EXCELLENCE FOR ALL
WORLD-CLASS INSTRUCTIONAL SYSTEMS FOR OUR SCHOOLS

Setting College-Ready Qualification Scores for Physics

The *Excellence for All* initiative calls for students to demonstrate competence in five subject matter areas – mathematics, English language arts, history, the sciences and the arts -- to be eligible to claim a proficiency-based diploma as early as the close of their sophomore year in high school. Depending on the aligned instructional system their school has chosen, students will take end-of-course examinations in each of these subjects from either the University of Cambridge International General Certificate of Secondary Education (IGCSE) or ACT *QualityCore* systems. The National Center on Education and the Economy's (NCEE) Technical Advisory Committee (TAC) has established the qualification scores for English and mathematics for both systems, but the states are responsible for setting the qualification scores in the other three subjects.

Ascertaining what qualification scores are associated with future college success is critical to the success of the initiative. At the request of the participating states, NCEE convened its Science Task Force for a third round of deliberations in October 2013 with a follow-up meeting in January 2014 to develop qualification score recommendations for IGCSE and *QualityCore* Physics having previously convened to do the same for Biology, Chemistry and Coordinated Science[1]. State education agencies in Arizona, Kentucky and Mississippi and the Capitol Region Education Council in Connecticut had each been invited to appoint members to the Task Force. Participants included high school science teachers, community college and university faculty, state education department curriculum professionals, and representatives of the private sector. The Task Force was reconvened with a somewhat revised membership (to reflect the change in emphasis to Physics). At each of these sessions they were advised by Andrew Shouse, a leader in science education from the University of Washington, and Lloyd Bond, one of the nation's premier measurement experts and a consulting scholar at the Carnegie Foundation for the Advancement of Teaching.

The Task Force was charged with two specific goals. First, each qualification score should be an indicator of readiness to move forward in education, either to an upper division high school science course or to the initial credit-bearing course in a science program of study in an open enrollment college. Second, each measure is also construed as an approximation of basic scientific literacy that would be consistent with a definition of a scientifically literate citizen, signaling that when students pass the exam they are conversant with fundamental concepts of science that may bear on their life experiences (at the ballot box, at the doctor's office, in the media, etc.). The qualification score is *not* intended to approximate readiness for a career in the sciences, nor for entrance into a science program at a selective post-secondary institution. The Task Force assumed that such college- or career-readiness paths would demand a higher benchmark than "literacy."

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[1] Coordinated Science is a two-year course offered by Cambridge that covers the core concepts of Biology, Chemistry and Physics in an integrated manner.

The two assessment systems use two different scales to report student proficiency. IGCSE scale scores range from G to A* with numerical equivalents, the Percentage Uniform Mark (PUM) scores, that range from 20 to 100,[2] and *QualityCore* scale scores range from 125 to 175. The Task Force had a limited body of student outcome data and correlated measures of college readiness to inform its recommendations. But it did have past examination tasks to inspect as well as scoring rubrics and exemplary models of student work for constructed response tasks that provided a window into the relationship between the quality of student knowledge and skills and exam scores.

In considering the evidence in hand the Task Force recognized that the qualification scores for these examinations needed to be seen as not just a mark for a single subject, but as one part of a larger qualification framework where students would also have to: (i) reach a satisfactory score in another science course (most likely Biology); (ii) reach similar standards in history and the arts; and (iii) meet demanding standards in English and mathematics that had already been set by the NCEE TAC. While the NCEE TAC placed special value on preventing false positives (i.e., ensuring that students not ready for credit-bearing courses in open enrollment colleges not be told they are), the Task Force placed special value on preventing false negatives (i.e., ensuring that students who could succeed in college were not misclassified and thus have their path to enrolling in credit-bearing community college courses after their sophomore year blocked). They also took the position that while English and math competence is essential for success in almost every college program, the same claim was more difficult to make for science, even as there was wide agreement that literacy in fundamental scientific principles and practices is essential to meet the shared objective that students leave high school ready to lead the life of an educated person. Taken together this line of reasoning led the Task Force to believe that the qualification scores for these science examinations need not be as stringent as the scores for English and mathematics.

Key considerations for developing qualification score recommendations for these examinations were to be found in the answers to these questions:

- What knowledge, skills and dispositions are priorities for each exam?
- How do these priorities align with what is necessary for success in open-enrollment colleges, in upper division high school science courses and, most importantly, for scientific literacy (referred to among the Task Force as the educated person standard)?
- What indicators of readiness for success at open-enrollment colleges exist, what are their strengths and weaknesses, and how are these reflected in end-of-course exam grades in each of the two programs?

[2] The numerical PUM range for A* is 90-100, for A it is 80-89, for B it is 70-79, etc.

ACT QualityCore Physics

The Task Force noted that one half of the ACT *QualityCore* Physics exam time and an even larger portion of the raw score (about 60%) is comprised of multiple-choice questions, with the remaining points and allotted time dedicated to three constructed response questions. The constructed response items are scored on a four-point scale. Raw scores are converted to the 125-175 point scale. This format was identical to the format for the ACT *QualityCor*e Biology and Chemistry exams.

Initial data analysis focused on identifying scores that are associated with future college success, using the ACT Science Benchmark, the ACT exam science score that predicts that in their first college science class there is a 50% chance of a student earning at least a B and a 75% chance of a student earning at least a C. At the time that the Task Force set qualification scores for Biology and Chemistry, the ACT Science Benchmark was 24. This benchmark recently was revised, based on new data and analyses, to 23 shortly before the Task Force met to consider the Physics exam.[3] With a benchmark at 23, the scale score for Physics most closely associated with this benchmark was 147-150. The Task Force was hesitant to set the score at this level, however, as the historical experience with this exam showed that only about 8% of the students who have taken the Physics exam score 150 or better. The Task Force saw this as excessively stringent and decided to approach the qualification score from a different angle.

This second approach involved using the Biology and Chemistry qualification scores developed in June 2012 and December 2012, respectively, as a benchmark, reasoning that while the Biology, Chemistry and Physics scale scores are not tightly related, the qualification scores for each should represent roughly equivalent prospects for future success. The Biology qualification score is now associated with an 77% chance of scoring an A or B in the next high school science course and a 34% chance of reaching the ACT science benchmark for college success. For Chemistry, there was a several point difference between the score associated with a similar likelihood of scoring an A or B in the next high school course and a similar chance of meeting the ACT science benchmark. The Task Force, at that point, decided to tie the qualification score to the ACT benchmark for two reasons. First, high school performance data can be distorted by the fact that a more select group of students is usually taking the next science course. Second, linking this decision to college performance rather than high school performance was more consistent with the task at hand.

Since the Biology and Chemistry recommendations were developed ACT has conducted new analyses on the character of its *QualityCore* exams, as noted above, and this yielded new college readiness tables that indicated that the probability of being college ready associated with the Biology qualification score was now 34% and was now 42% for the Chemistry qualification score.

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[3] ACT provided NCEE with new analyses about the relationship of the *QualityCore* Physics, Biology and Chemistry scale scores with the new ACT college benchmarks to reflect this change and the availability of another year of student performance data on each of these three science exams.

In the case of Physics there is not a typical next high school course for ACT to report on so the Task Force focused on the scores that are linked to a 34% and a 42% chance of being successful in college, and in doing so followed the same logic line as had been adopted for Biology and Chemistry. These scores were 141 and 143, respectively, with the latter score having been achieved by 50% of the students who previously took the test. This is a higher percentage of students than was found performing at the qualification levels in Biology and Chemistry, but was seen as acceptable as Physics classes tend to enroll a narrower slice of each student cohort and one that is typically drawn from the upper end of the achievement distribution.

In the *QualityCore* Physics exam, like its sister Biology and Chemistry exams, there are multiple ways for students to reach such scale scores as points are awarded in a compensatory manner where weaknesses in one set of questions can be offset by strengths in another. To reach the scale scores in Physics such as those noted above students would need to earn roughly one-third of the available points even as students need to earn 53% and 42% of the available points in Biology and Chemistry respectively to reach the recommended qualification scores. This relationship of lower criteria as one moves from Biology to Chemistry to Physics mirrors the raw score percentage correct at the new college benchmark levels for these three examinations where the figures are 53%, 49% and 44%[4] respectively, all of which suggests that the Physics exam is likely a more demanding exam than the science exams that typically precede it. Not surprisingly then, after reviewing several of the constructed response tasks along with exemplars of student work and associated scoring rubrics, Task Force members concluded that student performances that could yield the kinds of Physics scores they had focused on were consistent with their own views of where an educated person standard ought to be set.

Consideration of these multiple factors led to a unanimous recommendation of **143** as the qualification score for the ACT *QualityCore* Physics exam.

University of Cambridge IGCSE Physics

The Task Force went through the same exercise for the University of Cambridge IGCSE Physics examination. The IGCSE courses do not have a formal college benchmark set for each exam, but there is a general view across the Cambridge community that an entry level score of C, or 60 in PUM terms, indicates that students are ready to attend open enrollment colleges or move on to A-level studies, the equivalent of Advanced Placement and International Baccalaureate courses. These exams have a multiple-choice section, a constructed response section and a coursework component that students fulfill during the course of the school year. The "assessment objectives" are defined explicitly and are built into the assessment rubrics provided for scorers, teachers and students. The Task Force was impressed by the demanding nature of the courses, as well as the alignment of the syllabus, the test instruments and the assessment rubrics.

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[4] With ACT lowering the college readiness benchmark score in science the Biology qualification score is now at the benchmark when it had previously been positioned below the benchmark. Consequently, the two Biology criteria are identical while the qualification scores for Chemistry and Physics sit below the ACT college readiness benchmark scores for these two subjects.

The Task Force spent time examining students' responses to test questions at the B and C achievement levels (as the "A" and "A*" level responses were clearly going to qualify and "D" level performances were likely to be inadequate so neither received much scrutiny). They also reviewed the examiners' comments on the student work. Discussions largely revolved around the quality of student thinking and writing required by the test, in comparison to what is required for success in community colleges.

Each IGCSE exam allows a wide range of performance levels to allow the highest performing students to demonstrate their command of the subject matter (so at first glance each appears especially demanding). But this is coupled with rubrics that permit these instruments to recognize multiple levels of student competence. When translated into letter grades a Cambridge "B" is a tougher grade to earn than what we typically think is necessary to earn a B in U.S. schools and likewise for Cs and As.

After studying recent IGCSE Physics exams and associated examples of student work the Task Force came to a recommendation of ***60*** PUM***s*,** or a baseline C. Scores of 60-69 all fall under the definition of a Cambridge C, but the entry-level mark was seen as a solid performance for these purposes. A typical way a student might earn this score on the Physics exam is to get 60% of the multiple choice items right, earn 33% of the available constructed response points and receive 67% of the coursework points. While aspects of this standard may appear quite modest, when one considers the demands of the assessment tasks, it becomes apparent that an overall score of 60 represents a real accomplishment and is consistent with the notion of scientific literacy that animated these deliberations. This is very similar to the percentages of points needed for the other three IGCSE science exams.

These findings were also supported by the prior decision of the Task Force to set the IGCSE Biology, Chemistry and Coordinated Science qualification scores at 60 PUMs as these three IGCSE exams were seen as being roughly equivalent in terms of cognitive demand, plus there was no plausible argument that any member of the Task Force thought had merit that might suggest that one of these science courses had greater value or importance than the other.

Over the coming years the *Excellence for All* initiative, at the states' request, will gather additional evidence and suggest refinements to the qualification scores where appropriate. Future recommendations may take into consideration the performance of pilot school students on more advanced ACT and Cambridge courses, as well as how they do on college admissions exams as they advance from grade to grade and eventually on the grades they receive in college.

January 2014

Science Task Force - Physics

Sue Cain

Sue Cain is the Coordinator of the College Readiness and Developmental Education Initiative at the Kentucky Council on Postsecondary Education. She serves as a representative of the Council on the implementation of Senate Bill 1 (2009) efforts to align content and assessments from K-12 to postsecondary. She led the postsecondary team which developed unified strategies to reduce college remediation rates of recent high school graduates and increase college completion rates of students entering postsecondary institutions not meeting college readiness benchmarks. Ms. Cain also oversees the coordination of the professional development for postsecondary faculty for the Common Core Standards and Assessment Initiative. She serves as the director of Academic Readiness and Testing at Eastern Kentucky University, where she is on the Department of Mathematics and Statistics faculty and chairs the University Developmental Education Advisory Committee. Her research interests include the development of a scientific basis for curriculum structures, assessment of developmental education programs and services, college readiness policy, student success and college completion. Ms. Cain served on the Kentucky Developmental Education Task Force and the Kentucky Committee for Mathematics Achievement. Recently, she led the statewide effort to develop common English, reading, and mathematics college readiness benchmarks and the related learning outcomes to align K-12 and postsecondary standards and assessments.

Richard B. Condit

Richard B. Condit is senior vice president at Sundt Construction in Tempe, Arizona. Previously, he taught vocational agriculture for nearly nine years in three high schools in Arizona. He spent 13 years at the Arizona Department of Education (ADE) in various roles with his last position being Associate Superintendent for Career and Technical Education and Adult Education. One of the projects he managed while at ADE was the identification of the science standards for the State Board. After nearly 19 years with Sundt Construction, he now is responsible for the people aspects of the business - information technology, strategic and tactical planning, and until recently, corporate business development and marketing. Sundt is the 45th largest contractor in America, 120 years old and 100 percent employee owned. Mr. Condit earned his B.S. from the University of Arizona.

J.J. DePasqua

J.J. DePasqua is a physics teacher at the Capitol Region Education Council's (CREC) Medical Professions and Teacher Preparations Academy in Windsor, CT. He is teaching Cambridge IGCSE Physics this year. He started teaching at CREC in 2009 at the Academy of Aerospace and Engineering where he taught middle school science. His students have been featured on

Discovery Channel's Daily Planet and he has served as a consultant for Six Flags New England's new Science Adventure program. Mr. DePasqua received a B.A. in theoretical and operational meteorology with a minor in physics from Western Connecticut State University and is certified to teach physics and earth sciences.

Walt Drane

Walt Drane is the Assistant Director of Student Assessment at the Mississippi Department of Education. He is currently providing oversight over assessments in mathematics and English Language Arts for grades 3-8, end-of-course high stakes assessments in the areas of Algebra I, English II, Biology I and U.S. History, and alternate assessments for those students in grades 3-8 and 12 who have severe cognitive disabilities. He is also a member of the Leadership Team for the Partnership for Assessment of Readiness for College and Careers (PARCC). Prior to serving at the Mississippi Department of Education, Mr. Drane served as an assistant principal, athletic director and elementary and middle school teacher. He holds a B.A. in Political Science with a focus on International Relations, a Master's degree in Education, and an Education Specialist degree in Educational Leadership.

Sean Elkins

Sean Elkins is an Instructional Specialist for Science with the Kentucky Department of Education. He began teaching in 1989 at Bowling Middle School in Owen County, KY where he taught 7th and 8th grade earth and integrated science for 12 years. He has also served as a regional science consultant for the Kentucky Department of Education and as an instructional coach for Shelby County Public Schools. Mr. Elkins has been a science consultant for the Kentucky Department of Education since 2005. He is a board member of the Council of State Science Supervisors and served as the state lead for Kentucky's involvement in developing the Next Generation Science Standards. Mr. Elkins earned a B.S. in Geology with minors in Chemistry and Physics and a M.A. in Science Education from Eastern Kentucky University.

Thomas R. Tretter

Thomas R. Tretter is Associate Professor of Science Education and Director of the Gheens Science Hall & Rauch Planetarium at the University of Louisville. His research includes a focus on science teacher assessment development and validation, particularly through leading the science education team's work developing the Diagnostic Teacher Assessments in Mathematics and Science for middle school science teachers. His assessment development work has also included using structural equation modeling techniques to adapt and validate instruments to measure various constructs with English language learner populations in K-12 schools. Other research efforts focused on investigations of the most effective ways to bring concepts from the emerging field of nanotechnology into middle and high school science classrooms. In 2004, Dr. Tretter was awarded the Outstanding Dissertation award by the National Association for Research in Science Teaching (NARST), and in 2010 he was awarded the NARST Early Career

Research Award. He has served on journal editorial boards and committees for the Journal of Research in Science Teaching and the Journal of Science Teacher Education, and has served on numerous grant review panels including for the National Science Foundation and as a principal grant review panel member for Mathematics and Science Education for the U.S. Department of Education's Institute for Education Sciences. He earned his doctorate in curriculum and instruction with a specialization in science education from the University of North Carolina at Chapel Hill.

Christopher D. Wilson

Christopher D. Wilson is a science educator/research at the Biological Sciences Curriculum Study in Colorado Springs. He has training and experience in measurement of student learning and reasoning, development of learning progressions, teacher education, undergraduate science teaching and learning, and developing inquiry-based curriculum materials. In addition, he is trained in classical and Rasch item analysis, and regularly consults on assessment and item development. Dr. Wilson is an active member of the National Association for Research in Science Teaching, the American Educational Research Association and the National Association of Biology Teachers, and is co-PI on an NSF DRK-12 project examining the effects of inquiry-based modules in genetics. He holds a Ph.D. in Science Education from Michigan State University.

Jason Young

Jason Young has been teaching physics, chemistry, physical science and other science and math courses for the Drew School and Pearl School districts in Mississippi since 1994. He received his Bachelors in Physics from Rensselaer Polytechnic Institute and his Masters in Secondary Education from the University of Mississippi.

Advisors

Lloyd Bond

Lloyd Bond is a consulting scholar with the Carnegie Foundation for the Advancement of Teaching and emeritus professor of education at the University of North Carolina, Greensboro. From 2002 to 2008 he was a senior scholar at Carnegie working in the area of assessment across several Carnegie Foundation programs. Dr. Bond has published widely in the area of assessment, measurement theory and testing policy and has made fundamental contributions to the literature on measuring complex performance and cognitive processes underlying test performance. He has held editorial positions on the leading journals in educational and psychological measurement and serves on numerous commissions and panels devoted to testing and testing policy. He is a member of the Data Analysis Committee of the National Assessment

of Educational Progress (NAEP) and the Psychometric Panel of The College Board. Previously he served on the National Academy of Sciences' Committee on Indicators of Science and Mathematics Education and their Committee on Science Assessment Standards. A fellow of both The American Psychological Association (APA) and the American Educational Research Association (AERA), he is the recipient of numerous honors and awards, including the Presidential Citation from AERA for Contributions to Educational Measurement and an APA Distinguished Service Award for his work on the Joint Standards for Educational and Psychological Testing. He has served as a trustee for The College Board, and currently sits on the boards of the Human Resources Research Organization and the National Center for Research on Evaluation, Standards & Student Testing. Dr. Bond obtained a Ph.D. in Psychology from the Johns Hopkins University, specializing in psychometrics and quantitative methods. He taught test theory and psychometrics at the University of Pittsburgh, and at the University of North Carolina, Greensboro.

Andrew W. Shouse

Andrew W. Shouse is a member of the research faculty and associate director of the University of Washington's Institute for Science and Math Education. In this position, he focuses on equitable science education in formal and informal settings, and communication of research to policy and practice audiences. Dr. Shouse's work is informed by a breadth of experiences in practice, including teaching elementary and middle grades, science center administration and policy analysis. Prior to his appointment at the University of Washington he was a senior program officer at the National Research Council's Board on Science Education where he directed two consensus studies and edited the reports, *Learning Science in Informal Environments: People, Places, and Pursuits* (NRC, 2007; with Bell, Lewenstein, and Feder) and *Taking Science to School: Learning and Teaching Science in Grades K-8* (NRC, 2007; with Duschl and Schweingruber) and authored *Ready, Set, Science! Putting Research to Work in K-8 Science Classrooms* (with Michaels and Schweingruber). Dr. Shouse serves on advisory bodies for numerous organizations, including the National Geographic Society, the National Association for Research in Science Teaching, the Pacific Science Center (Seattle), The Museum of Science and Industry (Chicago), and The NSF Center for Biophotonic Science and Technology at the University of California-Davis. He holds a Ph.D. in Curriculum, Teaching, and Educational Policy from Michigan State University.