell identifications. Missed cell identifications are defined in the program as errors of commission in which a cell that was not present was identified as being present. There were $53 \times 2 = 106$ possible correct responses for casts, and the group scored 76 (72%; green column, second column from left) correctly. There were $53 \times 2 = 106$ possible correct responses for normal crystals, and the group scored 104 (98%; turquoise column, third column from left) correctly. There were $53 \times 2 = 106$ possible correct responses for abnormal crystals, and the group scored 93 (88%; red column, fourth column from left) correctly. There were $53 \times 4 = 212$ possible correct responses for organisms/artifacts, and the group scored 195 (92%; magenta column, fifth column from left) correctly. There was one quantification question; therefore, there was $53 \times 1 = 53$ possible correct answers for the group, and the group scored 37 (70%; yellow column, sixth column from the left) correctly. The menu at the bottom left of Fig. 4 shows the exam date field, which indicates that these results pertain to the December 1996 exam. Results for a different exam or for all exams cumulatively can be selected using the mouse. The field in the bottom center of Fig. 4 indicates that these results are group performance on the Dec 1996 exam. The other option, “Performance over time”, can be activated only when “All Exams” has been selected from the exam date field. There are two buttons located in the lower right of the screen. One is a help button, which leads to instructions on how to interpret the display, and the other is a control panel button, which leads to the general menu for the results section of the program.

March 1997. Fig. 5 shows the group performance (n = 56 examinees) on the March 1997 exam. For this exam, the quantification question was about red blood cells. The nine structure identification questions had a total of 20 urine sediment structures to identify, consisting of 10 cells (4 questions containing red blood cells, 3 containing white blood cells, 1 containing renal tubular cells, 1 containing squamous epithelial cells, 1 containing transitional epithelial cells), 3 casts (1 hyaline, 1 waxy, 1 granular), 4 normal crystals (1 triple phosphate, 1 ammonium biurate, 1 urate, 1 calcium oxalate), 1 abnormal crystal (sulfonamide), and 2 organisms/artifacts (1 bacteria, 1 yeast). The most

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**Fig. 5.** Group performance (n = 56) for the March 1997 exam. See text for details.
obvious finding in Fig. 5 is the low score on the abnormal crystal (13 of 56, or 23%). The results on the normal crystals (143 of 224, or 64%) were just above the minimum competency point. The group performance on cells (485 of 560, or 87%), casts (150 of 168, or 89%), and the quantification question (53 of 56, or 95%), although suggesting room for improvement, were well above the 60% competency threshold.

GROUP PERFORMANCE: CUMULATIVE RESULTS ON ALL EXAMS, AND PERFORMANCE OVER TIME

A statistical summary of the ability of the University of Washington Medical Center laboratory staff to provide proper microscopic interpretations of urine sediment is shown in Fig. 6, which shows the cumulative results on all eight exams taken over a 2-year period. These exams contained a total of 80 questions on urine sediment and covered the majority of microscopic findings in urine, many of the structures being covered multiple times. For the laboratory staff to get every structure identification question correct, they would have to give 8019 correct answers regarding urine sediment structures. Overall, the laboratory scored 6369 (79%) correct responses for urine sediment structures. The performance on specific structures was 84% (3143 of 3759) for cells, 72% (1102 of 1526) for casts, 79% (842 of 1068) for normal crystals, 65% (293 of 448) for abnormal crystals, and 81% (989 of 1218) for organisms and artifacts. The laboratory scored 89% (414 of 465) on the quantification questions.

The group performance over time is shown in Fig. 7. This is the screen that is displayed when “All Exams” is selected in the exam field and “Performance over time” is selected in the graph options field. For this graph, the program combines all urine sediment structures into one category. The graph indicates that the overall performance of the University of Washington Medical Center laboratory staff on urine sediment structures (blue line in the graph) has remained relatively constant over a 2-year period. The performance on quantification questions (green line in the graph) varied from 70% on the December 1996 exam to 100% on the June 1997 exam, but it does not show an upward or downward trend.

INDIVIDUAL PERFORMANCE: SPECIFIC EXAM, MARCH 1997

For each individual technologist in the laboratory, Urinalysis-Review can show the results of a single exam, results on all exams cumulatively, and results over time. Fig. 8 shows the performance of an individual on the March 1997 exam. Fig. 8A is a one-screen statistical summary of the performance on this exam. The fields at the top of Fig. 8A show the exam date and the technologist’s name (which has been changed for publication). Either field can be changed using the scroll bars and clicking on the desired date and name. The results listed in the lower left of Fig. 8A indicate that the technologist was correct on six of the nine (67%) structure identification questions and the one quantification question. The nine structure iden-
Identification questions contained 20 structures to identify, and 16 of these (80%) were identified correctly. For the individual structure categories, the technologist correctly identified 10 of 10 examples of cells, 2 of the 3 casts, 3 of the 4 normal crystals, and 1 of the 2 organisms/artifacts. The one example of abnormal crystals was missed.

The one example of abnormal crystals was missed.

The panel of buttons in the lower right of Fig. 8A allows the supervisor to view the questions in the exam and the answers given by each technologist. The incorrect responses are indicated in red. Thus, in this example, the technologist was incorrect on questions 1, 5, and 7. (In Urinalysis-Review the structure identification questions are questions 1–9, and the quantification question is number 10.) Selection of question 7 leads to the screen presented in Fig. 8B, which shows the question and the answer given by this technologist. The answer given was “Leucine crystal”, and the correct answer was “Sulfonamide crystal”. Because this was the only abnormal crystal on the March 1997 exam, this answer was scored as 0 of 1 abnormal crystals correctly identified, and one missed identification because leucine was selected when it was absent.

The ability to rapidly view the answers to questions in the exam also allows the supervisor to detect error trends. Thus, by toggling through the list of technologists taking the March 1997 exam, the supervisor could determine that leucine crystals were frequently confused with the sulfonamide crystals in question 7, that yeast and red blood cells were sometimes confused in question 5 (not shown), and that uric acid crystals and triple phosphate crystals were occasionally confused in question 1 (not shown). The supervisor can analyze errors for their clinical relevance and direct continuing education efforts toward reducing the most serious errors.

**INDIVIDUAL PERFORMANCE: CUMULATIVE RESULTS ON ALL EXAMS, AND PERFORMANCE OVER TIME**

The cumulative results on all exams for an individual technologist (whose name has been changed for publication) in our laboratory are shown in Fig. 9, which is a statistical summary of the ability of an individual to provide proper microscopic interpretation of urine sediment. Fig. 9 has the same basic features of Fig. 6 except that the statistics are for an individual and not a group. This individual took all eight exams, which represents a total of 80 questions, consisting of 72 structure identification questions and 8 quantification questions. Overall, there were a total of 134 urine sediment structures to identify, and this technologist identified 115 (86%) correctly. The best performance (100% correct) was on abnormal crystals (red column) and the quantification questions (yellow column). This technologist also scored 87% (55 of 63; blue column) on cells, 80% (20 of 25; green column) on casts, 89% (16 of 18; turquoise column) on normal crystals, and 80% (16 of 20; magenta column) on organisms and artifacts. A comparison with the group cumulative performance presented in Fig. 6 shows that this technologist
Fig. 8. Performance of an individual technologist on the March 1997 exam. The technologist’s name has been changed for publication. See text for details.
Fig. 9. Performance of an above-average technologist on all exams cumulatively. The technologist's name has been changed for publication. See text for details.

Fig. 10. Performance of an individual technologist over time. The blue line shows the performance over time for the sediment structures, which are combined into one category; the green line shows the performance for the quantification questions. See text for further details.
had an above-average performance. The individual cumulative results were also used to detect technologists with below average performance, and these technologists received additional continuing education.

The individual performance over time for the technologist in Fig. 9 is shown in Fig. 10, which is similar in appearance to the screen on group performance over time shown in Fig. 7. For this graph, the program combines all urine sediment structures into one category. The graph indicates that the overall performance of this individual has remained relatively constant over a 2-year period. The performance-over-time graph can also identify technologists who are improving or declining over time, or it can be used to rapidly detect a particularly problematic exam for a technologist. That exam can then be further dissected to define specific areas for improvement.

**Discussion**

The first accomplishment of this study was the development and implementation of a computer program to assess competency in microscopic urinalysis. The program has advantages over the traditional approaches to competency assessment. Unlike the microscope-based approach, the computer program does not require microscopes or fresh specimens, and it is therefore easier to administer to any size laboratory and at any time. In contrast to a photo or textbook exam, the computer program can simulate manipulations of the microscope, such as stage movement and configuring the microscope for polarization or phase contrast. Another advantage of the computer program is that it automatically records results and allows supervisors to efficiently document and display these results for each individual in the laboratory as well as the laboratory as a whole (Figs. 4–10).

A second achievement of this study is the publication of 2 years of urinalysis competency data from a large clinical laboratory (Figs. 6 and 7). Despite using a detailed literature search, we were unable to find similar studies. These baseline results are a starting point for our laboratory as we attempt to measure the effects of educational programs designed to improve urinalysis performance. In addition, other laboratories could use these data for comparison as they implement their own procedures for competency assessment and continuing education.

Because competency assessment results for microscopic urinalysis are not published routinely, many clinical laboratory scientists use proficiency testing results to compare the competency of their institution with other institutions. Compared with the exams and results provided by Urinalysis-Review, proficiency testing is not as useful for assessing and comparing competency in microscopic urinalysis. This is because proficiency testing is not as comprehensive and proficiency testing specimens are not handled by all technologists in the laboratory. In addition, although proficiency testing specimens should be handled like any other laboratory specimen, many laboratories give these specimens special attention because of the importance of maintaining accreditation. Thus, proficiency testing tends to overestimate competency.

The group performance results presented in Figs. 6 and 7 are probably a conservative estimate of our laboratory’s competency because the technologists analyzed the images without urine dipstick or other urine chemistry results and without the ability to chemically manipulate the urine with acid, alkali, stains, or other treatments. In addition, no patient history was provided, and the program only occasionally allowed the technologist to invoke polarization (11% of structure identification questions) or phase contrast microscopy (1% of structure identification questions) and did not allow changes in focusing. Lastly, the display quality on the laboratory computer was slightly inferior to the computer display used to develop the questions. This might have caused some unfairness in a few questions related to bacteria.

Thus, although a very skilled technologist should have been able to identify the images in Urinalysis-Review without further aid, additional information and a better computer display would have improved performance. For example, many technologists confused the sulfonamide crystal in question 7 on the March 1997 exam (Fig. 8B) with a leucine crystal. In actual practice, technologists might take a variety of actions when faced with the crystal in Fig. 8B. Because leucine crystals are rare and are associated with liver disease, most technologists would look for confirmatory evidence such as a positive bilirubin on the urine dipstick. In addition, a technologist, suspecting a sulfa crystal, might perform a sulfa confirmatory test and call the clinic to ask if the patient was taking a sulfa drug. Another technologist error we detected was confusion of yeast and red blood cells. In this case, many technologists would have treated the urine with dilute acetic acid, which lysed red blood cells while leaving yeast intact, to differentiate the two. Similarly, several crystals would have been identified correctly if the technologists knew the pH of the urine and the solubility characteristics of the crystals. Some technologists who missed hyaline casts would have identified them correctly if phase contrast microscopy and changes in focusing were available.

Despite its limitations, the study clearly indicates that the laboratory could substantially improve its ability to identify all categories of urine sediment structures. Specifically, we should focus on abnormal crystals because the laboratory performed most poorly (64% correct) on these clinically important structures.

There are several areas where Urinalysis-Review will be improved. As discussed above, the program would be more realistic if it included urine chemistry results, patient history, and allowed more microscope manipulation. In addition, it would be useful if the technologist had the option to chemically manipulate the urine with acid,
analyzing the Microsoft Access® database that underlies Review (Figs. 4–10). Another on-going study involves available using the display options within Urinalysis-Visors to identify and provide education regarding the problematic to the laboratory would greatly help super-
A more rapid display of the specific structures that are problematic in the program, it is possible to determine specific structures that are problematic, but this is a time-consuming task because it requires dissecting the results of each exam by going through each individual’s performance (Fig. 8).

In this study, we concentrated on results that are available using the display options within Urinalysis-Review (Figs. 4–10). Another on-going study involves analyzing the Microsoft Access® database that underlies Urinalysis-Review and collecting survey data from technologists who have been using Urinalysis-Review. This detailed analysis will help us more rigorously define the current state of competence in our institution. For example, we will be able to compare and contrast the performance of the two geographically distinct core laboratories in our academic institution, the first step in ensuring that the laboratories are performing at the same level. In addition, we will be able to determine what specific structures are commonly confused with each other and what clinically relevant errors are made most frequently. Lastly, the addition of the survey results might help us identify modifiable factors that affect competency in microscopic urinalysis.

In addition to a more detailed data analysis, we are pursuing other logical extensions of our work. One obvious extension is to repeat the study after enhancing both Urinalysis-Tutor and Urinalysis-Review. This will allow us to establish even more accurate competency data. A second project is an interlaboratory comparison based on collecting competency data from other laboratories that subscribe to Urinalysis-Review. A third project is to implement the program outside the core clinical laboratory as a competency assessment tool in point-of-care settings. In this case, the examinees are healthcare personnel outside the laboratory who perform microscopic urinalysis—for example, physicians, nurses, and physician assistants—and the supervisor could be the staff member who oversees laboratory testing.

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4 The cost of the program is $100 per year.
References