Operator Certification in the Water/Wastewater Industry and the Fallacy Behind Comparing Examination Passing Rates between Programs

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Abstract: Water and wastewater treatment plant operators across North America and in a variety of other countries are required to be certified to protect the public health and the environment as they operate treatment plants. Water Professionals International (WPI) is an association of over 100 certifying authorities representing than 49 states, 12 Canadian provinces and territories, and several international, Canadian First Nations, and U.S. tribal programs. This white paper introduces WPI and the Certification Commission for Environmental Professionals (C2EP); provides a synopsis of the operator certification and examination development processes; examines the credentialing requirements of six operator certification programs; discusses the disparity of certification program requirements in various jurisdictions; and notes the fallacy behind comparing examination passing rates between programs. The primary conclusion that emerges from the study of these six programs is that higher passing rates are due to a combination of education and operating experience. The one factor that does seem to lead to higher passing rates in the higher levels is time in direct responsible charge, with its attendant responsibilities for real-time analysis, troubleshooting, and decision-making.

1. Introduction and Background

WPI, formerly the Association of Boards of Certification (ABC), based in Urbandale, IA, was created in 1972 through the efforts of an ad hoc Committee to form an association led by the American Water Works Association (AWWA) and the Water Pollution Control Federation (now called the Water Environment Federation – WEF). At its organizational meeting, certification examinations were listed as one of the priority issues of the Association. Through a series of EPA grants, WPI developed its first certification examinations and began pilot testing them in 1981. ABC's testing service began officially operating in 1982 and today is the leading organization in North America providing certification and testing services for a wide range of operator disciplines including, but not limited to, water treatment, wastewater treatment, wastewater collection, and water distribution.

While operator certification guidelines published by the Environmental Protection Agency (EPA) in January of 2000 stated ABC could assist certifying bodies by providing validated exams, the implementation of certification programs and the method to establish eligibility requirements were left largely to the discretion of each state or certifying body. This lack of standardization has resulted in significant variability within certification programs across the United States and North America (AWWA 2018). WPI notes this variability "limits the career opportunities for operators, restricts employer recruitment efforts, and undermines the value of operator certification in the water environment."

In 2012, WPI established C2EP to oversee the Professional Operator program, which includes exam development, policies & procedures, and technical program management. C2EP is identified in WPI's Bylaws as an independent commission, and functions under the governing authority of its Board of Directors. To ensure strong continuity with WPI's mission, the chair of C2EP also serves as a member of the WPI Board of Directors. C2EP was established for credentialing integrity, as technical decisions related to psychometrics and program development need to be performed by individuals who can

demonstrate acceptable experience to serve in those positions (rather than by governing board members who are elected by the general membership). A primary objective of C2EP is overseeing the validation of WPI's standardized examinations in the four core disciplines of Collection System Operator, Distribution System Operator, Wastewater Treatment Plant Operator, and Water Treatment Plant Operator. Exam validation is an integral component of the certification process. By definition, a valid exam has been independently reviewed by subject matter experts to ensure that it is based on a job analysis and related to the classification of the system or facility.

2. The Certification Process

The primary purpose of credentialing programs is to ensure protection of the public (ICE 2005). Operator certification programs ensure the protection of public health and the environment. Certification is the process by which an organization or agency evaluates an individual's knowledge, skills, and abilities in a specific field and grants recognition that the individual has met predetermined standards. The certification process typically involves several steps, including meeting eligibility requirements, application for certification, an examination, and ongoing professional development.

The first step in the certification process is to determine eligibility. The credentialing organization typically outlines the requirements for eligibility, which may include education, work experience, and other qualifications. These eligibility requirements are intended to identify minimum qualifications necessary for the candidate to adequately perform the job duties encompassed under the certification. The candidate must demonstrate that they meet the eligibility requirements before they can apply for certification.

The next step is the application process. The candidate must complete an application form and provide documentation to support their eligibility. This may include transcripts, continuing education documentation, resumes, documentation of duties performed, and letters of reference. The candidate will typically pay an application fee.

Best practice dictates that only after the application is approved, the candidate will take a validated examination. The examination is designed to test the candidate's knowledge and skills in the specific field of the certification. The examination may be paper-based or computer-based and may be offered at a testing center or online. The examination typically covers a broad range of topics in the field and may include multiple-choice questions, essays, and other types of questions.

After the examination, the candidate will receive their results. If the candidate has passed the examination, they will be granted certification. If the candidate does not pass the examination, they may be allowed to retake the examination after a certain period. Additional training may be necessary to bolster their knowledge in a specific area of expertise.

Once the candidate has been certified, they will need to maintain their certification through ongoing professional development. The certification organization may require the candidate to complete a certain number of continuing education units (CEUs) or attend professional development workshops or conferences during the certification period. The candidate may also need to pay a fee to maintain or renew their certification.

Finally, the credentialing organization may also have a code of ethics that the certified individual must follow. The code of ethics outlines the standards of conduct for professionals in the field and provides guidance on ethical decision-making.

In summary, the certification process involves determining eligibility, completing an application, passing a validated examination, maintaining certification through ongoing professional development, and abiding by a code of ethics. The process is designed to ensure that individuals who hold certification have met predetermined standards and are qualified to practice in their field.

3. The Exam Development Process

The exam development process for certification programs is a complex and detailed endeavor that involves several steps. The process typically begins with a job analysis, which is a systematic process for identifying the knowledge, skills, and abilities required for a particular job. The job analysis is used to develop a test blueprint that outlines the topics and their weightings that will be covered on the examination.

Once the test blueprint has been developed, subject matter experts are recruited to develop the examination questions. These subject matter experts may be practitioners in the field or academics with expertise in the subject matter. The subject matter experts develop the questions and review them to ensure that they are relevant, accurate, and reflect the content of the exam blueprint.

After the examination questions have been developed, they are typically reviewed by a psychometrician, who is an expert in the science of measurement. The psychometrician reviews the questions to ensure that they are valid, reliable, and fair. This involves analyzing the questions to ensure that they measure the intended knowledge and skills, are free from bias, and are scored in a consistent and reliable manner.

Once the examination questions have been finalized, they are typically pretested on a sample of individuals who are representative of the target population. The pretest is used to evaluate the quality of the questions and to ensure that they are appropriate for the target population. The results of the pretest are analyzed to identify questions that are functioning well and to identify any questions that need to be revised or eliminated.

Finally, the examination is administered to the target population, and the results are scored and reported to the candidates. The results are typically reported in a pass/fail format, and candidates who pass the examination are awarded the certification. The examination is usually administered on a regular basis, and the questions are reviewed and revised periodically to ensure that they remain current and relevant.

A note on exam security: As stated earlier, best practice dictates that an applicant must meet specified criteria before being allowed to take an examination. When standardized examinations are allowed to be taken by individuals who haven't applied for the certification or passed an application confirming their eligibility to take the exam, the entire process becomes vulnerable. With no strict parameters determining who is allowed to sit for a certification exam, the potential of exposing the exam material to unauthorized access increases exponentially. Over exposure and item harvesting are two threats this

practice invites. Additionally, the accuracy of the pass/fail rate becomes skewed which misleads any discussion surrounding the use of the exam. All jurisdictions using standardized exam content need to be aware of the importance of exam security and enforce adherence to practices that protect exam content. A clear and comprehensive test security policy which includes structured test access can prevent many testing irregularities from occurring.

4. Certification Requirements by Program

Across the United States, all states have implemented the 1999 Operator Certification Guidelines issued by the United States Environmental Protection Agency, which were developed as recommended by the 1996 revisions to the Safe Drinking Water Act. Because the Safe Drinking Water Act allows states to assume primacy, states are allowed to exceed the federal requirements, which in turn has resulted in some variability among operator certification programs that share common minimum standards.

In 2011, the Water Environment Federation (WEF) Board of Trustees issued a position statement in support of federally mandated requirements for wastewater operator certification under the Clean Water Act, like those already established under the Safe Drinking Water Act in 1999. In 2023, there was still no comparable federal mandate in the Clean Water Act. WEF noted that many states had implemented wastewater operator certification guidelines or requirements, but without required federal minimum standards, there was great variability between wastewater operator certification programs.

Among WPI's international clients, there is even greater variability in drinking water and wastewater regulations and operator certification programs, due to differing regulatory philosophies and approaches, available resources, and experience in managing operator certification programs.

Surveys of operator certification programs have been conducted in the past, allowing for comparisons of various program requirements and components. Reports include:

- Operator Certification Program State-to-State Comparison, William Edgar, CEU Plan, 2013. (Drinking water and wastewater)
- Summary of State Operator Certification Programs, United States Environmental Protection Agency Office of Water, EPA 816-R-16-002, March 2016. (Drinking water only)
- Operator Licensing Requirements Across the United States, Jeff Oxenford and Jim Ginley, American Water Works Association, February 2018. (Drinking water and wastewater)

Note that one limitation of the 2013 CEU Plan information is that while it does distinguish between water and wastewater disciplines, it is not further refined into requirements for specific classifications within each discipline. The EPA document compares requirements for each classification for drinking water, and the AWWA document compares those requirements for both the water and the wastewater disciplines.

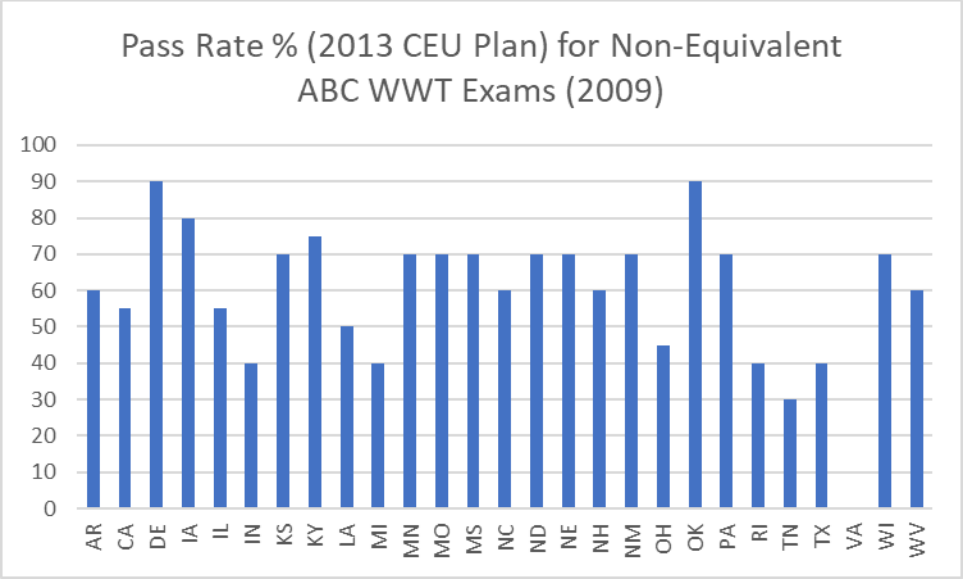
Since 2013, operator certification programs in many states have made changes, so caution must be used when using these reports in 2023 to compare programs. Nevertheless, these reports do provide useful illustrations of the differences between programs. For example, an examination of the 2013 CEU Plan data reveals the following differences in programs.

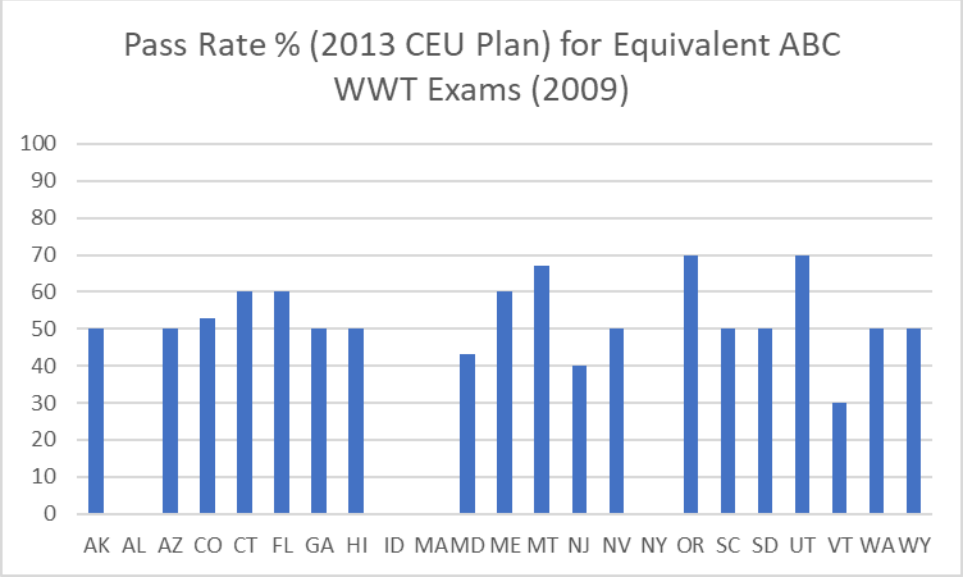
Number of States	Minimum Education for WWT Exam (2013 CEU Plan)
3	None or N/A
1	Read / Write
46	High School Diploma / GED / 12-14 years

Number of States	Minimum Months of Experience for WWT Exam (2013 CEU Plan)
11	0 months
2	1 month
3	3 months
7	6 months
22	12 months
3	24 months
2	Varies

Number of States	Pre-Exam Training Required for WWT Exam (2013 CEU Plan)
31	No
1	Grade 4
16	Yes
2	No response listed

Two charts compare the self-reported wastewater treatment exam passing rates in the 2013 CEU Plan data with the 2009 ABC Examination Equivalency Charts, one for non-equivalent exams, and one for equivalent exams.





Generally, the exam passing rates are higher for the non-equivalent exams than for the equivalent exams. This raises several questions that point to further differences between operator certification programs, which fall into a few categories.

Exam Development Process for Non-Equivalent Exams

- Was the exam based on a current job analysis?
- How qualified were the subject matter experts who participated in exam development?
- Was the exam properly validated and psychometrically sound?

- How often was it updated?

Education / Continuing Education

- How stringent are content relevancy requirements? For example, is any general workplace safety course approved, or only those that cover safety measures and practices specifically required to perform water and wastewater facility installation, operation, and maintenance?
- What are the minimum instructor qualifications?
- Is training developed to IACET standards, even if not submitted to IACET?
- Does the number of CEUs required to maintain certification increase as the operator upgrades their certification?
- For online coursework or webinars, how is operator engagement documented?

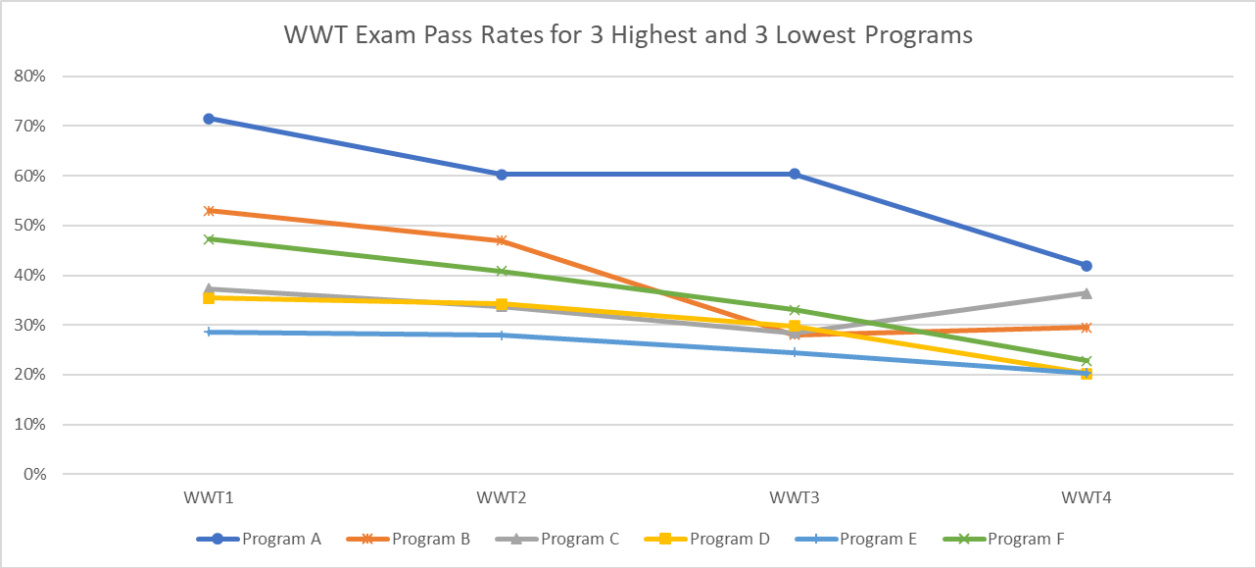
System complexity / Experience

- How much variation is there in plant complexity / plant point ratings?
- For higher classifications, is direct responsible charge time required? Does the required minimum experience specify experience in specific types or classifications of plants?
- Are operators failing because of math? Do they fail because they're not familiar with lab work, process control, other content, or a broad range of facilities? Do they fail because they can recall and apply, but have more difficulty with analysis? How often are they failing before they pass?
- How much opportunity do operators have to gain experience in systems with different processes or of increasing complexity?

2017 ABC Wastewater Treatment Exams

To better understand how differences in operator certification programs might be reflected in exam passing rates, WPI selected Wastewater Treatment (2017) exam data from three programs with highest passing rates and three with the lowest passing rates.

Education and experience requirements for these six programs were then matched to their passing rates. Each jurisdiction's website was consulted to confirm current minimum education, experience, and continuing education requirements for each level. These requirements are summarized in the table in the appendix. Where needed to be consistent with WWT exam levels, Grades A-D were converted to Classes 1-4. Where Classes 1-4 were highest to lowest level, they were converted to Classes 1-4 lowest to highest level.



5. Analysis

Passing rates generally follow the expected trend, where passing rates decrease as exam difficulty increases. There are two exceptions to this trend, where passing rates for the WWT4 exam increase slightly for Program B, and more significantly for Program C. Trends for Programs C and D are nearly identical through the WWT1, WWT2 and WWT3 exams, but then diverge, with Program C increasing for WWT4 and Program D continuing its declining trend.

Program A has the highest passing rate across all 4 levels, most notably at the WWT3 level.

Program E has the lowest passing rate across all 4 levels.

WWT3 – Programs B, C, and D

Passing rates for the WWT3 exam are nearly identical, at 28%, 28%, and 30%, for Programs B, C, and D, respectively.

The minimum education required for a WWT3 by Programs B and D is an HS equivalent. Program C requires two years post-secondary education or 90 CEUs.

The minimum experience required by Programs B and D is a Class 2 certification plus 3 years of operating experience. Program B allows 50% of the experience to be in a drinking water treatment plant. Program C requires 4 years of operating experience at a Class 1 or higher plant.

For continuing education to maintain a WWT3, Program B requires a rate of 0.8 CEUs/year, Program C requires 1.0 CEUs/year, and Program D requires 0.6 CEUs/year.

Program	WWT3 Pass Rate	WWT3 Exam Minimum Education	WWT3 Exam Minimum Experience	WWT3 CEU Rate /Year

B	28%	HS equivalent	Class 2 certification; 3 years of operating experience, 50% can be in drinking water plant	0.8
C	28%	2 years post-secondary or 90 CEUs	4 years of operating experience in Class 1 or higher plant	1.0
D	30%	HS Equivalent	Class 2 certification; 3 years of operating experience	0.6

WWT4 – Programs B, C, and D

Passing rates for the WWT4 exam are 30%, 36%, and 20% for Programs B, C, and D, respectively.

The minimum education required for a WWT4 by Programs B and D is a HS equivalent. Program C requires four years post-secondary education or 180 CEUs.

The minimum experience required by Programs B and D is a Class 3 certification plus 4 years of operating experience. Program B allows 50% of the experience to be in a drinking water treatment plant. Program C requires 4 years of operating experience at a Class 1 or higher plant, plus two years of direct responsible charge time (DRC) at a Class 3 or higher plant.

For continuing education to maintain a WWT4, Programs B and C require a rate of 1.0 CEUs/year. Program D requires 0.6 CEUs/year.

Program	WWT4 Pass Rate	WWT4 Exam Minimum Education	WWT4 Exam Minimum Experience	WWT4 CEU Rate /Year
B	30%	HS equivalent	Class 3 certification; 4 years of operating experience, 50% can be in drinking water plant	1.0
C	36%	4 years post-secondary or 180 CEUs	4 years of operating experience in Class 1 or higher plant; 2 years of DRC at Class 3 or higher plant	1.0
D	20%	HS Equivalent	Class 3 certification; 4 years of operating experience	0.6

Program A

Program A has the highest passing rate across all four levels, and by a significant margin for the first three levels. The pass rate for the WWT3 is 60%, while the other programs range from 24% to 33%.

The education requirement for WWT1 and WWT2 is a HS equivalent. A WWT3 requires 2 years of post-secondary education or 90 CEUs. A WWT4 requires 4 years of post-secondary education or 180 CEUs.

The operating experience requirements for Program A are:

- WWT1 – 12 months at a Class 1 plant or higher
- WWT2 – 3 years at a Class 1 or higher plant
- WWT3 – 4 years at a Class 2 plant or higher, plus 2 years DRC at a Class 2 plant or higher

- WWT4 – 4 years at a Class 3 or higher plant, plus 2 years DRC at a Class 3 or higher plant

For continuing education to maintain certification at all levels, Program A requires a rate of 1.2 CEUs/year.

Program E

Program E is the only one of the six that does not have a minimum education requirement, for any level of certification. Minimum experience requirements for each level vary, depending upon the candidate's level of education, previous experience, and current certification. For a WWT4, current certification is required, in addition to experience ranging from 2 years if one has a 4-year degree, to 9 years if one does not have a high school equivalent education.

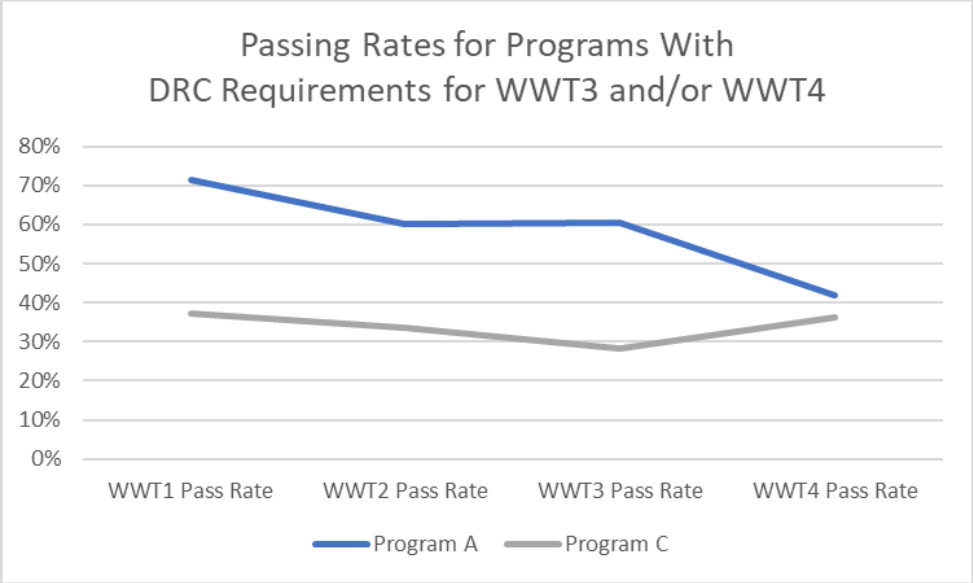
Continuing education to maintain a certification in Program E is 0.8 CEUs/year for WWT1, and 1.0 CEUs/year for WWT2, WWT3, and WWT4.

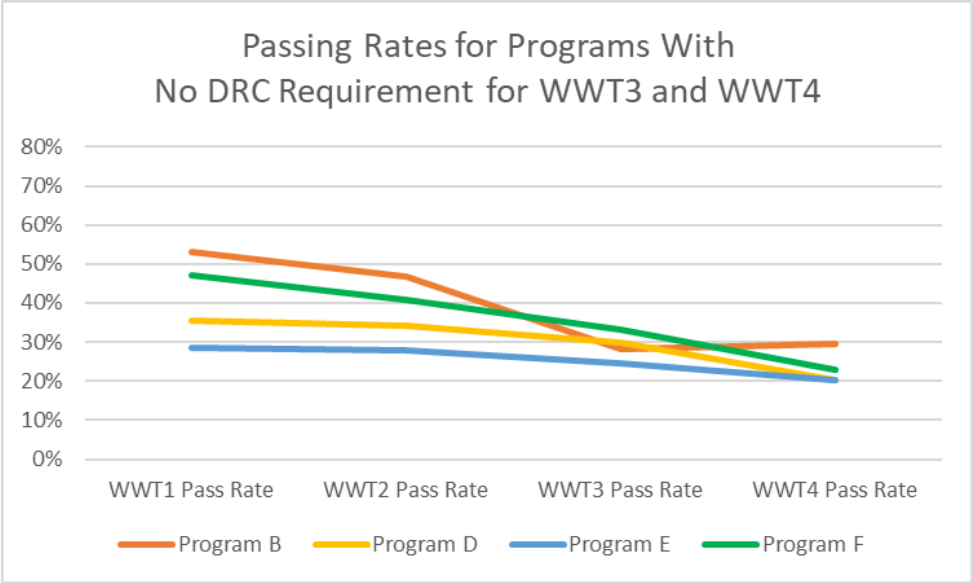
6. Conclusions

ABC exams are standardized, but the same cannot be said for the certification programs using the exams. Some aspects are similar, such as the near-universal requirement of a high-school equivalent education. Nominal operating experience requirements are similar across these six programs as well, although some programs specify that for the higher levels the experience is to be in a plant with a classification immediately lower than or equal to the exam level (e.g., a WWT4 would require experience in a class 3 or higher plant).

For the initial certification levels, some programs require less experience but also require the candidates to complete an approved training course. At the WWT3 and WWT4 levels, the two programs with direct responsible charge time requirements also had the highest exam passing rates. Program A is the only program of these six that requires DRC for a WWT3 exam.

Programs A, C, and F require the equivalent of two years of post-secondary education for a WWT3, and the equivalent of four years of post-secondary education for a WWT4. Program F is the only one of these 3 programs that does not also require DRC time for a WWT4. Program F's WWT4 passing rate is 23%, compared with 42% and 36% for Programs A and C, respectively. This indicates that post-secondary education is less of a factor in WWT4 passing rates than DRC time.





The data also suggest that continuing education may be a factor. For the lowest level of certification, Program A requires three times as much continuing education as Program B. At the WWT4 level, four of the six programs require 1.0 CEUs/year, while Program D requires 0.6 CEUs/year for all levels. Even without knowing the quality of the continuing education, it is logical to assume that more of it would expose an operator to a greater range of topics and broaden their knowledge. The table below compares the highest and lowest required minimum number of CEUs earned during the time required to meet the minimum operating experience requirements for each exam level.

Program	Minimum CEUs Earned as WWT1 to Sit for WWT2	Minimum CEUs Earned as WWT2 to Sit for WWT3	Minimum CEUs Earned as WWT3 to Sit for WWT4	Total Minimum CEUs Earned to Sit for WWT4
Program A (1.2 CEUs/year x minimum years' operating experience to advance to next grade)	3.6	4.8	4.8	13.2
Program D (0.6 CEUs/year x minimum years' operating experience to advance to next grade)	1.2	1.8	2.4	5.4

The conclusion that emerges from the study of these six programs is that higher passing rates are due to a combination of education and operating experience. The one factor that does seem to lead to higher passing rates in the higher levels is time in direct responsible charge, with its attendant responsibilities for real-time analysis, troubleshooting, and decision-making.

Evaluating the quality and relevancy of continuing education, instructor qualifications & capabilities, and operator engagement in these 6 programs is beyond the scope of this paper but is a basic responsibility of every certification program. Study and exam preparation materials that operators utilize vary widely in quality. Operators using study materials that do not emphasize the importance of understanding the science behind the processes and operations so that their current knowledge can be effectively applied to new situations will be at higher risk of failing rigorous, psychometrically sound exams.

There may be other factors that influence passing rates. For example, if a certification program has undergone a major revision and has implemented more rigorous requirements, it will likely be a few years before passing rates for lower classifications begin to climb. It will take longer for higher classification rates to reflect those changes, as it generally takes four to five years to accumulate enough experience to upgrade through each level.

Poor exam security can also affect passing rates. Test takers allowed to sit for an exam with no prior vetting and no waiting period between repeated attempts to pass an exam are two high risk practices in use in some jurisdictions today. If there is no testing integrity, there is no accuracy in the results. It is essential to establish a culture which prioritizes exam security to mitigate scoring irregularities.

Another factor, albeit a minor one, could be reciprocity. If a province or state grants reciprocity by accepting an exam score from a different jurisdiction, that passing score would not be reflected in the grantor's passing rate. If a province or state does not accept a score from another state as a condition of reciprocity, it is possible that the other jurisdiction's exam is less rigorous. If the operator is not ready for the more rigorous exam in the new jurisdiction, the result will be a failing score.

These are a few examples that jurisdictions could examine in a review of their programs and passing rates. Comparing the exam scores among candidates from the same program is valid because they are subject to the same requirements. However, a comparison of passing rates between programs is invalid

comparison, unless the underlying program components and requirements are also compared and found to be equal.

Comparison of Operator Certification Programs Education and Experience Requirements for Three Highest and Three Lowest Passing Rates

2017 WPI WWT Exams

Exam Requirements	WWT1 Minimum Education*	WWT1 Minimum Experience*	CEU Rate Per Year WWT1*	WWT2 Minimum Education*	WWT2 Minimum Experience*	CEU Rate Per Year WWT2*	WWT3 Minimum Education*	WWT3 Minimum Experience*	CEU Rate Per Year WWT3*	WWT4 Minimum Education*	WWT4 Minimum Experience*	CEU Rate Per Year WWT4*
Program A	HS or equivalent	12 months at Class I or higher plant	1.2	HS or equivalent	3 years operating at Class I or higher plant	1.2	HS equivalent and 2 years post-secondary or 90 CEUs	4 years at Class II plant or higher and 2 years DRC at Class II or higher	1.2	HS equivalent and 4 years post-secondary or 180 CEUs	4 years at Class III or higher plant and 2 years DRC at Class III or higher plant	1.2
Program B	HS or equivalent	1 month, or approved training	0.4	HS or equivalent	Class I certification and 2 years, of which 50% may be water treatment instead of wastewater treatment	0.6	HS equivalent	Class II certification and 3 years, of which 50% may be water treatment instead of wastewater treatment	0.8	HS equivalent	Class III certification and 4 years, of which 50% may be water treatment instead of wastewater treatment	1.0
Program C	HS or equivalent	12 months, or 6 months plus approved training	0.5	HS or equivalent	3 years operating experience	0.5	HS equivalent and 2 years post-secondary or 90 CEUs	4 years operating at a Class I or higher plant	1.0	HS equivalent and 4 years post-secondary or 180 CEUs	4 years operating at a Class I or higher plant and 2 years DRC at Class III or higher plant	1.0
Program D	HS or equivalent	12 months, plus OIT cert	0.6	HS or equivalent	Class I certification and 2 years operating experience	0.6	HS equivalent	Class II certification and 3 years operating experience	0.6	HS equivalent	Class III certification and 4 years operating experience	0.6
Program E	None	6 months at Class I or higher plant with HS equivalent, 12 months without HS equivalent	0.8	None	Depending on education, experience in Class I plant: 1 year with HS equivalent; 9 months with AA degree; 6 months with 4-year degree or higher. Without HS equivalent, 3 years in Class II plant and current Class I certification.	1.0	None	Depending on education, experience in Class II plant: 2 years with HS equivalent; 18 months with AA degree; 1 year with 4-year degree or higher. Without HS equivalent, 5 years in Class III plant and current Class II certification.	1.0	None	Current Class III certification, and depending on education, experience in Class III or higher plant as follows: 9 years without HS equivalent, 4 years for HS equivalent, 3 years with AA degree, 2 years with 4-year degree or higher.	1.0
Program F	HS or equivalent	12 months	1.0	HS or equivalent	3 years operating experience	1.0	HS equivalent and 2 years post-secondary or 90 CEUs	4 years operating experience, with at least 2 years at Class III or higher plant	1.0	HS equivalent and 4 years post-secondary or 180 CEUs	4 years operating experience, with at least 2 years at a Class III or higher plant	1.0

*To be consistent with WWT exam levels, Grades A-D were converted to Class I-IV. Where Grades I-IV were highest to lowest level, they were converted to Class I-IV lowest to highest.

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