Indiana Academic Standards
Mathematics: Probability and Statistics
I. Introduction

The college and career ready Indiana Academic Standards for Mathematics: Probability and Statistics are the result of a process designed to identify, evaluate, synthesize, and create the most high-quality, rigorous standards for Indiana students. The definitions that guided this work were created by the Indiana Education Roundtable, Department of Education, Center for Education & Career innovation, Commission for Higher Education and the Department of Workforce Development. The definition for college and career ready by this group and used throughout this process is as follows: “College-and – career ready means an individual has the knowledge, skills and abilities to succeed in post-secondary education and economically-viable career opportunities.” Additionally Public Law 31-2014 [SEA 91] defines college and career readiness educational standards as “the standards that a high school graduate must meet to obtain the requisite knowledge and skill to transition without remediation to post-secondary education or training, and ultimately into a sustainable career.”

Standards Process

The Indiana Academic Standards were created through a collaborative process with input from teams of K-12 educators and parents representing school corporations located throughout the state of Indiana; professors of higher education, representing a wide range of Indiana’s public and private colleges and universities; and representatives from Indiana businesses and industries. The purpose of the standards process was to design college and career ready standards that would ensure students who complete high school in Indiana are ready for college and careers.

History

Public Law 286 was passed by the Indiana General Assembly in 2013, which created Indiana Code 20-19-2-14.5. The law requires the Indiana State Board of Education to perform a comprehensive review of Indiana’s current standards (which were the 2010 Common Core State Standards) and to adopt college and career ready educational standards no later than July 1, 2014.

In the fall of 2013, the Indiana Department of Education established Technical Teams, which were comprised of K-12 educators in English/Language Arts and Mathematics. The Technical Teams were responsible for reviewing the existing Indiana Academic Standards (Common Core State Standards) and providing suggestions for edits and word changes to improve the clarity and progression of the standards. The Department also created Advisory Teams, which were made up of educators from k-12, parents, community members, and higher education institutions across Indiana. The Advisory Teams were responsible for reviewing the work of the Technical Teams and providing additional input.

Evaluation Process

In January of 2014, the Indiana Department of Education, in collaboration with the Indiana State Board of Education, established Evaluation Teams. The Evaluation Teams were responsible for additional layers beyond the work of the Technical and Advisory Teams. The Evaluation Teams were tasked with conducting a comprehensive analysis of several sets of standards, with the goal of identifying the standards that most clearly aligned with the content and skills that Hoosier students would need to know and be able to do in order to be college and career ready.

Membership for the Evaluation Teams was gleaned from individuals who had previously participated on either a Technical Team or an Advisory Team. The Evaluation Team members were selected for their subject matter expertise (in English/Language Arts or Mathematics) and their classroom teaching experience.

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The Evaluation Teams were made up of K-12 educators who represented a wide variety of Indiana school corporations with over 445 years of combined classroom teaching experience, and higher education subject matter experts in English/Language Arts and Mathematics, representing Indiana’s public and private institutions of higher education.

The Evaluation Teams met for the first time in February of 2014. The English/Language Arts evaluation teams were given the E/LA Common Core State Standards, as well as Indiana’s 2006 E/LA Academic Standards and the standards created by the National Council of Teachers of English. The Mathematics evaluation teams were given the Mathematics Common Core State Standards, as well as Indiana’s 2000 Math Academic Standards, Indiana’s 2009 Math Academic Standards, and the standards created by the National Council of Teachers of Mathematics.

The panel was instructed to independently evaluate each set of standards, identifying whether the standard was wholly aligned with what a Hoosier student would need to know and be able to do in order to be college and career ready; partially aligned with what a Hoosier student would need to know and be able to do in order to be college and career ready; or not aligned with what a Hoosier student would need to know and be able to do in order to be college and career ready. The results of the evaluation were processed according to a consensus requirement—a majority requirement was calculated for each group of standards that was reviewed. Any standard that received a fully aligned rating by the majority of reviewers was marked as fully aligned; any standard that received a not aligned rating by the majority of reviewers was marked as not aligned; and any standard that received a partially aligned rating by the majority, or did not have a majority result, was marked as partially aligned.

Once the evaluations were complete, the results were compiled, and the Evaluation Teams were brought together to conduct a consensus process. The consensus process was blind (meaning that the Evaluation Team members did not know the origin of the standards that they were discussing). Through the consensus process, the Evaluation Teams were asked to select the standards that best and most thoroughly represented what students should know and be able to do in various areas of English/Language Arts and Mathematics in order to be college and career ready. The Evaluation Teams selected the standards that they found to be most appropriate; combined standards to create a more appropriate, rigorous, or clear standard; or, if they determined that gaps existed, wrote standards, or reviewed standards from other states (for example, the English/Language Arts Evaluation Teams reviewed the 2010 draft standards from Massachusetts).

Once the Evaluation Teams had selected the standards (from Common Core State Standards, Indiana Academic, or other states) or had written standards where they found gaps, the list of knowledge and skills identified as necessary for students to be college and career ready was posted for public comment.

**Public Comment, Public Hearings, and National Expert Review**

The draft college and career ready Indiana Academic Standards were posted for the public to review on February 19, 2014. The public was invited to provide comment through March 12. Over 2000 public comments were received. There were also three public hearings, which were held in southern, central, and northern Indiana, to receive public comment on the draft standards.

The comments from both the online public comment and the public hearings were compiled, reviewed and used to contribute to further iterations of the standards.

In addition, a variety of national experts were contacted to review the draft standards posted on February 19. The results of the reviews were discussed, and portions of the reviews were incorporated into further iterations of the standards.
Reconvening of Evaluation Teams

The Evaluation Teams were reconvened in March of 2014. The teams were tasked with incorporating public comment, and national expert review to ensure that the draft standards were aligned across grade levels and showed appropriate progression from grade to grade. The Evaluation Teams were also tasked with editing and revising standards for clarity, and addressing any other public comments and national expert review around grade appropriateness, bias, embedded pedagogy, or other factors.

Once the Evaluation Teams completed their reviews, the results were sent to the College and Career Ready (CCR) Panels for final review and approval. The results were also shared with additional national experts, who provided reviews. The results of those reviews were analyzed and synthesized and shared with the CCR Panels.

College and Career Ready (CCR) Panels

The College and Career Ready Panels were created in order to ensure that the standards that Indiana developed were aligned with what colleges, universities, industries, and businesses deem necessary for students to be college and career ready. The CCR Panels were made up of subject matter experts from a variety of Indiana public and private colleges and universities, as well as individuals representing Indiana’s businesses and industries.

The CCR Panels were brought together in late March of 2014 to review the draft Indiana Academic Standards that had been reviewed and vetted by the Evaluation Teams in mid-March of 2014. The CCR Panels were tasked with reviewing the standards from 12th grade through kindergarten to ensure that the standards were clear and understandable; aligned across grade levels, showing appropriate progression from grade to grade; and designed to prepare students for college and career readiness. The CCR panels met several times throughout the end of March 2014 and early April 2014 to accomplish this task. At their last meeting, the CCR panel members were asked to sign-off on the draft standards, indicating whether, in their professional opinion, the standards were poised to prepare Hoosier students to be college and career ready.

Indiana Academic Standards

The culmination of the efforts of the Technical Teams, Advisory Teams, Evaluation Teams, and CCR Panels is the college and career ready Indiana Academic Standards that are college and career ready. While many of the standards originated from various sources, including the Common Core State Standards; 2000, 2006, and 2009 Indiana Academic Standards; Massachusetts 2010 Draft English/Language Arts Standards; Virginia Standards of Learning; Nebraska English/Language Arts Standards; the National Council of Teachers of Mathematics; and the National Council of Teachers of English, a number of original standards were also written by members of the Evaluation Teams or CCR Panels.

The process was designed to identify the clearest, most rigorous, and best aligned standards in Mathematics and English/Language Arts to ensure that Hoosier students will graduate meeting the definitions for college and career as defined in Indiana’s processes.
**What are college and career ready Indiana Academic Standards?**

The college and career ready Indiana Academic Standards are designed to help educators, parents, students, and community members understand what students need to know and be able to do at each grade level, and within each content strand, in order to exit high school college and career ready. The Indiana Academic Standards for English/Language Arts demonstrate what students should know and be able to do in the areas of Reading, Writing, Speaking and Listening, and Media Literacy. The Indiana Academic Standards for Mathematics demonstrate what students should know and be able to do in the areas of K-8 Mathematics; Algebra I, II, and Geometry; and higher-level high school Mathematics courses. The Indiana Academic Standards for Content Area Literacy (History/Social Studies and Science/Technical Subjects) indicate ways in which students should be able to incorporate literacy skills into various content areas at the 6-12 grade levels.

**What are the college and career ready Indiana Academic Standards NOT?**

1). *The standards are not curriculum.*

While the standards may be used as the basis for curriculum, **the college and career ready Indiana Academic Standards are not a curriculum.** Therefore, identifying the sequence of instruction at each grade—what will be taught and for how long—requires concerted effort and attention at the corporation and school levels. While the standards may have examples embedded, and resource materials may include guidelines and suggestions, the standards do not prescribe any particular curriculum. Curriculum is determined locally by a corporation or school and is a prescribed learning plan toward educational goals that includes curricular tools and instructional materials, including textbooks, that are selected by the corporation/school and adopted through the local school board.

2). *The standards are not instructional practices.*

While the standards demonstrate what Hoosier students should know and be able to do in order to be prepared for college and careers, the standards are not instructional practices. The educators and subject matter experts that worked on the standards have taken care to ensure that the standards are free from embedded pedagogy and instructional practices. **The standards do not define how teachers should teach.** The standards must be complemented by well-developed, aligned, and appropriate curricular materials, as well as robust and effective instructional best practices.

3). *The standards do not necessarily address students who are far below or far above grade-level.*

The standards are designed to show what the average Hoosier student should know and be able to do in order to be prepared for college and career. However, some students may be far below grade level or in need of special education, and other students may be far above grade level. The standards do not provide differentiation or intervention methods necessary to support and meet the needs of these students. It is up to the district, school, and educators to determine the best and most effective mechanisms of standards delivery for these students.

4). *The standards do not cover all aspects of what is necessary for college and career readiness*

While the standards cover what have been identified as essential skills for Hoosier students to be ready for college and careers, the standards are not—and cannot be—an exhaustive list of what students need in order to be ready for life after high school. Students, especially younger students, require a wide range of
physical, social, and emotional supports in order to be prepared for the rigors of each educational progression (elementary grades to middle grades; middle grades to high school; and high school to college or career).

II. Acknowledgements

The college and career ready Indiana Academic Standards could not have been developed without the time, dedication, and expertise of Indiana’s K-12 teachers, parents, higher education professors, and representatives of Indiana business and industry. Additionally, the members of the public, including parents, community members, policymakers, and educators who took time to provide public comments, whether through the online comment tool or in person at the various public hearings, have played a key role in contributing to the Indiana Academic Standards.

The Indiana Department of Education and Indiana State Board of Education would like to thank Ms. Sujie Shin of the Center on Standards and Assessment Implementation for providing expert facilitation throughout the process and acting in an advisory capacity. The Department and Board would also like to thank the individuals and organizations who provided national expert reviews of the draft standards.

We wish to specially acknowledge the members of the Technical Teams, Advisory Teams, Evaluation Teams, and College and Career Ready Panels who dedicated hundreds of hours to the review, evaluation, synthesis, rewriting, and creation of standards designed to be of the highest quality so that our Hoosier students who are ready for college and careers.
**PROCESS STANDARDS FOR MATHEMATICS**

The Process Standards demonstrate the ways in which students should develop conceptual understanding of mathematical content, and the ways in which students should synthesize and apply mathematical skills.

<table>
<thead>
<tr>
<th>PROCESS STANDARDS FOR MATHEMATICS</th>
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<tbody>
<tr>
<td><strong>PS.1: Make sense of problems and persevere in solving them.</strong></td>
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<td><strong>PS.2: Reason abstractly and quantitatively.</strong></td>
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<td><strong>PS.3: Construct viable arguments and critique the reasoning of others.</strong></td>
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<td>PS.4: Model with mathematics.</td>
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<td>PS.5: Use appropriate tools strategically.</td>
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<td>PS.6: Attend to precision.</td>
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<td>PS.7: Look for and make use of structure.</td>
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<td>PS.8: Look for and express regularity in repeated reasoning.</td>
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The standards for Probability and Statistics are supplemented by the Process Standards for Mathematics.

The Mathematics standards for Probability and Statistics are made up of three strands: Data Analysis, Experimental Design, and Probability. The skills listed in these strands indicate what students should know and be able to do in Probability and Statistics.

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<thead>
<tr>
<th>PROBABILITY AND STATISTICS</th>
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<tbody>
<tr>
<td>PS.DA.1: Create, compare, and evaluate different graphic displays of the same data, using histograms, frequency polygons, cumulative frequency distribution functions, pie charts, scatterplots, stem-and-leaf plots, and box-and-whisker plots. Draw these with and without technology.</td>
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<tr>
<td>PS.DA.2: Compute and use mean, median, mode, weighted mean, geometric mean, harmonic mean, range, quartiles, variance, and standard deviation. Use tables and technology to estimate areas under the normal curve. Fit a data set to a normal distribution and estimate population percentages. Recognize that there are data sets not normally distributed for which such procedures are inappropriate.</td>
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<td>PS.DA.3: Understand the central limit theorem and use it to solve problems.</td>
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<td>PS.DA.4: Understand hypothesis tests of means and differences between means and use them to reach conclusions. Compute and use confidence intervals to make estimates. Construct and interpret margin of error and confidence intervals for population proportions.</td>
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<td>PS.DA.5: Recognize how linear transformations of univariate data affect shape, center, and spread.</td>
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<td>PS.DA.6: Construct and interpret two-way frequency tables of data when two categories are associated with each object being classified. Use the two-way table as a sample space to decide if events are independent and to approximate conditional probabilities.</td>
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<td>PS.DA.7: Decide if a specified model is consistent with results from a given data-generating process, e.g., using simulation.</td>
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<td>PS.DA.8: Understand the meaning of measurement data and categorical data, of univariate and bivariate data, and of the term variable.</td>
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<td>PS.DA.9: Understand statistics and use sampling distributions as a process for making inferences about population parameters based on a random sample from that population.</td>
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<td>PS.DA.10: Use data from a sample survey to estimate a population mean or proportion; develop a margin of error through the use of simulation models for random sampling.</td>
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<td>PS.DA.11: Find linear models by using median fit and least squares regression methods to make predictions. Decide which among several linear models gives a better fit. Interpret the slope and intercept in terms of the original context. Informally assess the fit of a function by plotting and analyzing residuals.</td>
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<td>PS.DA.12: Evaluate reports based on data by considering the source of the data, the design of the study, the way the data are analyzed and displayed, and whether the report confuses correlation with causation. Distinguish between correlation and causation.</td>
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<tr>
<td>PS.E.D.1: Formulate questions that can be addressed with data. Collect, organize, and display relevant data to answer the questions formulated.</td>
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<td>PS.E.D.2: Use election theory techniques to analyze election data. Use weighted voting techniques to decide voting power within a group.</td>
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<td>PS.E.D.3: Construct simulated sampling distributions of sample proportions and use sampling distributions to identify which proportions are likely to be found in a sample of a given size.</td>
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<td>PS.E.D.4: Use simulations to explore the variability of sample statistics from a known population and to construct sampling distributions.</td>
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<td>PS.E.D.5: Model and solve real-world problems using the geometric distribution or waiting-time distribution, with or without technology.</td>
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<td>PS.E.D.6: Model and solve real-world problems involving patterns using recursion and iteration, growth and decay, and compound interest.</td>
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<tr>
<td>PS.E.D.7: Understand and apply basic ideas related to the design, analysis, and interpretation of surveys and sampling, such as background information, random sampling, causality and bias.</td>
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<td>PS.E.D.8: Understand how basic statistical techniques are used to monitor process characteristics in the workplace.</td>
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<td>PS.E.D.9: Understand the differences among various kinds of studies and which types of inferences can legitimately be drawn from each.</td>
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<td>PS.P.1: Understand and use the addition rule to calculate probabilities for mutually exclusive and nonmutually exclusive events.</td>
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<td>PS.P.2: Understand and use the multiplication rule to calculate probabilities for independent and dependent events. Understand that two events A and B are independent if the probability of A and B occurring together is the product of their probabilities, and use this characterization to determine if they are independent.</td>
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<td>PS.P.3: Understand the multiplication counting principle, permutations, and combinations; use them to solve real-world problems. Use simulations with and without technology to solve counting and probability problems.</td>
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<td>PS.P.4: Calculate the probabilities of complementary events.</td>
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<tr>
<td>PS.P.5: Calculate the expected value of a random variable; interpret it as the mean of the probability distribution.</td>
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<td>PS.P.6: Analyze decisions and strategies using probability concepts. Analyze probabilities to interpret odds and risk of events.</td>
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<td>PS.P.7: Define a random variable for a quantity of interest by assigning a numerical value to each event in a sample space; graph the corresponding probability distribution using the same graphical displays as for data distributions.</td>
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<tr>
<td>PS.P.8: Develop a probability distribution for a random variable defined for a sample space in which theoretical probabilities can be calculated; Compute and interpret the expected value of random variables.</td>
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<td>PS.P.9: Derive the binomial theorem by combinatorics. Use combinatorial reasoning to solve problems.</td>
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<tr>
<td>PS.P.10: Describe events as subsets of a sample space (the set of outcomes) using characteristics (or categories) of the outcomes, or as unions, intersections, or complements of other events.</td>
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<td>PS.P.11: Understand the multiplication counting principle, permutations, and combinations; use them to solve real-world problems. Use simulations with and without technology to solve counting and probability problems.</td>
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