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IN THE TRISTATE AREA CONSISTING OF KANSAS, MISSOURI, AND OKLAHOMA, A LOCAL AND STATE LEVEL COMPARISON OF HIGH SCHOOL CHEMISTRY PREREQUISITES, HIGH SCHOOL CHEMISTRY INSTRUCTOR PREPARATION, AND THE READINESS OF A HIGH SCHOOL STUDENT FOR COLLEGE CHEMISTRY

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An Abstract of the Thesis by
Gregory Louis Howard

The purpose of this thesis is to create an awareness among secondary and post-secondary instructors as to the student's preparation in high school Chemistry I and the student's readiness for General Chemistry I in college for a tristate area consisting of Kansas, Missouri, and Oklahoma. Student preparation in this research included chemistry I course prerequisites, high school chemistry teacher qualifications including preparation, and student exposure to rigorous science and math course patterns in high school as these relate to college readiness.

Data was gathered from a local cohort group consisting of high schools in Southeast Kansas (SEK), Southwest Missouri (SWM), and Northeast Oklahoma (NEO). This local cohort data consisted of chemistry course prerequisites to depict the differences in course rigor required by students before entering Chemistry I in high school. In addition, representing both the local and a state cohort group of KS, MO, and OK, teacher preparation information was assembled and compared. Finally, representing only the state cohort group, ACT science and math scores from each school were collected and related to science and math course patterns to measure the "readiness" of the student for their first college chemistry course.

In comparing the local cohort, it was determined that Chemistry I prerequisites are quite diverse and potentially inadequate in math preparation, and chemistry teacher demographics were similar. For the state cohort, most of the universities preparing high school chemistry instructors did not require a laboratory practicum, and the percentage of students that are college chemistry ready was highest for Kansas, followed by Missouri and then Oklahoma.

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CHAPTER I

INTRODUCTION

The High School Graduation and Enrollment Picture Is Changing in Kansas, Missouri, and Oklahoma

In the tristate area of Kansas, Missouri, and Oklahoma, the number of high school graduates is expected to increase at an average annual pace of approximately 1.0% and 1.1% in Kansas and Oklahoma respectively over the next ten years, and although its average annual percentage increase remains almost flat at 0.2%, Missouri is certainly not showing any signs of decreasing its graduation numbers.[1] As the number of graduates increases, so are the high school enrollment numbers in Kansas and Oklahoma. From 2016-2024 the total enrollment increase in Kansas high schools is expected to be 1.5% and Oklahoma's change is predicted to be 3.4%, while Missouri is showing a smaller 1.2% increase in enrollment.[2] As can be seen from these anticipated educational developments, it will be increasingly important for high schools to provide graduates with viable coursework and experiences to prepare them for college and/or career. A disturbing research finding has revealed that almost twenty eight percent of high school graduates in the United States will find it necessary to enroll in remedial coursework in college.[3] The increased difficulty level in high school courses and capabilities will become progressively more significant in preparing students for these upcoming college and career challenges.

Importance of Prerequisites, Rigorous Courses, and Teacher Preparation

The importance of rigorous chemistry courses is embedded in a student's path to advanced science related fields, and it has been shown that positive student attitudes, prior conceptual knowledge and math abilities are excellent predictors of success.[4] As depicted in the previous statement, prerequisites to the chemistry course and rigorous course patterns would have a positive impact on college readiness, however, one must be careful and remember that rigor not only includes the afore mentioned aspects, but equally important the pedagogical traits of the chemistry instructor as well.[5] In any case, as the high school student's educational foundation is constructed, the "big ideas" in chemistry should be included in this experience. The "big ideas" in chemistry: conservation of matter and energy, behavior and properties of matter, particulate nature of matter, and equilibrium and driving forces really have not changed over the years and should be the basis of any well-rounded chemistry curriculum.[6] These ideas are often embedded in additional course rigor through mathematics, physics, biology, geology, etc. which make these courses equally as important in dictating student success. To increase academic rigor, curriculum should do its best to teach chemistry as an interrelated subject and not as a stand-alone entity.[6] However, college instructors noted that not *all* of the course content related to these "big ideas" need be included in the high school experience, and it was more important to emphasize thinking or processing skills which are normally related to a higher degree of rigor.[7] A collaboration among high school instructors to require students to take a minimum number of rigorous science courses could go a long way in increasing a student's postsecondary success in General Chemistry I. In addition, according to a study from 1992-2000 conducted for students succeeding in higher level math courses such as calculus reveal a strong relationship to college success, because they are 83% more likely to graduate with a bachelor's degree having taken a calculus course.[8]

Increasing Rigor through Prerequisites and Teacher Certification

To improve the rigor of a high school chemistry course, a closer look at "rigor" is necessary. *"Rigor"*, as the name implies, can be defined or thought of as an inflexibility demonstrated by a teacher that forces the student to take on and conquer increasingly immense challenges.[9] We can argue many different ways to define "rigor" as it pertains to education, but as educators there is one aspect of this definition we all can agree upon: *"We would like to prepare our students, to more often than not, successfully tackle the difficulties of life beyond the classroom!"* With that being said, there are multiple ways to accomplish this, but one way to aid in this quest is simply to hold the student to higher standards in the classroom. This could equate to more stringent prerequisite requirements taken by the student for the chemistry course, better teacher preparation through higher certification standards in chemistry subject matter, and a more rigorous schedule of courses taken in high school.[10]

Inconsistencies of Prerequisites for High School

Research supports that prerequisite math skills including a minimum of high school algebra and geometry be in place before a student enters into a university chemistry program and likewise in high school chemistry, but there is much disagreement among colleges and high schools on these prerequisites.[9] This aspect becomes even more problematic when one considers the rigor of the math courses taken by the student. Relating this to the math prerequisites taken by the student prior to general chemistry in high school, it could easily be surmised that there would be variances in math rigor given the fact that the school districts in this study showed inconsistencies, and the school districts in this study represent a mere 0.12% of the total number of public school districts in the United States.[11]

Impact of Various Teacher Certifications on Chemistry Course Rigor

Teacher certification and preparation is another factor that influences the postsecondary success enjoyed by the graduating high school student.[12] Across the country there is a myriad of teacher certification requirements which greatly affect teacher preparedness, and the tristate area is no exception. As it relates to rigor, it has been shown that in their classroom, teachers with more content knowledge in chemistry are more likely to ask students an increasing number of higher level questions related to the subject.[13] Teacher certification exams could also be revamped to test a teacher's ability to provide these higher order thinking skills in the classroom. In fact, student preparation for the rigors of chemistry could go back to the elementary instructor's preparedness.[14] Finally, the lack of high quality teaching standards can negatively affect a student's postsecondary success especially when teachers are needed to teach a chemistry course that is out of their certification area.[15] Not surprisingly, it has been shown that one of the greatest predictors of student success in after high school endeavors is a teacher's expertise in chemistry content and teaching.[16]

Course Pattern Rigor and Student Readiness for College General Chemistry

Lack of a rigorous course pattern is another stumbling block that high school students are faced with in preparation for college level chemistry. What does a rigorous course pattern consist of, and what is meant by "college readiness"? To begin with, research has revealed that students taking rigorous content in high school including biology, chemistry, and physics, and higher level math courses including algebra II, trigonometry, and calculus enjoy higher levels of success in the first year of college than their counterparts.[8] Also a problem arises in first year university performance when students take more rigorous courses only through a student's junior year, but settle for mediocrity during their final year in high school. As this study turns to “college readiness”, it seems like the term might encompass a broad spectrum of meanings, but it is simply defined as what we want students to be able to do before they enter college.[17] It can be assumed that university instructors would like their students to receive credit and pass their course with at least a “C” grade. There, of course, are varying degrees of readiness, but the focus of this research is based on a benchmark value of “23” for science and “22” for math that has been determined by the ACT in conjunction with college admission criteria from a sampling of 214 institutions and 233,000 freshman college students across the United States taking introductory science courses including General Chemistry I.[17] A student reaching at least the benchmark value on the science or math section of the ACT exam has a 50% probability of obtaining a B or higher or about a 75% probability of attaining a C or higher in college General Chemistry I or College Algebra respectively.[17] In fact, students improving on or attaining a higher degree of science processing skills (as equated to a more rigorous course pattern) are more likely to do better in reading, math and oral and written communications.[18] The interpretive value of college readiness set forth by the ACT was chosen in this research for three basic reasons: First, and probably foremost, it represents one of the most standardized assessments available and even though another widely taken standardized exam, the Scholastic Aptitude Test (SAT) is offered, the SAT does not provide an adequate connection to chemistry. Secondly, a very large number of graduating students (about 55 percent) nationwide took the ACT.[19] In the local portion of the tristate area schools returning the survey, about 66 percent of the graduates took the ACT exam, while about 75% of the of the graduates from each state in the state cohort took the exam. Finally, the assessed items for the chemistry portion of ACT cover three cognitive levels: understanding, analysis, and generalization. Being college ready in this research means the student has met or exceeded the benchmark ACT science score and statistically would have a much better opportunity to be successful in General Chemistry I.[17] It was noted that the ACT exam provided science processing skills that include a chemistry context in ***all*** of their exams. The science section always contains passages and questions that are all inclusive of topics in chemistry, biology, and physics contexts. Two sample passages and the corresponding questions provided in this research are taken from the chemistry context only part of the ACT test and are located in Appendix A.

Chapter II

METHODOLOGY

Local and State Cohort Groups: General School Information, Prerequisites, Teacher Preparation, and College Readiness

The local cohort group consists of schools in Southeast Kansas (SEK), Southwest Missouri (SWM), and Northeast Oklahoma (NEO) that responded to a chemistry survey. Comparisons of general school information in the local cohort included the number of counties represented, the number and percentage of schools represented, the number and percentages of graduates, and also the graduating class sizes and the school enrollments. After compiling chemistry survey results consisting of prerequisites for high school chemistry I and chemistry teacher information, a rating system was employed to compare the local cohort group. Data was then collected that included graduating seniors' science and math ACT scores drawn from the SEK schools that responded to the survey, and SWM's and NEO's state departments' of education respectively. Additionally, data was collected from a state cohort group consisting of KS, MO, and OK graduating seniors who took the ACT exam. Science and math course patterns along with corresponding science and math ACT scores were collected for evaluation from each state's department of education and ACT state profile reports.[20-25]

Local School Districts' Chemistry Surveys

The local cohort selected in this study resided geographically within a one hundred mile radius of Pittsburg State University (PSU) in Pittsburg, Kansas. Identical surveys consisting of four simple response questions were sent to each high school principal, except the Kansas survey required an additional question regarding specific ACT information. The surveys that were employed in this research are found in Appendix B. It was determined an electronic transmission method of the survey to area high school principals would be the most efficient method for data collection. Surveys were emailed to principals representing ninety seven public school districts including thirty three high schools in SEK covering twelve counties, thirty two high schools in SWM covering seven counties, and thirty one high schools in NEO covering six counties. A reminder email of the survey was sent two weeks after the initial submission. All data was collected within a four week time period. Failure to return a survey response was noted as a 'no response', and these schools were not included in the local cohort study. No private schools were included in this research.

Local High School Prerequisites for High School Chemistry I

This research looked at the prerequisites required for Chemistry I for the local cohort of area high schools from the survey results. The types of prerequisites from the individual high schools from each state were recorded. Each state's percentage of schools requiring at least Algebra I or greater math requirement as a prerequisite was compared. Also, data on prerequisite diversity was collected.

Local Teacher Degree, Highly Qualified Teacher (HQT), and Chemistry Teaching Experience

Survey results from the local cohort were gathered from the survey that answered the three following questions about teacher preparation: Does the teacher hold a bachelor's degree in chemistry? It should be noted that a bachelor's degree in chemistry would include the following: Bachelor of Science or Arts in Chemistry with necessary teacher certification hours. Is the teacher considered a "highly qualified teacher" (HQT)? How many years of chemistry teaching experience does the instructor have? Please note that an HQT must have: a bachelor's degree, full state certification or licensure, and prove they know the subject they teach.[26] (Evidence of proof that a teacher knows the subject they teach is depicted by at least one or more of the following: 1) a major in the subject they teach, 2) credits equivalent to a major in the subject, 3) passage of a state-developed test, 4) HOUSSE (High, Objective, Uniform State Standard of Evaluation—for current teachers only), 5) an advanced certification from the state, or 6) a graduate degree.[26]

Rating System for Local High Schools

After compiling survey data, a rating system was employed that accounted for teaching degree, teaching experience in chemistry, teacher quality, and chemistry I prerequisites. The impetus for the rating system is derived from the importance shown in this research of a student's exposure to several different academic aspects in support of the student's success in the postsecondary world. Points for teaching degree and teacher quality were one point for yes responses and zero points for no responses. In addition, if an instructor had ten or more years of experience teaching then a point was also added. Points were then assigned based on the chemistry prerequisites. A maximum of 4.5 points was available for assignment to each high school, and a point could be subtracted if the school did not have any prerequisite requirements or a 0.5 point subtracted if there were no math required prerequisite. An extra 0.5 point could be added, if higher math prerequisites, i.e., Algebra II were requirements. A weighted average of the prerequisite ratings was calculated by accounting for the percentage of students taking the ACT. The weighted average rating for each school district in each state was calculated as seen in Equation 1 below:

Equation 1: Weighted Average Rating = Rating x (% of Graduates Taking the ACT)/100

Even though an exact number of students enrolled in Chemistry I for each high school was not available for the 2014 year, this study speculated that students taking the ACT would be more likely to include chemistry in their course scheduling before graduation, because of high school curriculum recommendations from most colleges and universities.[17] A comparison of Chemistry I courses including overall ratings and teacher ratings was made.

ACT Average Science and Math Scores in the Local and State Cohort Groups and College Readiness Benchmark Values

The percentage of graduates taking the ACT within the local cohort of schools in SEK, SWM, and NEO for each state and the state cohort of graduates in KS, MO, and OK was recorded. In the local cohort group, 2014 ACT average science and math scores were gathered from the Missouri State Department of Elementary and Secondary Education (DESE), and the Oklahoma State Department of Education (OSDE) and the Kansas chemistry survey and, and the weighted average science and math score percentages below the benchmark values were calculated. Average science and math scores were assembled from the ACT state profile reports for KS, MO, and OK. A weighted average of ACT math and science scores was calculated that took into account the number of students taking the ACT at each school and was used to determine and compare the college readiness in each local cohort group. The weighted average science score was determined using the Equation 2 shown below, and the math score calculation is identical except that the average math score was used:

Equation 2: Weighted Average ACT Science Score = Average Science Score from School District x (% of Graduates Taking ACT exam in particular school)/100.

The weighted average science score was then subtracted from the science readiness benchmark value. Similarly the weighted average math score was subtracted from the math readiness benchmark value. For the state cohort, average ACT values for science and math were determined and subtracted from the college readiness benchmark values.

State Cohort Course Patterns and the College Readiness of Graduates

Next, rigorous course patterns in science and math taken by graduates in each state were determined and recorded as follows. The total number of students from each state taking rigorous course patterns in science and math was first determined and, and then percentages of students in each state taking a science course pattern including at least biology, chemistry, and physics were noted along with the percentage of graduates meeting the college readiness benchmark science score of 23. Similarly, math course patterns, percentages of students taking at least Algebra I, Algebra II, Geometry, and Trigonometry were collected, as well as the percentage of graduates meeting the college readiness benchmark math score of 22. Collected mathematics data was then compared among the state cohort of graduates from KS, MO, and OK.

Teacher Certification Requirements and Programs of Study in Kansas, Missouri, and Oklahoma

This study ended with state certification requirements to teach chemistry and programs of study from four tri-state area universities. Current state teacher certification requirements were assembled from the Kansas State Department of Education (KSDE), DESE, and the OSDE respectively. Also programs of study to become certified to teach high school chemistry were gathered from the websites of Pittsburg State University (PSU) and the University of Kansas (KU) in Kansas, the University of Missouri (MU) in Missouri, and the University of Oklahoma (OU) in Oklahoma. A combination of course descriptions and credit hours from each university was developed from university information found in appendices (F-I), and a comparison of each university's course of study was then made.

CHAPTER III

RESULTS

Local Cohort General Information: Counties, School Districts, Graduating Class Sizes, and Enrollments

This study analyzed a local cohort of schools from counties in SEK, SWM, and NEO. General information about the schools in SEK, SWM, and NEO reveals a majority response from counties in SEK and NEO, but at least one school from each county responded in SWM as seen in Table 1. The percentage of schools responding to the survey from each state was lower than the fifty percent that was desired as shown in Figure 1. Figure 2 shows the largest number of graduates from SWM, while SEK has the smallest. SEK represented the smallest percentage of graduates as depicted in Figure 3. SEK also lacked the larger graduating class sized schools and larger school enrollments as seen in Figure 4 and Figure 5 respectfully.

Table 1. Counties in SEK, SWM, and NEO that received local cohort chemistry survey. There were a total of 12 counties in SEK, 7 counties in SWM, and 6 counties in NEO that received surveys. Parentheses indicate the number of schools from each county that responded to the survey out of the number of schools available in county. Details of data may be found in Appendix C.

SEK Counties	**SWM Counties**	**NEO Counties**
Allen(2/3)	Barry (3/6)	Craig(0/4)
Bourbon(0/2)	Jasper(2/6)	Delaware(2/5)
Chautauqua(1/2)	Lawrence(1/6)	Mayes(1/3)
Cherokee(1/4)	McDonald(1/1)	Nowata(0/3)
Crawford(1/5)	Newton(2/5)	Ottawa(2/6)
Elk(0/2)	Barton(3/5)	Rogers(3/3)
Greenwood(1/2)	Dade(1/3)	
Labette(1/3)		
Montgomery(1/4)		
Neosho(1/2)		
Wilson(0/2)		
Woodson(0/1)		
( ) Number of Schools Responding/Total Number in County		

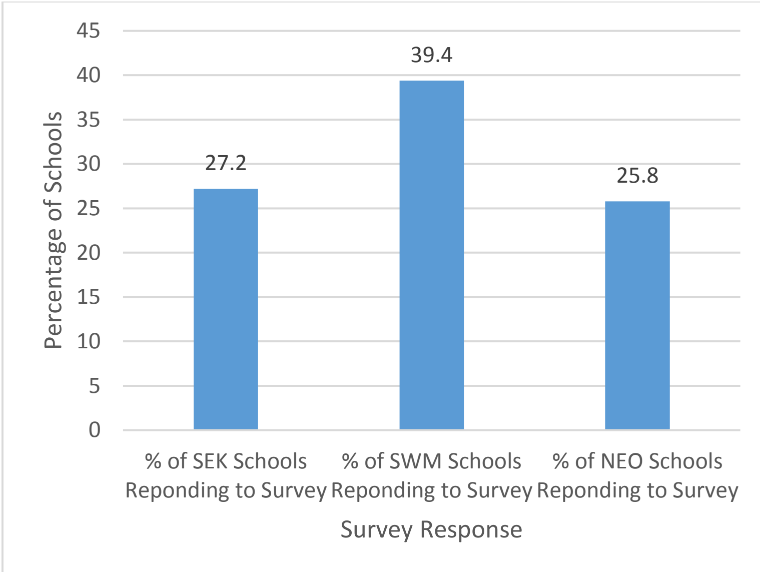

Figure 1. Percentage of schools that responded to the survey from the number of schools available in the SEK, SWM, and NEO tristate area. 33 schools in SEK, 32 schools in SWM and 31 schools in NEO received the survey as shown in Appendix J. Details of data may be found in Appendix C.

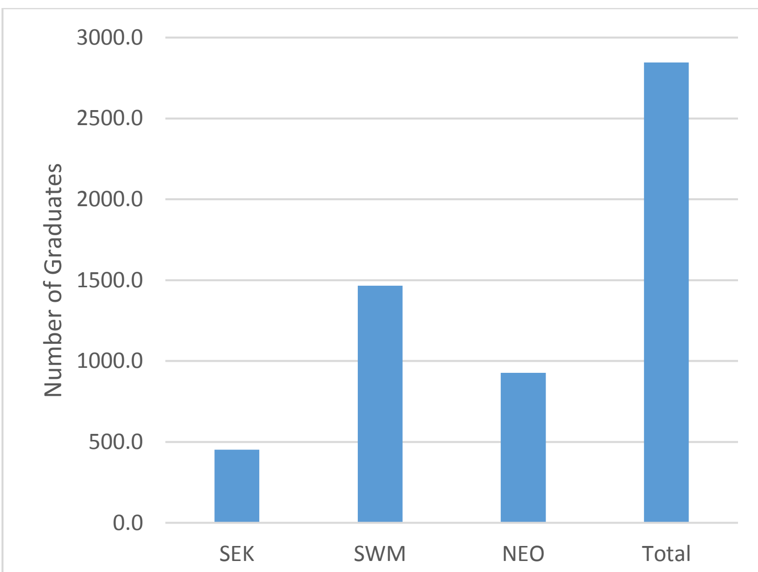

Figure 2. Number of graduates from the local cohort. SWM has more graduates represented in the study than the combined totals of SEK and NEO. Details of data may be found in Appendix C.

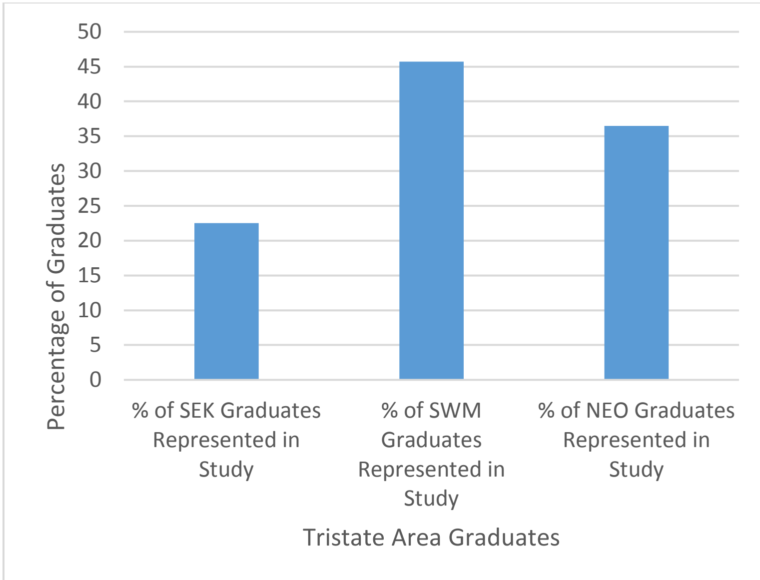

Figure 3. Percentage of graduates from the local cohort that are represented in the study. SWM had the highest percentage of graduates represented in the study, while SEK had the lowest. Details of data may be found in Appendix C.

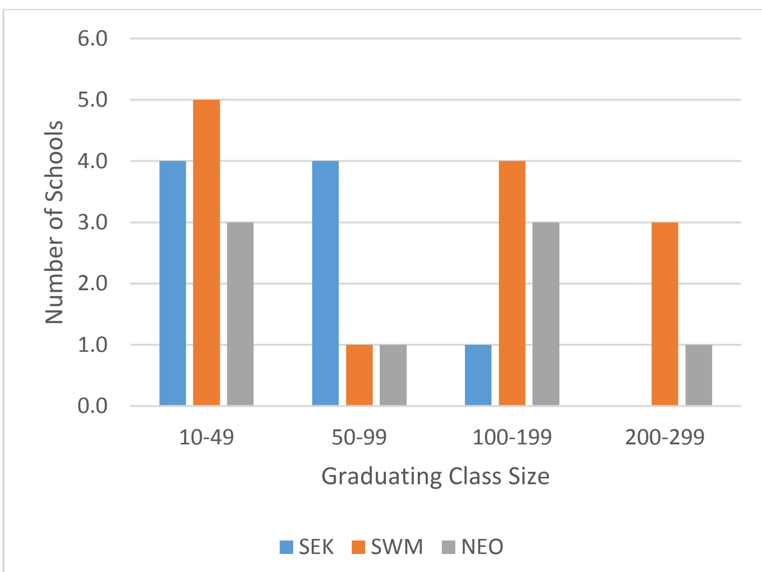

Figure 4. Graduating class sizes for schools that responded to the survey. SEK only had one school of over a graduating class size of 100 that responded, while SWM and NEO revealed the most diversity in graduating class size. Details of data may be found in Appendix C.

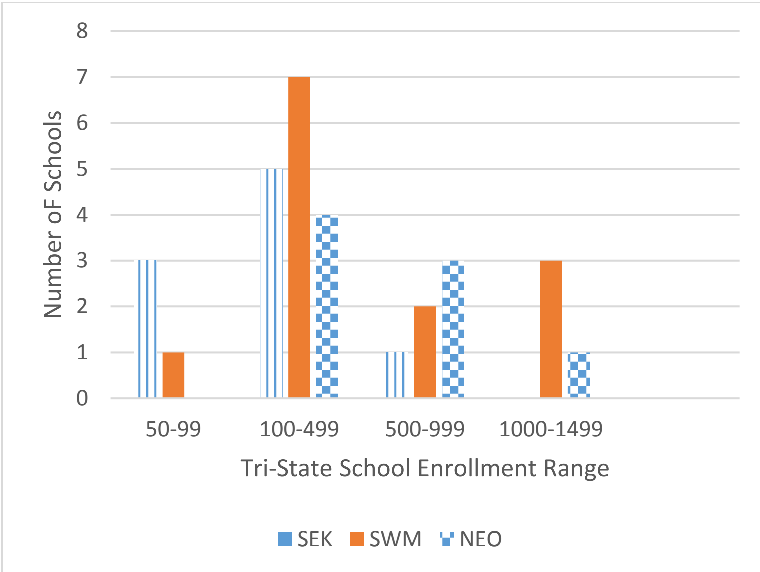

Figure 5. Enrollment sizes of the local cohort responding to survey. 4 schools represented the 50-99 range, 6 schools represented the 500-999 range, and 4 schools represented the 1000-1499 range. The schools with 100-499 students represented the greatest number of schools in this research with 16. This is greater than all other enrollment ranges combined. Details of data may be found in Appendix C.

SEK, SWM, and NEO Chemistry I Prerequisite Requirements

A comparison of Chemistry I prerequisite requirements was made among the local cohort of SEK, SWM and NEO. One of the goals of this study was to determine if significant differences in prerequisites existed in the tri-state area. As seen in Tables (2-4) dissimilarities do exist, and as noted in Figure 6, 50% of the schools in SWM and NEO required Algebra I or higher as a prerequisite to Chemistry I. Approximately three out of four SEK schools required this minimum math prerequisite. Diversity of prerequisites was also discovered as revealed in Figure 7 with maximum diversity (100%) occurring in the NEO population.

Table 2. Prerequisite requirements for Chemistry I classes for SEK schools. Please note that some schools required a minimum grade for entry into chemistry. All but three schools require at least Algebra I. Details of data may be found in Appendix C.

School	Prerequisite Requirements
A	C or Better in Algebra I
B	C or Better in Algebra I
C	Physical Science, Biology, and Algebra I
D	Freshman Physical Science and Passing Algebra 1
E	Biology
F	Algebra II
G	Junior or Senior having completed Principle of technology/physical science an biology
H	Earth Space
I	Algebra II or Concurrent

Table 3. Prerequisite requirements for Chemistry I classes for SWM schools. Please note that some schools required a minimum grade for entry into chemistry. Six schools did not require Algebra I. Details of data may be found in Appendix C.

School	Prerequisite Requirements
J	Physical Science and Biology
K	Physical Science, Biology, and Algebra I
L	Algebra I
M	Physical Science and Algebra I
N	2 Previous Science Classes
O	C or Better in Physical Science, Biology I , and Algebra I
P	Biology and Physics
Q	Environmental Science
R	Biology or Physical Science
S	C or Better in Algebra I and Physical Science
T	Algebra I with a “B” or Above and Biology
U	Physical Science, Biology, and Algebra I
V	Biology I and Biology II and Physical Science

Table 4. Prerequisite requirements for Chemistry I classes for NEO schools. Please note that one school required a minimum grade for entry into chemistry. Four schools did not require an Algebra prerequisite and one school did not require any prerequisites. Details of data may be found in Appendix C.

School	Prerequisite Requirements
W	Physical Science and Biology
X	Algebra I
Y	Physical Science, Biology I and Biology II
Z	Biology and Algebra I with a "C"
AA	None
BB	Biology and Algebra II
CC	Biology
DD	Algebra and Physical Science

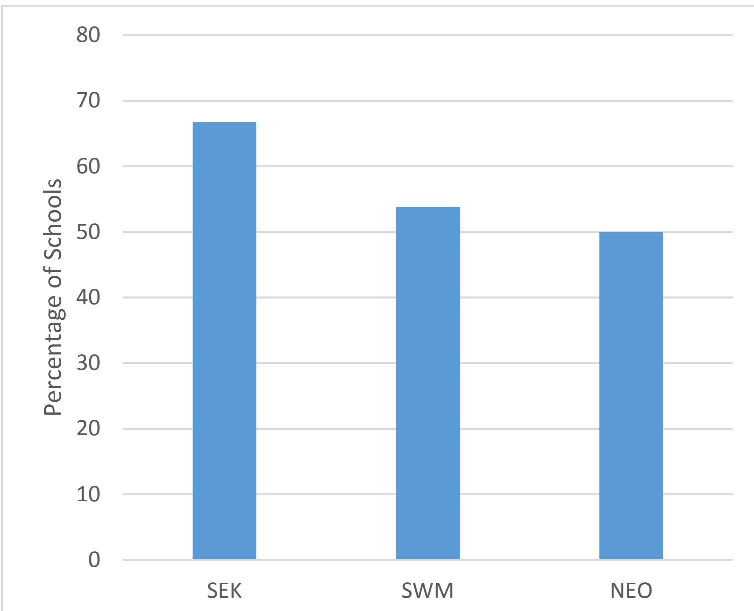

Figure 6. Percentage of schools in the local cohort that require at least Algebra I as a prerequisite requirement. Higher mathematics requirements were also included in the percentages. Details of data may be found in Appendix C.

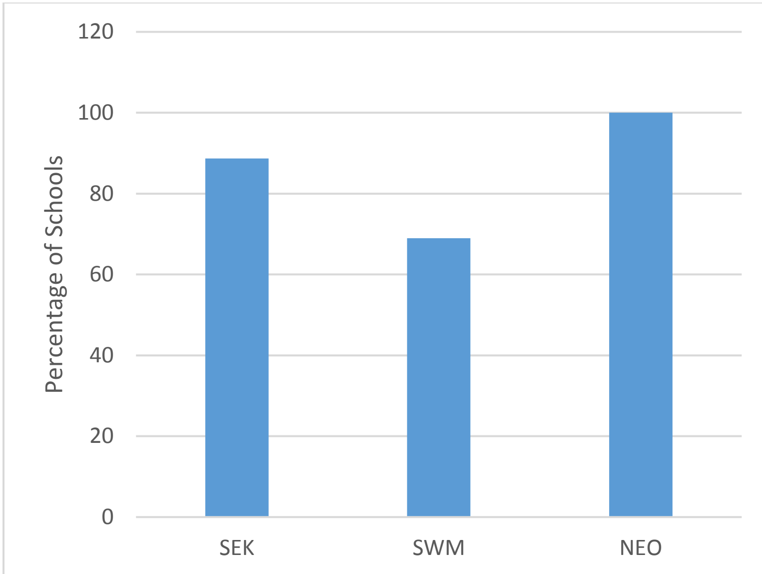

Figure 7. Percentage of schools in the local cohort that have different types of prerequisites. All of the NEO schools represented in the study have different prerequisite requirements. Details of data may be found in Appendix C.

Local Cohort Teacher Comparison

Another important aspect of this study was a comparison of the teacher qualifications which included whether or not a teacher is considered HQT, years of teaching experience, and chemistry degree attainment. As noted in Figure 8, over 80% of all teachers in this studied are considered HQT with NEO showing 100% of its teachers as HQT. The percentage of teachers with a bachelor's degree is much lower for the local cohort. Less than half of SWM instructors have attained a chemistry degree, while SEK and NEO are approximately at 60% and 75% attainment respectively. It should be noted that NEO had the fewest number of teachers in the study at 8, while SEK had 9, and SWM had 13 instructors. As seen in Figure 9, the median years of teaching experience is similar for all states settling in at an 8-10 year range.

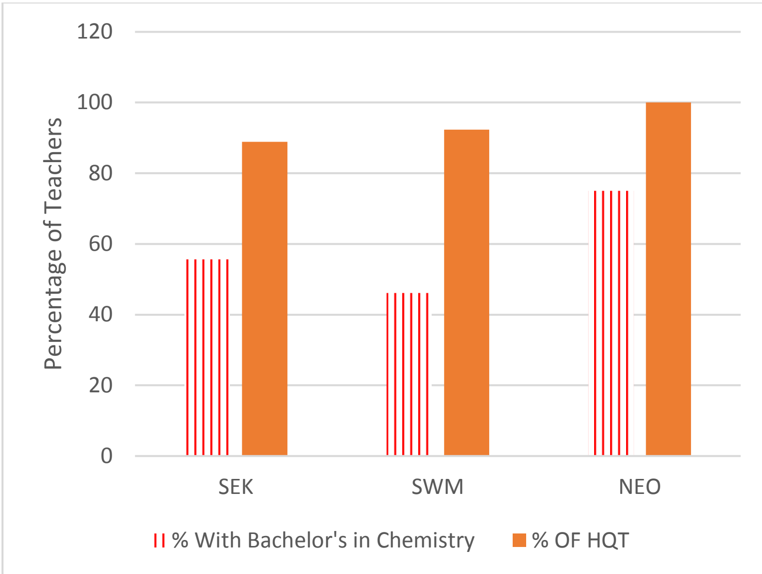

Figure 8. Teacher qualifications in the local cohort group. Bachelor's degree in chemistry for arts or science was not discerned. Highly qualified teachers (HQT) parameters are from the NCLB directive.[26] *Details of data may be found in* Appendix C.

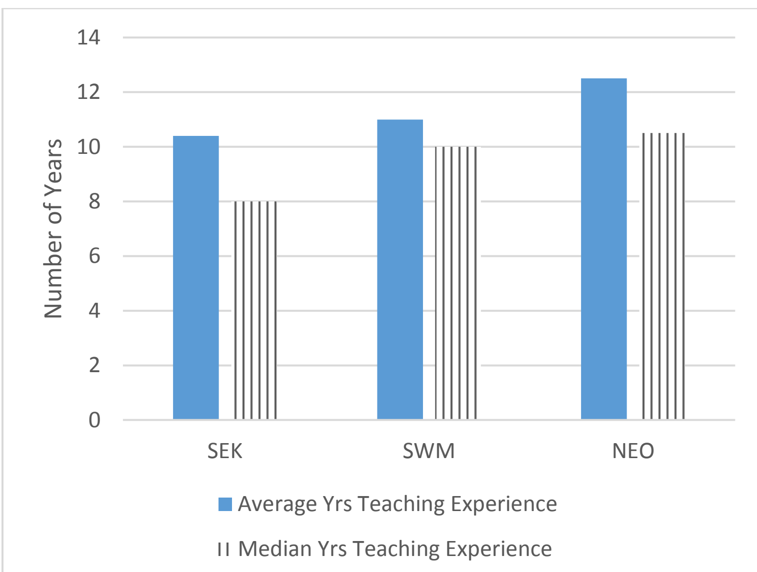

Figure 9. Average years of teaching experience among the local cohort including median years of teaching experience. NEO revealed the highest average and highest median number of years of teaching experience. Details of data may be found in Appendix C.

Local Cohort Rating System

A simple rating system for the local cohort was developed for this research that included teacher quality and prerequisites. As seen in Table 5, teacher quality was divided into chemistry degree attainment, whether or not the instructor was considered HQT, and chemistry teaching experience. Each teaching parameter was assigned one point. The other parameter factored into the rating system was Chemistry I prerequisites. Table 5 shows the prerequisites separated into Algebra I or higher math requirements, no math prerequisites, and no prerequisites. Negative point value assignments were made if there was a lack prerequisites. A maximum value of 4.5 points was available. Figure 10 reveals SEK with the overall average highest point value, while NEO has the highest average teacher rating.

Table 5. Different rating parameters for the local cohort and point values for each parameter used in this study. Point values that are assigned to each parameter are: 1, 0.5, -0.5, or -1. Details of data may be found in Appendix C.

Parameter #	**Rating Parameter**	**Rating Points Assigned**
1	Bachelor's Degree in Chemistry	1
2	Highly Qualified Teacher	1
3	Ten or More Years of Chemistry Teaching Experience	1
4	Prerequisites That Include Algebra I	1
4A	Prerequisites That Include Math Higher Than Algebra I	0.5
4B	No Math Prerequisites	-0.5
4C	No Prerequisites*	-1
	Maximum Number of Rating Points Possible	4.5
	*One School Did Not Require Prerequisites	

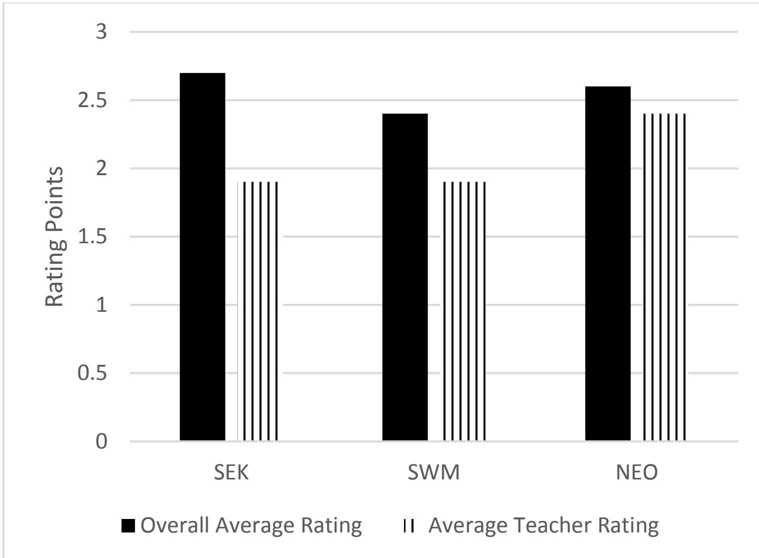

Figure 10. Overall average rating values and the teacher rating values for SEK, SWM, and NEO. Ratings are based upon parameter point values from Table 3. Overall average ratings are based on a combination of chemistry teacher qualifications and prerequisites for the Chemistry I course, while teacher rating values are dependent upon teacher having a bachelor's degree in chemistry, years of experience teaching chemistry, and the teacher being considered as highly qualified. Details of data may be found in Appendix C.

Local Cohort ACT Data

ACT data was gathered to compare science and math scores among the local cohort. It should be noted that SWM had the most schools responding to the study. When comparing within the local cohort, the percentages were very similar as seen in Figure 11 at around 60-70%. When viewing the state cohort, it is shown to be an even tighter percentage range of graduates taking the ACT at 75% also seen in Figure 11. As seen in Figure 12, science and math scores are shown as weighted values that accounted for the number of graduates in each state that took the ACT. To show college readiness in the local cohort, Figure 13 is used to compare these scores to the benchmark for science and math.

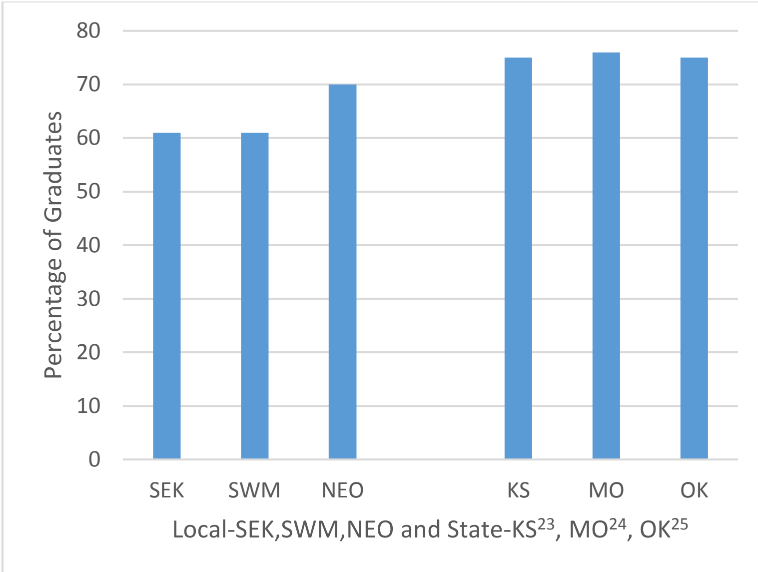

Figure 11. Percentage of graduates in both local and state cohorts that have taken the ACT exam. The percentage represented is for each local cohort and is several percentage points lower than the state group. All state groups show approximately the same percentage of graduates taking the exam. Details of data may be found in Appendix C.

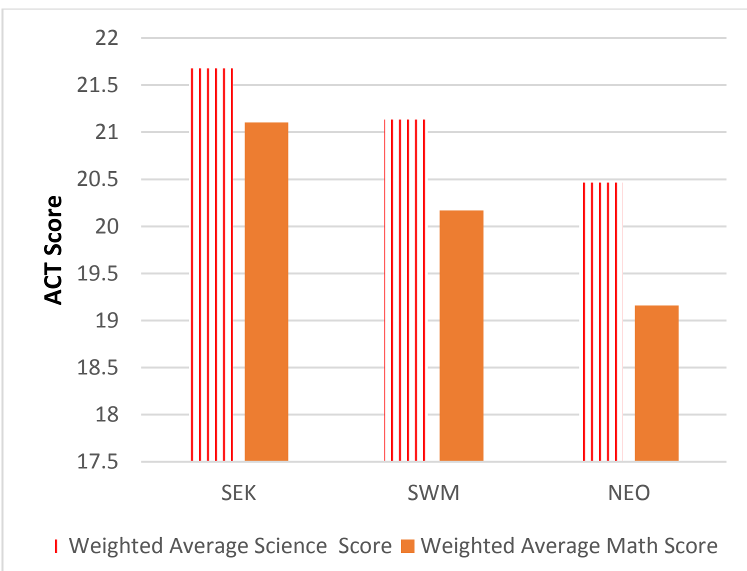

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Figure 12. Weighted average ACT science and math scores for the local cohort group. The weighted average accounts for the percentage of graduates in the study that took the ACT exam. Details of data may be found in Appendix C.

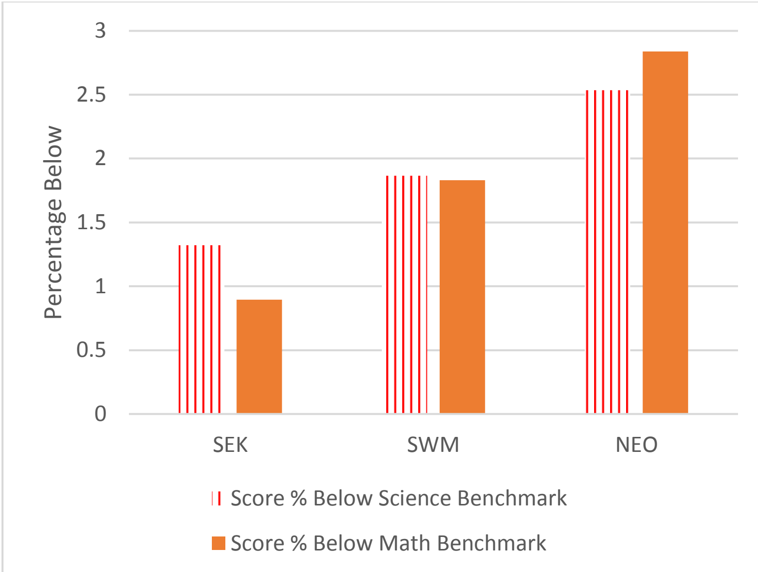

Figure 13. Weighted average percentages of the local cohort that are below the benchmark scores in science and math. The weighted average score accounts for the percentage of graduates in study that took the ACT exam.

State Cohort ACT Data

State cohort data included graduates' ACT science and math scores and the number and percentage of graduates taking rigorous science and math course pattern. ACT science and math scores were collected for each state and compared in Figure 14. In addition these scores were compared to benchmark values and shown in Figure 15. If a graduate had taken at least biology, chemistry, and physics then they were considered to have taken a rigorous science pattern, and if a graduate had taken at least Algebra I, Algebra II, Geometry, and Trigonometry then they were considered to have taken a rigorous math pattern. As seen in Figure (16-18), MO had the largest number of graduates taking a rigorous course pattern in science and math, while KS had the largest percentage of graduates in its state taking a rigorous science and math course pattern.

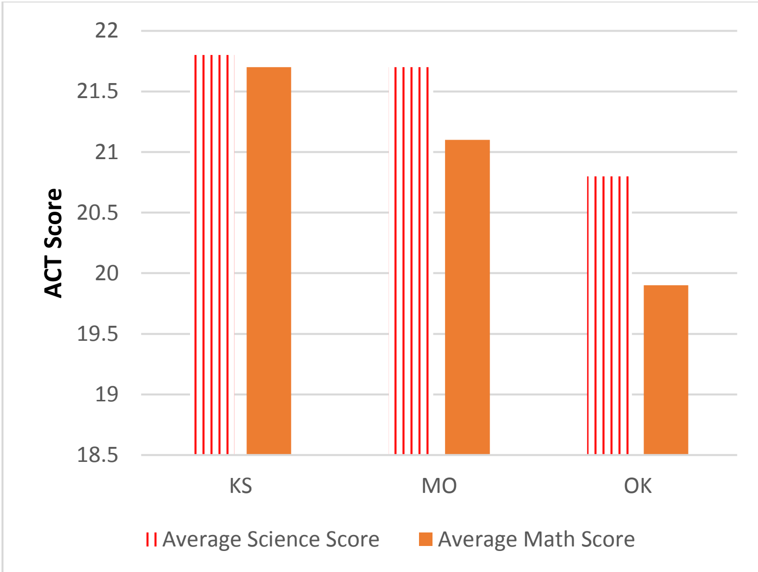

Figure 14.[23-25] *Average science and math ACT scores for the state cohort group. Details of data may be found in* Appendices D and E.

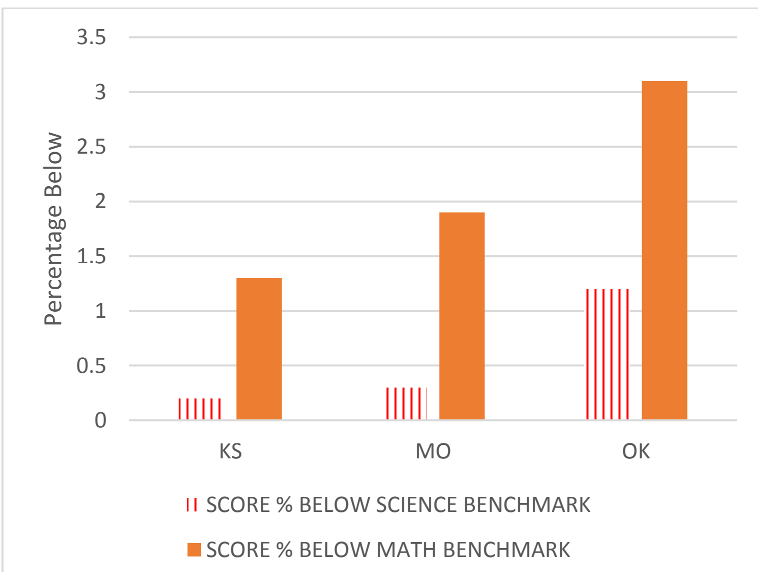

Figure 15.[23-25] *Average score percentage below the benchmark values for both science and math for the state cohort group. KS has the smallest percentage difference, while OK has the largest. Details of data may be found in* Appendices D and E.

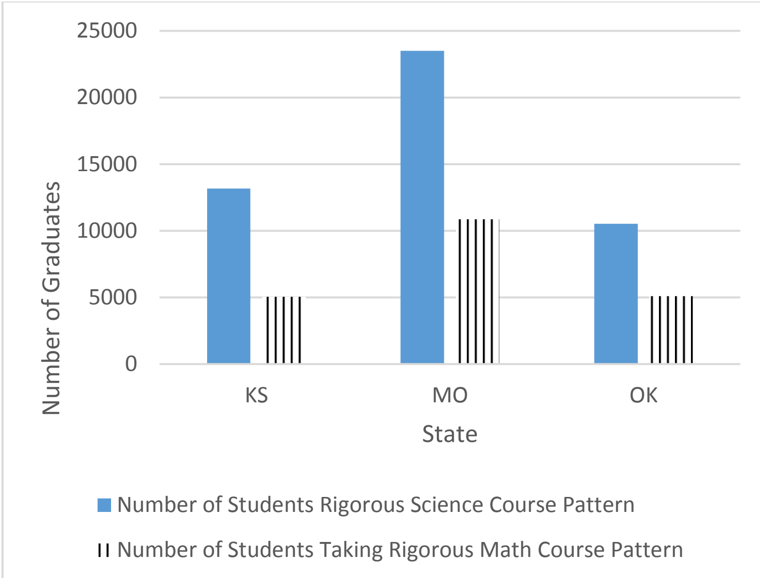

Figure 16. Number of students in the state cohort that are taking a rigorous science or math course pattern in high school. The rigorous science pattern must contain at least Biology I, Chemistry I and Physics. The rigorous math pattern must contain at least Algebra I, Algebra II, Geometry and Trigonometry. The order in which these courses were taken is not distinguished in this study. Details of data may be found in Appendices D and E.

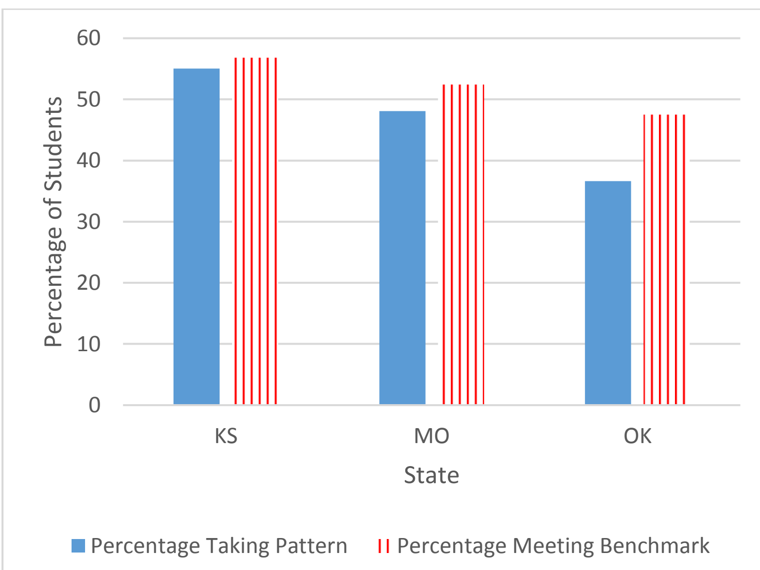

Figure 17. Percentage of students in the state cohort that are taking a rigorous science course pattern in high school and the percentage meeting the benchmark score of 23 for science. The rigorous science course pattern must contain at least biology, chemistry and physics. The order in which these courses were taken is not distinguished in this study. Details of data may be found in Appendix D.

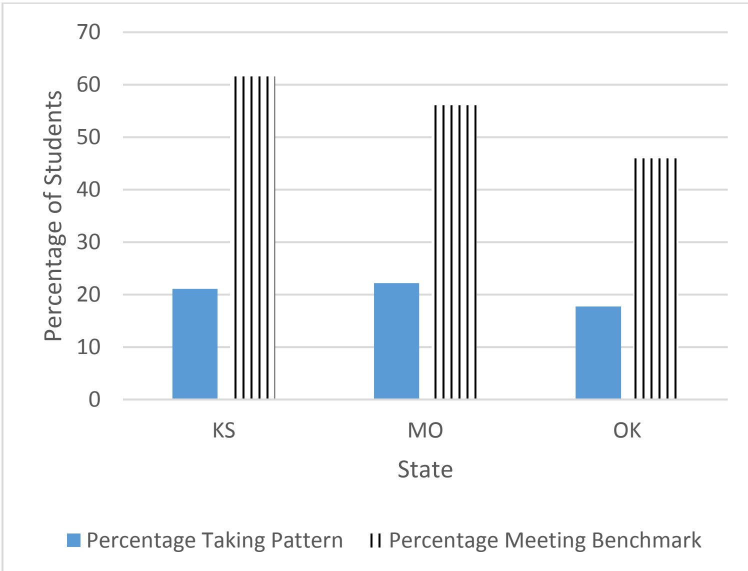

Figure 18. Percentage of students in the state cohort that are taking a rigorous course pattern of mathematics in high school. The rigorous pattern must contain at least Algebra I, Algebra II, Geometry, and Trigonometry. KS has the highest percentage of students meeting the benchmark, while OK has the lowest percentage. Details of data may be found in Appendix E.

KS, MO, and OK State Certification Data

Chemistry teacher certification data from KS, MO, and OK were gathered and shown in Table 6. Please note the variety of certification pathways available in each state and that occupational and/or chemistry related experience is not available for certification in any state. All states require prospective teachers to pass some kind of standardized test. Oklahoma has the least available paths available for certification in chemistry.

Table 6.[20-22] Certification pathways for the state cohort. Please note that all states have a traditional path for their state. All three have different testing requirements as well as a different number of years of training required if a person holding a degree in chemistry wanting to teach chemistry has not met the pedagogical course requirements.

Certification Pathway	**Kansas**	**Missouri**	**Oklahoma**
Traditional Preparation	Complete An Accredited Teacher Certification Program in the State of KS	Complete An Accredited Teacher Certification Program in the State of MO	Complete An Accredited Teacher Certification Program in the State of OK
Currently Licensed in Another State	Complete Praxis Chemistry Test With A Passing Score	Complete Missouri General Assessment (MoGEA) Consisting of 4 Parts: Pass The Following Competencies English-186, Writing-167, Math-183, Science-183, and Social Studies-183	Complete OSAT (Oklahoma Subject Area Test in Chemistry)
Holds Degree in Chemistry	Degree in Chemistry, 5 Years' Experience In Chemistry Related Field, and Assigned By The District Only To Teach Chemistry	Degree In Chemistry And Works Under Two Year Provisional Certificate While Completing 30 Educational Hours	Degree In Chemistry, 2 Years' Experience In Chemistry Related Field And Pass OGET And OSAT
Occupational Experience And Skill/Expertise In Field Of Chemistry	Not Available	Not Available	Not Available
Individual Distinction In The Field Of Chemistry Through Experience, Advanced Studies or Talent	Must Meet 2 Out Of 3 Of The Following: Experience, Advanced Studies, Or Exceptional Talent	Doctorate In Chemistry And Pass Professional Knowledge Test With Minimum Score of 220	Not Available
Visiting International Teacher's Program (VIT)	Visiting Scholar License	Doctorate In Chemistry And Pass Professional Knowledge Test With Minimum Score of 220	Not Available
American Board Of Certification For Teacher's Excellence (ABCTE)	Not Available	Complete The ABCTE Program And Pass The Following Competencies English-186, Writing-167, Math-183, Science-183, and Social Studies-183	Not Available

Area University Chemistry Hour and Teaching Hour Requirements

Four area universities, (2 from KS, 1 from MO, and 1 from OK), were selected and chemistry hour and teaching hour requirements were compared. As seen in Table 7 and Table 8, the course and course hours shown for chemistry content and teaching content are related to the traditional teaching path shown in Table 6. Figure 19 and Figure 20 compare these hour requirements for each state as well as chemistry content and teaching content percentages for each state.

Table 7. Chemistry content hours needed by area universities to complete the traditional path of high school chemistry teacher certification. Hours are very similar except that the Laboratory Practicum course hours are required by only by PSU. Total hours for KU are the lowest, while PSU has the highest number of required hours. Details of data may be found in Appendices G, H, and I.

Chemistry Courses	**PSU**	**KU**	**OU**	**MU**
Gen Chemistry I With Lab	**5**	**5**	**5**	**4**
Gen Chemistry II With Lab	5	5	5	4
Organic Chemistry I With Lab	5	5	4	5
Organic Chemistry II With Lab	5		4	5
Fundamentals of Inorganic Chemistry				3
Advanced Inorganic Chemistry			3	
Quantitative Methods	5	5	5	4
Instrumental Analysis			3	
Fundamentals of Physical Chemistry With Lab				3
Undergraduate Investigations		1		3
Laboratory Assistant Practicum I	3			
Laboratory Assistant Practicum II	3			
Laboratory Assistant Practicum III	3			
Chemistry Colloquium	1			
Senior Review and Assessment	1			
Intro To Biochemistry With Lab			3	
Biological Physical Chemistry With Lab		5		
Total Chemistry Hours	**36**	**26**	**32**	**31**

Table 8. Teaching chemistry hours needed by area universities to complete the traditional path of high school chemistry teacher certification. Total teaching hours is greatest for KU, while OU requires the least number of hours. All universities include student teaching hours. Details of data may be found in Appendices G, H, and I.

Courses In Teaching Chemistry	**PSU**	**KU**	**OU**	**MU**
Chemistry Teaching Practicum				3
Inquiry Into Learning				3
Inquiry Into Learning I Field Experience (F.E.)				1
Inquiry Into Schools, Community, and Society I				3
Inquiry Into Schools, Community, and Society I (F.E.)				1
School Health And School Wellbeing				3
Foundations/Explorations In Education	3	3		
Governance And Organization Of Schools		3		
Foundations Of Curriculum And Instruction	3	3		
Multicultural Education		3	3	
Reading And Writing Across The Curriculum	3	3		
Educational Measurement	3	3	3	
Advanced Educational Psychology		3		
Constructive Classroom Discipline		3	3	
Introduction To Computing In Education		3	3	3
Psychology Of Exceptional Children And Youth	3	3	4	3
Curriculum And Instruction Methods	3	3		
Advanced Practices In Teaching Methods		3	3	
Advanced Teaching Practicum		1		
Student Teaching Practicum	8	6	9	14
Seminar		3		
Techniques Of Teaching Chemistry	3			
Developmental Psychology	3			
Educational Psychology	3			
Secondary And Middle Level Education	2			
Supervised Student Teaching Follow-Up	2			
Teaching Science In Secondary Schools			3	
Total Course Hours In Teaching Chemistry	**39**	**46**	**31**	**34**

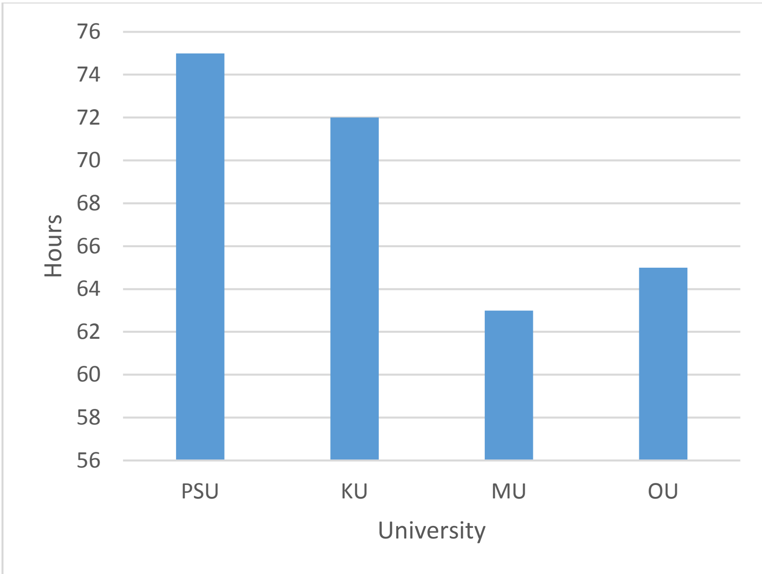

Figure 19. *Total number of credit hours required by each university for chemistry certification in each state. PSU requires the highest number of hours, while MU requires the lowest total.*

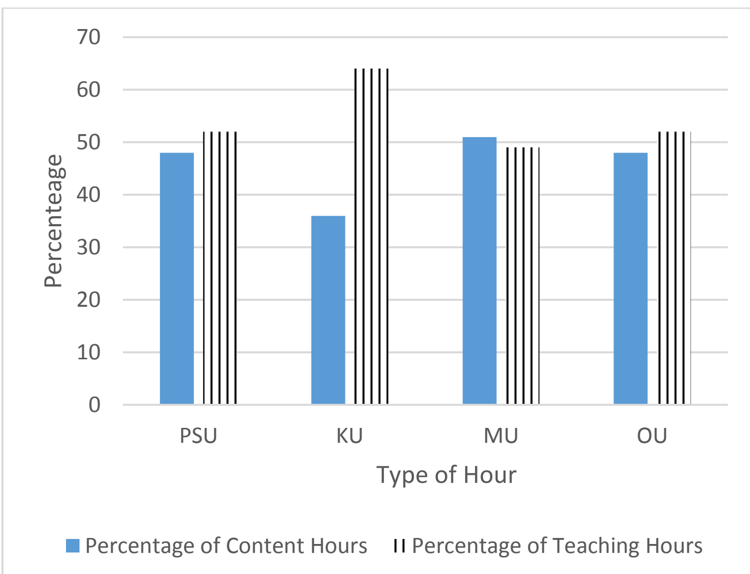

Figure 20. *Percentage of content hours and teaching hours by each university for certification to teach chemistry in high school. Percentages are similar, but KU requires just over 10% more teaching hours than the closest university.*

CHAPTER IV

DISCUSSION

Local Cohort General Information

A somewhat unanticipated discovery made in the survey responses for counties represented in the study was SWM's high return rate. At least one school from each county in SWM returned a survey, which gave this study a geographically widespread population to draw from in SWM. SEK and NEO revealed similar return rates of around 60%, but the SEK population had a net six more counties to draw from than NEO and five more than SWM. SWM also had the highest percentage of school responses when compared to SEK and NEO by about 10%. This report speculates that since this study originated at a Missouri junior college that Kansas and Oklahoma might be less likely to return the questionnaires. As far as graduating class size and school enrollment, SEK lacked the most diversity in both of these categories. Only one of the SEK schools represented in the local cohort contained more than 100 students in the graduating class. At least a 50% return of the surveys from schools in each state would have been desirable from all counties available. The first problem this research recognizes in drawing statistically significant conclusions is lack of an adequate sampling in the local cohort.

Local Cohort Chemistry I Prerequisites

Starting with Kansas, 66.7% of the SEK schools required Algebra I or greater, and even though 88.7% of those same schools revealed different prerequisites, only 3 out of 9 schools did not have Algebra I or higher included in those differences. This is an important finding, because having an Algebra I or higher prerequisite was important to the success in a Chemistry I course no matter what other prerequisites were included with the math requirements. 53.8 % of the SWM schools required an Algebra I or greater prerequisite, and they too had a fairly high 69% with different prerequisites. However, this diversity included 5 out of 13 schools that did not require the minimum math condition. Finally this study looked at NEO Chemistry I prerequisites. NEO exposed the largest diversity among prerequisites. All of the schools that responded to the survey required different prerequisites to get into Chemistry I. One school had no requirements at all. Out of these different prerequisites, only half required Algebra I.

An overall comparison of the responding schools reveals SEK with the highest math rigor, followed by SWM and NEO respectively. As recognized earlier with the lack of SEK diversity in school size, this research is cautious in drawing any in depth conclusions. Even though strong statistical evidence is not available due to the small local cohort, a case can be made for lack of rigor in some schools in the study that would affect student performance in both high school and college chemistry. It is ventured that if such a small sample contains such diversity and lack of rigor then an analysis of a larger sample would reveal a higher probability of the same diversity and rigor problems. Since this research show the positive impact of course rigor on success in chemistry, it is disturbing to find around half of the schools lacking in Algebra I preparation for General Chemistry I in high school.

Teacher Quality for the Local Cohort

NEO had a higher percentage of instructors with a bachelor's degree in chemistry and instructors considered highly qualified as well as a higher average years of chemistry teaching experience and median years of teaching experience. The overall teacher rating assigned to NEO was 2.4, and both SEK's and SWM's ratings were 1.9. It should be noted that NEO had the lowest sample of schools returning the survey, and this study does not merit any significance in this higher rating.

Rating System for the Local Cohort

A simple rating system was used to quantify prerequisites and teacher quality. It cannot be concluded that it is a perfectly correlated system, but it does apply data that are predictors of student success in first year college chemistry. Although SEK's teacher quality rating was about one-half of a point less than NEO, its overall rating was slightly higher, and this is possibly attributed to more rigorous math requirements in its prerequisites for Chemistry I.

Average ACT Science and Math Scores and College Readiness for the Local Cohort

In the schools responding to the survey, approximately 60% of the graduates in SEK and SWM took the ACT exam, while about 70% of students in NEO completed the exam. Taking into account the number of graduates completing the ACT, SEK's weighted average science and math scores were the smallest percentages below the benchmark of the local cohort, and SEK's weighted average science and math scores were among the highest in the group. NEO's weighted scores were the highest percentages below the benchmark value and also showed the lowest average ACT values for math and science. This research is aware that these values represent average math and science scores for each school and a median and standard deviation could not be obtained, because individual scores were unavailable. So what this research concluded is that the SEK's schools' average science and math "scores" available exhibit a greater college readiness than SWM or NEO schools. In addition, the research shows that there is positive correlation between student success in math competency and chemistry success, and as SEK reveals it possesses the lowest differences from the math standard and the lowest differences for the science standard.

Comparison of College Readiness and Course Pattern in KS, MO, and OK

KS had both the largest percentage of students taking a rigorous science course pattern, and the largest percentage of graduates meeting the benchmark. In addition KS was just under MO in the percentage of graduates taking a rigorous math course pattern, but revealed a much higher percentage of graduates meeting the benchmark score. As shown earlier, the patterns of scores in math and science in the local cohort are following the state cohort trends. Again this trend solidifies the position of this research that course rigor is a factor in college readiness for general chemistry. The prerequisite part of this research gives a glimpse into the rigor of schools in the local cohort.

Chemistry Teacher Certifications for KS, MO, and OK

OK has the fewest ways to obtain certification to teach chemistry. In OK, a prospective teacher can complete an accredited teacher certification program, complete an OSAT chemistry exam (if licensed in another state), or hold a degree in chemistry and have two years in a chemistry related field and passing the OSAT chemistry exam and OGET exam. In comparing OK to KS and MO, this study finds this common ground in all of these avenues to certification. MO holds the distinction of the only state to allow for the completion of the ABCTE program to fulfill licensure requirements. An interesting part of the tristate area chemistry certification is the different tests that each state requires of prospective teachers. The different tests can be used as support for teachers knowing the chemistry course they are teaching, but the fact remains that the tests are different. As noted earlier, NEO had high teacher ratings, but low ACT scores in math and science. A factor contributing to these scores could possibly be a lower testing standard than SEK or SWM.

Sample tests for each state were unavailable for comparison, so this research simply puts forth speculation. The different tests consisting of Praxis, MoGEA, and OSAT reveal a lack of standardization (possibly different rigor). Looking more closely at the “accredited program requirements” this study turned to area universities for guidance. PSU and KU in KS, MU in MO, and OU in OK were analyzed to look at chemistry certification courses and hour requirements. Appendices (F-I) provide detailed information for an entire four year degree, but this research was only concerned with teaching hours and chemistry content hours. The total chemistry content hours varied from 26 hours to 36 hours, and a major finding was the lack of any laboratory practicum for 3 out of 4 the schools. This research posits that these schools might believe that the student gets enough laboratory experience through the chemistry courses taken, but this study speculates that a laboratory practicum would include pedagogical methods in the application of experimental work in the classroom. PSU provides 9 hours of much needed laboratory practicum for the student, and it is surprising that larger schools do not explicitly show courses that provide this experience. It is reasoned that a more qualified instructor to teach chemistry in high school would have had some laboratory practicum hours in addition to the many laboratory hours provided within the chemistry courses taken. Research also reveals that solid chemistry programs in high school should be well supported by a meaningful student laboratory experience.[6] With respect to pedagogical hours, KS appeared to be the most diversified in its requirements with an average of 14 courses necessary for certification at PSU and KS, while MU and OU required 9 and 8 courses respectively. The total number of teaching hours put KS on top with an average of 43 hours needed, while MO and OK required 34 and 31 hours respectively. MO required a 14 hour student teaching practicum to OK’s 9 and KS’s 7 average. In addition, one of the KS schools included two hours of a supervised teaching follow-up.

CHAPTER V:

CONCLUSION/RECOMMENDATIONS

Conclusion

This research made comparisons of high school Chemistry I prerequisites, and teacher preparation and high school student college readiness for university General Chemistry I for a local cohort in SEK, SWM, and NEO. In addition, an analysis was made of chemistry teacher state certification requirements from KS, MO, and OK, traditional paths of study as set forth by four area universities for a prospective high school chemistry instructor, and finally the college readiness of high school graduates in KS, MO, and OK. For SEK, SWM, and NEO the sample population that was analyzed was not of sufficient magnitude and quality to conclude solid relationships, however several interesting comparisons were discovered.

Based on data gathered, high school Chemistry I prerequisites were quite diverse among the schools in SEK, SWM, and NEO. All of the schools compared revealed different prerequisites for over half of their schools and NEO showed that 100% of their schools had different prerequisites for Chemistry I. The most disturbing point exposed about prerequisites was the lack of Algebra I or greater as a prerequisite to this course. Having solid mathematics preparation for students entering high school Chemistry I is well supported by research and should be a directive by all schools to meet this obligation.[27]

Teacher preparation was the next facet of this study, and for the local cohort, there were very similar teacher demographics. A recommendation of this research, to better quantify teacher impact on student success, would be to provide all local cohort teachers with a set of standardized chemistry objectives and a standardized chemistry assessment to administer in their classrooms and followed up by a study of first semester General Chemistry I students' performance.[28] This, of course, would be difficult to enact, but it would give a future study a greater ability to draw conclusions about the direct effect teacher preparation has on student success in General Chemistry I in college. Lack of state testing rigor might also be a negative aspect in how well a teacher is prepared to teach chemistry. Individualism still remains in the classroom, but at least standards are presented so real comparisons in student success can be made.

The final look at the local cohort was for high school graduate college readiness based on ACT science and math scores. Since individual scores could not be determined, an average score for each school was used to determine college readiness of high school graduates from the local cohort. This study can conclude that out of the schools returning surveys the local cohort can be ranked from average scores as SEK, SWM, and NEO as the order in which each is college ready university chemistry and introductory math courses including Algebra I.

Finally, this research looked at the state cohort of KS, MO, and OK which included chemistry teaching degree preparation and the rigor of science and mathematics courses patterns. The most significant finding was the lack of a laboratory practicum for prospective high school chemistry instructor preparation. Only one out of the four universities analyzed required a laboratory practicum, and student laboratory experiences should be a significant part of the high school chemistry curriculum.[12, 29] This study recognizes that only four universities were analyzed, but three of these schools were among the largest in their respective states, and one was at the geographic center of the research. "Beefing" up the laboratory practicum requirements might return dividends in the form of better prepared instructors and in turn better college chemistry prepared students.

Lastly, based on ACT science and math scores, the highest percentage of KS graduates are college ready followed by MO and then OK. There is a strong probability that these scores could be related to the course patterns taken by graduates in each state. More rigorous course pattern equate to higher attained scores in math and science.

Recommendations

On information gathered, this study recommends strengthening high school Chemistry I prerequisites to include at least Algebra I, ensuring superior quality high school instructors that are properly trained in chemistry and teaching pedagogy, including at least one laboratory practicum course in the chemistry instructor's college preparatory work, and increasing the number of rigorous high school courses in science to include at least Biology, Chemistry, and Physics and in mathematics to include Algebra I, Algebra II, Geometry, and Trigonometry. These factors by no means make up the complete algorithm to increase the number of students successful in General Chemistry I in college, but all of these factors should be included in this process.

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[26] *"New No Child Left Behind Flexibility: Highly Qualified Teachers." Retrieved August, 2016, from website: https://www2.ed.gov/nclb/methods/teachers/hqtflexibility.pdf.*

[27]*Chandran, S., "The role of cognitive factors in chemistry achievement," Journal of Research in Science Teaching, 1987, 24(2): 145.*

[28]*Wagner, E.P., Sasser, H., and DiBiase, W.J., "Predicting Students at Risk in General Chemistry Using Pre-semester Assessments and Demographic Information," Journal of Chemical Education, 2002, 79(6): 749.*

[29]*Okebukola, P.A., "Students' Performance in Practical Chemistry: A Study of Some Related Factors. Journal of Research in Science Teaching, 1987, 24(2): 119.*

[30]*Ozsogomonyan, A., and Loftus, D., "Predictors of General Chemistry Grades," Journal of Chemical Education, 1979, 56: 173.*

APPENDIX

The *rate* of a chemical reaction can be measured as the change in the concentration of its products over a period of time. The following experiments were performed to investigate factors that influence the rate at which potassium permanganate ($KMnO_4$) reacts with oxalic acid ($H_2C_2O_4$) to form Mn^{2+} and other products.

Experiment 1

A 4.0 mL sample of 0.1 M (moles/liter) aqueous $KMnO_4$, which was purple in color, was measured with a clean graduated cylinder and poured into a test tube. A 4.0 mL sample of 1.0 M aqueous $H_2C_2O_4$ was then measured with a clean graduated cylinder and poured into a second test tube. The 2 test tubes were placed in a 25°C water bath. After 5 minutes the $H_2C_2O_4$ solution was mixed with the $KMnO_4$ solution and placed back in the water bath. The time until the purple color disappeared was recorded. This procedure was repeated at 3 other temperatures. The results are shown in Table 1.

Table 1

Trial	Temperature (°C)	Reaction time (sec)
1	25	210
2	35	105
3	45	48
4	55	25

Experiment 2

The procedure from Experiment 1 was repeated in every way except that 0.1 mg of manganous sulfate ($MnSO_4$), a *catalyst*, was added to each test tube containing $KMnO_4$ before the $H_2C_2O_4$ was added. Catalysts are substances that increase the rate of reactions without being used up. The results are shown in Table 2.

Table 2

Trial	Temperature (°C)	Reaction time (sec)
5	25	66
6	35	43
7	45	20
8	55	12

Experiment 3

The procedure from Experiment 1 was repeated at a constant temperature of 25°C and various concentrations of $H_2C_2O_4$. The results are shown in Table 3.

Table 3

Trial	Concentration of $H_2C_2O_4$ (M)	Reaction time (sec)
9	0.125	837
10	0.250	625
11	0.500	415

Predict how modifying the design or methods of an experiment will affect results

A student repeating Trial 9 unknowingly used a graduated cylinder that already contained 1.0 mL of H_2O to measure the $H_2C_2O_4$ solution. Based on the results of Experiment 3, the reaction time that she measured was most likely:

A. less than 415 sec.
B. greater than 415 sec and less than or equal to 625 sec.
C. greater than 625 sec and less than or equal to 837 sec.
***D.** greater than 837 sec.

APPENDIX A: ACT Sample Chemistry Context Exam Questions[17]

Determine how the value of one variable changes as the value of another variable changes in a simple data presentation	In Experiment 1, as the reaction temperature increased, the time until the purple color disappeared: **A.** remained the same. ***B.** decreased only. **C.** increased only. **D.** increased, then decreased.
Analyze given information when presented with new, complex information	According to the *collision theory* of reaction rates, 2 molecules or ions must collide in order to react with one another. Based on this information and the results of Experiment 1, the frequency of collisions was most likely the lowest at a temperature of: ***A.** 25°C. **B.** 35°C. **C.** 45°C. **D.** 55°C.
Identify similarities and differences between experiments	How is the experimental design of Experiment 1 different from that of Experiment 2 ? In Experiment 1: ***A.** $MnSO_4$ was not added to the reaction; in Experiment 2 $MnSO_4$ was added. **B.** the concentration of $KMnO_4$ was less than that used in Experiment 2. **C.** reaction temperatures were varied; in Experiment 2 they remained constant. **D.** the concentration of $H_2C_2O_4$ was varied; in Experiment 2 it remained constant.

APPENDIX A: ACT Sample Chemistry Context Exam Questions[17]

Understand a complex experimental design	Each of the following factors was investigated in the experiments EXCEPT: **A.** adding a catalyst to the reaction mixture. ***B.** changing the reaction solvent. **C.** varying the reaction temperature. **D.** changing the concentration of a reactant.
Determine the experimental conditions that would produce specified results	If the procedure described in Experiment 2 was repeated and a reaction time of 6 sec was measured, the temperature of the reaction was most likely: **A.** less than 25°C. **B.** greater than 25°C and less than 40°C. **C.** greater than 40°C and less than 55°C. ***D.** greater than 55°C.

The *molar heat of vaporization* (ΔH_{vap}) is defined as the energy in kilojoules (kJ) required to vaporize 1 mole of a liquid at its boiling point at constant pressure. The energy required to melt 1 mole of a solid at its melting point is called the *molar heat of fusion* (ΔH_{fus}). The *molar heat of sublimation* is the sum of the molar heats of fusion and vaporization.

The following table lists molar heats of vaporization and molar heats of fusion, as well as the boiling points and melting points for selected substances.

Substance	Melting point* (°C)	ΔH_{fus} (kJ/mol)	Boiling point* (°C)	ΔH_{vap} (kJ/mol)
Argon	–190.0	1.3	–164.0	6.3
Methane	–182.0	0.8	–159.0	9.2
Ethyl ether	–116.2	6.9	34.6	26.0
Ethanol	–117.3	7.6	78.3	39.3
Benzene	5.5	10.9	80.1	31.0
Water	0.0	6.1	100.0	40.8
Mercury	–39.0	23.4	357.0	59.0

*Measured at a pressure of 1 atmosphere (atm)

Select data from a complex data presentation (e.g., a table or graph with more than three variables; a phase diagram)

The amount of energy required to melt 1 mole of benzene at 5.5°C and a constant pressure of 1 atm is:

A. 6.1 kJ.
***B.** 10.9 kJ.
C. 31.0 kJ.
D. 80.1 kJ.

Interpolate between data points in a table or graph

The boiling point of pentane is 36.1°C. If pentane follows the general pattern of the other substances in the table, its molar heat of vaporization will be:

A. below 6 kJ/mol.
B. between 6 kJ/mol and 9 kJ/mol.
C. between 9 kJ/mol and 26 kJ/mol.
***D.** between 26 kJ/mol and 40 kJ/mol.

APPENDIX B: Survey Questionnaire

Dear Southeast Kansas High School Principal,

Hello, my name is Greg Howard, and I have been teaching chemistry courses at Crowder College on the Neosho, MO campus for the past six years. For the preceding 20 years I taught high school chemistry in Galena, KS and Seneca, MO. I do hope you are having a great, (but I know hectic), year. As if you already did not have enough to do, I am asking that if you are able to, over the next few days, fill out a very short survey to aid in a study that I am doing regarding tristate area schools in Southeast KS, Southwest MO, and Northeast OK. The questions are basically yes or no, fill in a number, or list prerequisites. NO ESSAYS, PARAGRAPHS, BUBBLE FILLING, OR SPENDING WEEKS GATHERING INFORMATION. The name of your school will not be mentioned in the study other than the state your school is located in. There are 35 KANSAS SCHOOLS, 37 MISSOURI SCHOOLS, and 31 OKLAHOMA SCHOOLS from area counties represented in the study.

Following are the survey questions. INSTRUCTIONS: You can simply copy the "blue/red" survey below, hit your reply button and paste the survey into the reply, and type your responses entering "X", entering a number or filling in a prerequisite.

Tristate Area Chemistry Survey

Question #1: Does your Chemistry I instructor hold a bachelor's degree in chemistry?

YES_____ NO_____

Question #2: Is your Chemistry I instructor considered a "highly qualified instructor"?

YES_____ NO_____

Question #3: What are the prerequisites for your Chemistry I course?

PREREQUISITES:

Question #4: How long has your present instructor been teaching Chemistry I including years at previous schools?

OF YEARS________

Question #5: What are your ACT subject area scores in math and science for the 2014 school year?

2014 MATH SCORE_____ 2014 SCIENCE SCORE_____ # OF GRADUATES TAKING ACT_____

That is it!!! Thank you for your time. It is MUCH appreciated!!! I will send you the results of the survey at the end of the semester to do with what you wish.

If there ever is any assistance I can be to you or your students, please fill free to contact me anytime. If you have any questions please send me an email, and I will give you a very prompt reply. Thank you for letting me know if you will not be participating in the survey.

Sincerely,

Greg Howard, greghoward@crowder.edu, 417-499-2249 cell, 414-455-5796 office

APPENDIX B: Survey Questionnaire

Dear High School Principal,

Hello, my name is Greg Howard, and I have been teaching chemistry courses at Crowder College on the Neosho, MO campus for the past six years. For the preceding 20 years I taught high school chemistry in Galena, KS and Seneca, MO. I do hope you are having a great, (but I know hectic), year. As if you did not already have enough to do, I am asking that if you are able to, over the next few days, fill out a very short survey to aid in a study that I am doing focused on tristate area schools in southeast KS, southwest MO, and northeast OK. The questions are basically yes or no, fill in a number, or list prerequisites. NO ESSAYS, PARAGRAPHS, BUBBLE FILLING, OR SPENDING WEEKS GATHERING INFORMATION. The name of your school will not be mentioned in the study other than the state your school is located in. There are 35 KANSAS SCHOOLS, 37 MISSOURI SCHOOLS, and 31 OKLAHOMA SCHOOLS from area counties represented in the study.

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Tristate Area Chemistry Survey

Question #1: Does your Chemistry I instructor hold a bachelor's degree in chemistry?

YES_____ NO_____

Question #2: Is your Chemistry I instructor considered a "highly qualified instructor"?

YES_____ NO_____

Question #3: What are the prerequisites for your Chemistry I course?

PREREQUISITES:

Question #4: How long has your present instructor been teaching Chemistry I including years at previous schools?

OF YEARS________

That is it!!! Thank you for your time. It is MUCH appreciated!!! I will send you the results of the survey to do with what you wish at the end of the semester.

If there is anything I can do to ever help you or your students, please fill free to contact me anytime. If you have any questions please send me an email, and I will give you a very prompt reply. Thank you for letting me know if your school will not be participating in the survey.

Sincerely,

Greg Howard, greghoward@crowder.edu, 417-499-2249 cell, 414-455-5796 office

APPENDIX C: Survey Questionnaire Results

KS	ENROLL	BS CHEM	HQT	YRS EXP.	ACT SCI-21.8/20.8	ACT MATH-21.7/20.9	TOTAL GRADS	# GRADS-ACT	% OF SEK TAKING ACT	PREREQ	RATING	WT RATE
A	269	NO	YES	2.0	22.5	21.1	61	41	14.9	C OR BETTER IN ALGEBRA I	2.0	0.3
B	72	YES	YES	13.0	20.7	20.2	18	12	4.4	C OR BETTER IN ALGEBRA I	4.0	0.2
C	541	YES	YES	18.0	21.7	21.9	108	63	22.9	PHYSICAL SCIENCE, BIOLOGY, ALGEBRA I	4.0	0.9
D	257	YES	YES	19.0	22.1	21.3	57	30	10.9	Freshman Physical Science and passing Algebra 1	4.0	0.4
E	344	YES	YES	5.0	21.9	22.3	80	35	12.7	BIOLOGY	2.5	0.3
F	87	NO	YES	22.0	20.6	18.8	18	17	6.2	ALGEBRA II	3.5	0.2
G	48	NO	NO	8.0	22.2	19.5	10	5	1.8	Junior or Senior having completed Principle of technology/physical science an biology	1.0	0.0
H	186	YES	YES	2.0	20.9	19.9	37	25	9.1	EARTH-SPACE	2.0	0.2
I	234	NO	YES	5.0	21.5	20.9	62	47	17.1	ALGEBRA II OR CONCURRENT	2.5	0.4
Total	2038	5.0	0.9	4.0	21.6	20.7	451	275	100.0	5		
Mean	226			9.8							2.8	3.0
Median	234			8.0	21.7	20.9	57	30	10.9			
S.D.	155			7.7	0.7	1.1	32.4	18.2	6.6			
MO	ENROLL	BS CHEM	HQ	YRS EXP.	ACT SCI-21.7	ACT MATH-21.1	TOTAL GRADS	# GRADS-ACT	% OF SWM TAKING ACT	PREREQ	RATING	WT RATE
J	570	YES	YES	10.0	20.2	19.3	107	70	7.7	PHYSICAL SCIENCE AND BIOLOGY	3.5	0.3
K	650	YES	Y	7.0	21.5	19.8	128	82	9.1	Physical Science, Biology, and Algebra I	3.0	0.3
L	121	YES	YES	15.0	20.2	19.2	36	21	2.3	ALGEBRA I	4.0	0.1
M	1238	YES	YES	15.0	21.2	20.2	285	176	19.4	Physical Science and Algebra I	4.0	0.8
N	150	NO	YES	4.0	20.3	19.8	39	32	3.5	2 PREVIOUS SCIENCE CLASSES	1.0	0.0
O	227	NO	YES	23.0	20.6	19.9	47	37	4.1	C or better in Physical Science, Biology I , and Algebra I	3.0	0.1
P	1125	YES	NO	3.0	20.3	20.2	214	114	12.6	Bio and Physics 1st	2.0	0.3
Q	1326	NO	Y	5.0	21.9	20.8	268	145	16.0	ENVIRONMENTAL SCIENCE	2.0	0.3
R	460	NO	YES	28.0	21.7	20.2	102	66	7.3	BIOLOGY OR PHYSICAL SCIENCE	2.0	0.1
S	404	NO	YES	10.0	21.4	20.2	100	71	7.8	C or better ALGEBRA I AND PHYSICAL SCIENCE	3.0	0.2
T	151	NO	YES	19.0	21.4	20.7	38	33	3.6	Algebra I with a "B" or above and Biology	3.0	0.1
U	374	YES	YES	1.0	22.3	21.0	81	41	4.5	ALGEBRA I, PHYSICAL SCI AND BIOLOGY	3.0	0.1
V	54	NO	YES	3.0	18.8	18.8	21	17	1.9	BIO I AND BIO II AND PHYSICAL SCIENCE	1.5	0.0
Total	6850	6.0	12.0	7.0	20.9	20.0	1466	905	100.0	6	2.7	2.8
Mean	527			11.0								
Median	404			10.0	21.2	20.2	100	66	7.3			
S.D.	440			8.5	0.9	0.6	89.1	49.1	5.4			
OK	ENROLL	BS CHEM	HQ	YRS EXP.	ACT SCI-20.8	ACT MATH-19.9	# GRADS	# GRADS-ACT	% OF NEO TAKING ACT	PREREQ	RATING	WT RATE
W	675	YES	YES	10.0	20.3	19.2	157	125	19.1	PHYSICAL SCI, BIOLOGY	3.5	0.7
X	225	YES	YES	3.0	18.1	16.4	46	28	4.3	ALGEBRA I	3.0	0.1
Y	307	YES	YES	11.0	16.6	16.4	55	50	7.6	PHYSICAL SCI, BIO I AND BIO II	3.5	0.3
Z	630	YES	YES	30.0	21.8	19.9	165	101	15.4	BIOLOGY AND ALGEBRA I WITH C	4.0	0.6
AA	175	NO	YES	5.0	18.6	17.7	38	20	3.1	NONE	0.0	0.0
BB	1343	YES	YES	18.0	21.4	19.8	297	184	28.1	BIOLOGY AND ALGEBRA II	4.5	1.3
CC	563	NO	YES	5.0	20.8	19.7	139	120	18.3	BIOLOGY	1.5	0.3
DD	104	YES	YES	18.0	19.3	18.5	31	26	4.0	ALGEBRA I AND PHYSICAL SCIENCE	4.0	0.2
Total	4022	6.0	8.0	5.0	19.6	18.5	928	654	100.0	4		
Mean	503			12.5								
Median	435			10.5	19.8	18.9	97	75.5	11.5		3.0	3.4
S.D.	403			9.1	1.8	1.5	92.0	59.7	9.1			

APPENDIX D: State ACT Science Course Pattern and College Readiness Data

2014 State of Kansas ACT Science Report for College Readiness[23]

NATURAL SCIENCE COURSE PATTERN	N	Percent Taking Pattern	Avg ACT Science	Percent Who Met Benchmark	N	Percent Taking Pattern	Avg ACT Science	Percent Who Met Benchmark
Gen Sci[1], Bio, Chem, & Phys	10,729	45	23.1	55	781,043	42	22.1	46
Bio, Chem, Phys	2,435	10	24.3	65	199,419	11	23.1	54
Gen Sci[1], Bio, Chem	7,022	29	20.6	31	505,460	27	20.0	28
Other comb of 3 years of Natural Science	543	2	20.5	34	52,236	3	19.2	24
Less than 3 years of Natural Science	2,737	11	19.0	21	220,701	12	18.1	17
Zero years / no Natural Science courses reported	458	2	17.1	13	86,928	5	17.7	17

[1]Includes General, Physical and Earth Sciences.

2014 State of Missouri ACT Science Report for College Readiness [24]

NATURAL SCIENCE COURSE PATTERN	N	Percent Taking Pattern	Avg ACT Science	Percent Who Met Benchmark	N	Percent Taking Pattern	Avg ACT Science	Percent Who Met Benchmark
Gen Sci[1], Bio, Chem, & Phys	18,425	38	22.8	52	781,043	42	22.1	46
Bio, Chem, Phys	5,069	10	23.3	54	199,419	11	23.1	54
Gen Sci[1], Bio, Chem	14,599	30	21.1	37	505,460	27	20.0	28
Other comb of 3 years of Natural Science	1,464	3	20.7	35	52,236	3	19.2	24
Less than 3 years of Natural Science	7,996	16	19.9	26	220,701	12	18.1	17
Zero years / no Natural Science courses reported	1,312	3	19.5	28	86,928	5	17.7	17

[1]Includes General, Physical and Earth Sciences.

2014 State of Oklahoma ACT Science Report for College Readiness[25]

NATURAL SCIENCE COURSE PATTERN	N	Percent Taking Pattern	Avg ACT Science	Percent Who Met Benchmark	N	Percent Taking Pattern	Avg ACT Science	Percent Who Met Benchmark
Gen Sci[1], Bio, Chem, & Phys	9,268	32	22.2	46	781,043	42	22.1	46
Bio, Chem, Phys	1,247	4	23.8	59	199,419	11	23.1	54
Gen Sci[1], Bio, Chem	9,002	31	20.8	34	505,460	27	20.0	28
Other comb of 3 years of Natural Science	980	3	20.4	32	52,236	3	19.2	24
Less than 3 years of Natural Science	7,039	25	19.1	20	220,701	12	18.1	17
Zero years / no Natural Science courses reported	1,146	4	17.2	13	86,928	5	17.7	17

[1]Includes General, Physical and Earth Sciences.

APPENDIX E: State ACT Math Course Pattern and College Readiness Data

2014 State of Kansas ACT Math Report for College Readiness[23]

MATHEMATICS COURSE PATTERN	N	Percent Taking Pattern	Avg ACT Math	Percent Who Met Benchmark	N	Percent Taking Pattern	Avg ACT Math	Percent Who Met Benchmark
Alg 1, Alg 2, Geom, Trig, & Calc	1,347	6	24.7	75	118,677	6	23.8	67
Alg 1, Alg 2, Geom, Trig, & Other Adv Math	2,518	11	22.7	64	157,764	9	21.8	55
Alg 1, Alg 2, Geom, & Trig	1,174	5	20.5	41	120,160	7	19.3	30
Alg 1, Alg 2, Geom, & Other Adv Math	4,285	18	20.5	42	356,555	19	19.4	31
Other comb of 4 or more years of Math	8,882	37	24.1	70	622,896	34	23.7	65
Alg 1, Alg 2, & Geom	3,323	14	17.8	14	220,037	12	17.1	11
Other comb of 3 or 3.5 years of Math	919	4	19.8	33	90,105	5	19.8	35
Less than 3 years of Math	1,008	4	16.6	8	74,627	4	16.4	8
Zero years / no Math courses reported	468	2	17.3	15	84,966	5	17.8	19

2014 State of Missouri ACT Math Report for College Readiness[24]

MATHEMATICS COURSE PATTERN	N	Percent Taking Pattern	Avg ACT Math	Percent Who Met Benchmark	N	Percent Taking Pattern	Avg ACT Math	Percent Who Met Benchmark
Alg 1, Alg 2, Geom, Trig, & Calc	2,519	5	24.1	69	118,677	6	23.8	67
Alg 1, Alg 2, Geom, Trig, & Other Adv Math	5,633	12	22.5	61	157,764	9	21.8	55
Alg 1, Alg 2, Geom, & Trig	2,720	6	19.7	34	120,160	7	19.3	30
Alg 1, Alg 2, Geom, & Other Adv Math	9,497	19	20.1	37	356,555	19	19.4	31
Other comb of 4 or more years of Math	15,447	32	23.8	67	622,896	34	23.7	65
Alg 1, Alg 2, & Geom	7,170	15	17.4	11	220,037	12	17.1	11
Other comb of 3 or 3.5 years of Math	1,780	4	20.2	38	90,105	5	19.8	35
Less than 3 years of Math	2,773	6	16.7	9	74,627	4	16.4	8
Zero years / no Math courses reported	1,326	3	18.3	23	84,966	5	17.8	19

2014 State of Oklahoma ACT Math Report for College Readiness[25]

MATHEMATICS COURSE PATTERN	N	Percent Taking Pattern	Avg ACT Math	Percent Who Met Benchmark	N	Percent Taking Pattern	Avg ACT Math	Percent Who Met Benchmark
Alg 1, Alg 2, Geom, Trig, & Calc	1,396	5	23.0	63	118,677	6	23.8	67
Alg 1, Alg 2, Geom, Trig, & Other Adv Math	1,675	6	21.5	50	157,764	9	21.8	55
Alg 1, Alg 2, Geom, & Trig	2,017	7	19.6	31	120,160	7	19.3	30
Alg 1, Alg 2, Geom, & Other Adv Math	3,492	12	19.5	30	356,555	19	19.4	31
Other comb of 4 or more years of Math	10,141	35	22.2	54	622,896	34	23.7	65
Alg 1, Alg 2, & Geom	5,970	21	17.1	9	220,037	12	17.1	11
Other comb of 3 or 3.5 years of Math	2,082	7	18.1	18	90,105	5	19.8	35
Less than 3 years of Math	773	3	15.8	4	74,627	4	16.4	8
Zero years / no Math courses reported	1,136	4	16.8	11	84,966	5	17.8	19

APPENDIX F: PSU Chemistry Teacher Certification Requirements

PITTBURG STATE UNIVERSITY REQUIREMENTS

Bachelor of Science in Education Degree with a Major

in Chemistry

General Education Component* (47-54 hours)

All students preparing to teach must meet the general education requirements for all baccalaureate degrees as well as the requirements for teacher certification. The following plan will satisfy both requirements.

Basic Skills** (12-14 hours)

General Education Electives (35-40 hours)

Sciences** (9-10 hours)

Social Studies (3 hours)

Political Studies (3 hours)

Producing and Consuming** (5-6 hours)

Fine Arts and Aesthetic Studies (2-3 hours)

Cultural Studies (3 hours)

Health and Well Being (4-6 hours)

Human Heritage (6 hours)

APPENDIX F: PSU Chemistry Teacher Certification Requirements

**MATH 150 and PHYS 104/130 required in the professional components will partially fulfill these requirements.

<u>Professional Studies Component</u>

In addition to the professional education courses listed in (1), the student must complete the courses for the teaching specialty listed in (2).

(1) Teaching and learning theory with laboratory and clinical experience*

EDUC-261: Explorations in Education (3 hours)

PSYCH-263: Developmental Psychology (3 hours)

PSYCH-357: Educational Psychology (3 hours)

CHEM-479: Techniques for Teaching Chemistry (3 hours)

SPED-510: Overview of Special Education (3 hours)

EDUC-520: Methods and Materials for Academic Literacy (3 hours)

Professional Semester (SR. year)

EDUC-458: Methods and Curriculum (3 hours)

EDUC-462: Secondary and Middle Level Education (2 hours)

EDUC-464: Foundations of Measurement and Evaluation (2 hours)

EDUC-480: Supervised Teaching in the Secondary School (3 hours)

EDUC-482: Supervised Teaching in the Secondary School (5 hours)

APPENDIX F: PSU Chemistry Teacher Certification Requirements

CHEM-579: Supervised Student Teaching and Follow-Up of Teachers (2 hours)

Content for the teaching specialty

Chemistry (36 hours)

CHEM-215: General Chemistry I (3 hours)

AND CHEM-216: General Chemistry I Laboratory (2 hours)

CHEM-225: General Chemistry II (3 hours)

AND CHEM-226: General Chemistry II Laboratory (2 hours)

CHEM-325: Organic Chemistry I (3 hours)

AND CHEM-326: Organic Chemistry Laboratory (2 hours)

CHEM-335: Organic Chemistry II (3 hours)

AND CHEM-336: Organic Chemistry II Laboratory (2 hours)

CHEM-369: Laboratory Assistant Practicum I (3 hours)

CHEM-445: Analytical Chemistry (3 hours)

AND CHEM-446: Analytical Chemistry Laboratory (2 hours)

CHEM-469: Laboratory Assistant Practicum II (3 hours)

CHEM-569: Laboratory Assistant Practicum III (3 hours)

CHEM-601: Chemistry Colloquium (0-1 hours)

CHEM-611: Senior Review and Assessment (1 hours)

One hour CHEM 601 Chemistry Colloquium is required.

APPENDIX F: PSU Chemistry Teacher Certification Requirements

- Other (15 hours)

MATH-150: Calculus I (5 hours)

PHYS-104: Engineering Physics I (4 hours)

OR PHYS-100: College Physics I (4 hours)

AND PHYS-130: Elementary Physics Laboratory I (1 hours)

PHYS-105: Engineering Physics II (4 hours)

OR PHYS-101: College Physics II (4 hours)

AND PHYS-131: College Physics Laboratory II (1 hours)

*Engineering Physics is recommended and required for physics certification or additional study in chemistry.

APPENDIX G: KU Chemistry Teacher Certification Requirements

KU DEPARTMENT OF CURRICULUM & TEACHING
The University of Kansas

KU School of Education
Graduate Licensure Program
Secondary (6-12) Chemistry Education Major

General Education Requirements: The following general education courses must be completed prior to admission to the Graduate Licensure Program with no grade lower than a "C":

		Credits	Semester	Grade
ENGL 101	Composition	3		
ENGL 102	Critical Reading and Writing	3		
COMS 130	Speaker-Audience Communication	3		
MATH 101	College Algebra	3		
MATH 105, 106, 111, 115, **or** higher	Introduction to Topics in Mathematics, Introduction to Finite Mathematics, Matrix Algebra, Probability and Statistics, Calculus 1, **or** higher	3		

Admission Requirements: An undergraduate major in Chemistry or related field, or prior completion of at least half of the courses listed below; however, all the major courses must be completed before student teaching.

Chemistry Major Courses (38 hrs.)

		Credits	Semester	Grade
CHEM 184	Foundations of Chemistry I	5		
CHEM 188	Foundations of Chemistry II	5		
CHEM 516	Analytical Chemistry	3		
CHEM 517	Analytical Chemistry lab	2		
CHEM 624	Organic Chemistry I	3		
CHEM 625	Organic Chemistry I lab	2		
CHEM 640	Biological Physical Chemistry	3		
CHEM 647	Physical Chemistry I lab	2		
CHEM 696	Junior/Senior Seminar	1		
CHEM 698	Undergraduate Research Problems	3		
PHSX 114	College Physics I	4		
PHSX 115	College Physics II	4		
MATH 115	Calculus I	3		
MATH 116	Calculus II	3		
HIST ______	History of Science course	3		

APPENDIX G: KU Chemistry Teacher Certification Requirements

Professional Education Courses (total of 40 hours in coursework plus 6 hours for the student teaching; only graduate level courses count toward a master's degree)

		Credits	**Semester**	**Grade**
ELPS 834, 835, or 250	Foundations of Education	3		
ELPS 537 (fall)	Governance and Organization of Schools	3		
C&T 709	Foundations of Curriculum & Instruction	3		
ELPS 830 or C&T 235 or 807	Multicultural Education	3		
C&T 748 (spring) or 448	Reading and Writing Across Curriculum	3		
PRE 725	Educational Measurement	3		
PRE 704 or 306 (fall)	Advanced Educational Psychology	3		
PRE 703 (summer) or 456 (fall)	Constructive Classroom Discipline	3		
ELPS 760 (fall) or 302	Introduction to Computing in Education	3		
SPED 725 or 326	Psychology of Exceptional Children & Youth	3		
C&T 53X: subject methods course I (spring in Lawrence)	Curriculum and Instruction in:	3		
C&T 54X: subject methods course II (fall in Lawrence)	Advanced Practices in Teaching:	3		
C&T 489 (fall, taken concurrently with C&T 54X)	Advanced Teaching Practicum in:	1		
C&T 501 (full-time, spring only)	Student Teaching Practicum (note: all other courses must be completed before student teaching)	6		
C&T 495 (spring only, taken concurrently with C&T 501	Seminar (seminar will support students during Student Teaching and prepare students for KPTP)	3		

University of Missouri, B.S.Ed. in Secondary Education with Emphasis in Chemistry

Major Program Requirements

Students must complete all university, general education, and content requirements, in addition to the degree requirements below.

Students have the choice to complete a single subject or unified science endorsement. The unified science endorsement creates the opportunity to teach any of the beginning sciences. A list of the additional courses for the unified science endorsement can be found at the end of the list of required courses for each of the science areas.

Professional Education		43
Phase I		
LTC 1155	Orientation: Science Education	1
ESC_PS 2010 & ESC_PS 2014	Inquiry Into Learning I and Inquiry into Learning I - Field Experience	4
LTC 2040 & LTC 2044	Inquiring into Schools, Community and Society I and Inquiry into Schools, Community and Society: Field	4
Phase II		
LTC 4560	Reading and Writing in the Content Areas	2
LTC 4631 & LTC 4634	Teach.Sci.Second.Sch.:Phil.,Hist., Sci.Inq.,Curr., Assm., & Teach I and Teaching Middle and Secondary Science I Field	4
SPC_ED 4020	Inquiry into Learning II	3
LTC 4641 & LTC 4644	Teaching Middle and Secondary Science II and Teaching Middle and Secondary Science II Field	4
ED_LPA 4060	Inquiring into Schools, Community and Society II	3
LTC 4651 & LTC 4654	Teach.Sci.Second.Sch.:Phil.,Hist.,Sci.Inq.,Curr.,Assm., & Tech III and Teach Sci Second Sch: Phil,Hist,Sci Inq,Curr,Assm & Tech III Fld	4
Phase III		
LTC 4971	Internship and Capstone Seminar	14
Content Area		46-47
Chemistry		

APPENDIX H: MU Chemistry Teacher Certification Requirements

CHEM 1320	College Chemistry I	4
CHEM 1330	College Chemistry II	4
CHEM 2100	Organic Chemistry I	3
CHEM 2110	Organic Chemistry II	3
CHEM 2130	Organic Laboratory I	2
CHEM 3200	Quantitative Methods of Analysis with Lab	4
CHEM 3300	Fundamentals of Physical Chemistry	3
BIOCHM 3630	General Biochemistry	3
Biology		
BIO_SC 1500	Introduction to Biological Systems with Laboratory	5
Earth Science		
GEOL 1200	Environmental Geology with Laboratory	4
Choose One:		3-4
ATM_SC 1050	Introductory Meteorology	
ASTRON 1010	Introduction to Astronomy	
Physics		
PHYSCS 1210	College Physics I	4
PHYSCS 1220	College Physics II	4
Unified Science-Chemistry Endorsement		18-21
Complete coursework for Chemistry plus:		
Biology		
BIO_SC 2200	General Genetics	4
BIO_SC 3650	General Ecology	5
BIO_SC 4600	Evolution	3
Botany-Choose One:		3-5
BIO_SC 1200	General Botany with Laboratory	
BIO_SC 3210	Plant Systematics	
BIO_SC 4400	Plant Anatomy	
BIO_SC 4320	Plant Physiology	
BIO_SC 4660	Plant Population Biology	
PLNT_S 4500	Biology and Pathogenesis of Plant-Associated Microbes	

Earth Science

Complete one (cannot be same course as completed in content area): 3-4

ATM_SC 1050 Introductory Meteorology

ASTRON 1010 Introduction to Astronomy

Semester Plan

Below is a sample plan of study, semester by semester. A student's actual plan may vary based on course choices where options are available.

Please meet with an academic advisor to discuss these options.

First Year

Fall	**Credits**	**Spring**	**Credits**
LTC 1155	1	ENGLSH 1000	3
MATH 1100	3	MATH 1500	5
HIST 1100	3	POL_SC 1100	3
PSYCH 1000	3	COMMUN 1200	3
CHEM 1320	4	CHEM 1330	4
	14		18

Second Year

Fall	**Credits**	**Spring**	**Credits**
ESC_PS 2010	3	LTC 2040	3
ESC_PS 2014	1	LTC 2044	1
MATH 1700	5	Humanities Elective	3
Humanities Elective	3	CHEM 2110	3
CHEM 2100	3	CHEM 2130	2
		GEOL 1200	4
	15		16

Third Year

Fall	**Credits**	**Spring**	**Credits**
LTC 4560	2	LTC 4641	3
LTC 4631	3	LTC 4644	1
LTC 4634	1	SPC_ED 4020	3
BIO_SC 1500	5	CHEM 3200	4
PHYSCS 1210	4	BIOCHM 3630	3
		PHYSCS 1220	4
	15		18

Fourth Year

Fall	**Credits**	**Spring**	**Credits**
ED_LPA 4060	3	LTC 4971	14
LTC 4651	3		
LTC 4654	1		
CHEM 3300	3		
Earth Science Course	3-4		
	13-14		14

Total Credits: 123-124

APPENDIX I: OU Chemistry Teacher Certification Requirements

REQUIREMENTS FOR THE BACHELOR OF SCIENCE IN EDUCATION AND CERTIFICATION IN FIELD OF STUDY

JEANNINE RAINBOLT COLLEGE OF EDUCATION — THE UNIVERSITY OF OKLAHOMA

For Students Entering the Oklahoma State System for Higher Education
Summer 2016 through Spring 2017

Credit Hours and Grade Average Requirements

Minimum Hours for Graduation	**124**
Minimum Overall Grade Point Average	**2.75**
Minimum OU Residence Grade Point Average	**2.75**
Minimum Grade Point Average in Major	**2.75**
Minimum Requirements for Certification: Undergraduate Degree PLUS Certification Exams	

Science Education: Chemistry
B831
Bachelor of Science in Education

OU encourages students to complete at least 31 hours of applicable coursework each year to have the opportunity to graduate in four years.

GENERAL EDUCATION REQUIREMENTS—41 Hours

These General Education courses meet minimum University, College and State General Education Requirements.

Areas	Courses	Hours
Communication Skills-9 hours	ENGL 1113, Prin. of English Composition (Core I) ENGL 1213, Prin. of English Composition (Core I), **or** EXPO 1213, Expository Writing COMM1113, Prin. of Communication (Core I), **or** COMM2613, Public Speaking	3 3 3
Mathematics-6 hours	MATH 1523, Precalculus & Trigonometry or higher (Core I) MATH 1823, Calculus & Analytic Geometry I, or higher	3 3
U.S. History & Government-6 hours	HIST 1483, U.S. 1492-1865, **or** (Core IV) HIST 1493, U.S. 1865-Present **and** P SC 1113, American Federal Government (Core III)	3 3
Natural Science-8 hours	BIOL 1114, Introductory Zoology (Core II-NL) GEOL 2014, The Earth System (Core II-LAB)	4 4
Arts & Humanities-6 hours	Any one course chosen from Core IV-Artistic Forms. ________________ (Core IV-AF) HSCI 3013, History of Science to Newton, **or** HSCI 3023, History of Science Since the 17th C. (Core IV-WC)	 3 3
Social & Behavioral Sciences-3 hours	GEOG 3253, Environmental Conservation (Core III-SS)	3
Foreign Language-0-10 hours	Students must meet both requirements outlined below: University-Wide General Education Requirement: Two college- level courses in a single foreign language are required; may be satisfied by successful completion of 2 years in a single foreign language in high school. (Core I), **and,** Oklahoma State Regents for Higher Education Requirement: Teacher candidates must demonstrate conversational skills at a novice-high level in a language other than English. *The novice-high level language requirement may be satisfied by classical, modern, Native or American Sign Language.	0-10
Non-Western Culture-3 hours	HSCI 3313, Science & Technology in Asian History, **or** HSCI 3453, Science & Civilization in Islam, **or** HSCI 3483, Technology, Politics, & International Development (Core IV-NWC)	3
Senior Capstone	EDSC 4533–Satisfied under Professional Education requirements. (Capstone, Core V)	

The 41 hours above, along with 14 hours notated by † in the Specialized Education column, comprise the 55 hours required for Liberal Arts & Sciences.

MAJOR REQUIREMENTS

PROFESSIONAL EDUCATION — 31 Hours

Courses	Hours
EIPT 3473, Learning, Development, & Assessment for Teachers	3
*EIPT 3483, Motivation, & Classroom Management for Teachers	3
EDSP 3054, Understanding & Accommodating Students with Exceptionalities	4
EIPT 3011, Productivity Tools for Education (may be satisfied by competency exam; if not satisfied by exam, this additional hour is required)	0-1
EIPT 3043, Learning with Educational Technologies	3
*EDS 4003, Schools in American Cultures	3
*EDSC 4513, Teaching Science in Secondary Schools	3
The following courses are taken together in the final semester:	
EDSC 4533, Advanced Methods in Science teaching (Capstone)	3
*EDUC 4060, Teaching Experiences in the Secondary School	9

*These courses require field experience.

Students must maintain a minimum of 2.75 grade point average with no grade less than a C in the Professional Education courses for graduation.

SPECIALIZED EDUCATION — 52 Hours

Courses	Hours
Biological Science - satisfied under gen Ed BIOL 1114, Introductory Zoology	
Chemistry - 27-32 hours †CHEM 1315, General Chemistry, **and** †CHEM 1415, General Chemistry, **or** †CHEM 1425 Gen. Chemistry for Majors	5-10
CHEM 3005, Quantitative Analysis	5
CHEM 3064, Organic Chemistry I	4
CHEM 3164, Organic Chemistry II	4
CHEM 3653, Intro. to Biochemistry	3
CHEM 4023, Instrumental Methods of Chemical Analysis	3
CHEM 4333, Adv. Inorganic Chemistry	3
Physics - 8 hours †PHYS 2414, Gen. Phys. for Life Sci. Majors, **or** PHYS 2514, Gen. Physics for Engr/Sci Majors	4
PHYS 2424, Phys. for Life Sci. Majors, **or** PHYS 2524, Gen. Physics for Engr/Sci Majors	4
Earth & Space Science - Satisfied under General Education GEOL 2014, The Earth System (Gen Ed) GEOG 3253, Environ. Conserv. (Gen Ed)	
Statistics - 3 hours †PSY 2003, Understanding Statistics	3
Research - 3 hours CHEM 3990, Independent Study, **or** CHEM 4990, Independent Study	3
Environmental Science - 3 hours EDSC 3233, Environmental Issues in the Community	3
Electives - 3-8 hours CHEM 3421, Physical Chemistry Laboratory CHEM 3423, Physical Chemistry I CHEM 3521, Physical Chemistry Laboratory CHEM 3523, Physical Chemistry II CHEM 3753, Introduction to Biochemical Methods CHEM 4033, Instrumental Methods of Chemical Analysis Laboratory	3-8

Students must maintain a minimum of 2.75 grade point average with no grade less than a C in the Specialized Education courses for graduation.

A minimum of 40 hours must be completed at the upper-division level.

CERTIFICATION: To be fully certified, students must pass Certification Examinations for Oklahoma Educators, apply for a license, and successfully complete the residency program.

SEE REVERSE SIDE FOR ADDITIONAL INFORMATION CONCERNING REQUIREMENTS. 2-15

APPENDIX I: OU Chemistry Teacher Certification Requirements

Suggested Semester Plan of Study — Science Education: Chemistry - B831

Year	FIRST SEMESTER	Hours	SECOND SEMESTER	Hours
FRESHMAN	ENGL 1113, Principles of English Composition (Core I)	3	ENGL 1213, Principles of English Composition (Core I), **or**	3
	MATH 1523, Precalculus & Trigonometry (Core I)	3	EXPO 1213, Expository Writing (Core I)	
	HIST 1483, U.S. 1492-1865, **or** HIST 1493, U.S. 1865-Present	3	MATH 1823, Calculus & Analytic Geometry I or higher	3
	COMM 1113, Prin. of Communication, **or**	3	P SC 1113, American Federal Government (Core III)	3
	2613, Public Speaking (Core I)		GEOL 2014, The Earth System (Core II-Lab)	4
	BIOL 1114, Introductory Zoology	4	CHEM 1315, General Chemistry	5
	TOTAL CREDIT HOURS	**16**	**TOTAL CREDIT HOURS**	**18**
SOPHOMORE	EIPT 3473, Learning, Development, and Assessment for Teachers	3	EIPT 3483, Motivation & Classroom Management for Teachers	3
	Understanding Artistic Forms (Core IV-AF)	3	PHYS 2414, General Physics for Life Sci. Majors, **or**	4
	PSY 2003, Understanding Statistics	3	2514, General Physics for Engineering and Science Majors	
	CHEM 1415, General Chemistry (continued)	5	CHEM 3005, Quantitative Analysis	5
			GEOG 3253, Environmental Conservation (Core III-SS)	2
	TOTAL CREDIT HOURS	**14**	**TOTAL CREDIT HOURS**	**15**
JUNIOR	EDSP 3054, Understanding & Accommodating Students with Exceptionalities	4	EDS 4003, Schools in American Cultures	3
	HSCI 3013, History of Science to Newton, **or** 3023, History of Science Since 17th Century.	3	EIPT 3043, Learning with Educational Technologies	3
	PHYS 2424, Gen. Physics for Life Sci. Majors, **or**	4	HSCI 3313, 3453, or 3483 (Core IV-NWC)	3
	2524, General Physica for Engineering and Science Majors		CHEM 3164, Organic Chemistry II	4
	CHEM 4023, Instrumental Methods of Chemical Analysis	3	CHEM Elective	3
	CHEM 3064, Organic Chemistry I	4		
	TOTAL CREDIT HOURS	**18**	**TOTAL CREDIT HOURS**	**16**
SENIOR	EDSC 4513, Teaching Science in Secondary Schools	3	EDUC 4060, Teaching Experiences in the Secondary School	9
	EDSC 3233, Environmental Issues in the Community	3	EDSC 4533, Advanced Methods in Science Teaching (Capstone, Core V)	3
	CHEM 3990 or 4990, Independent Study	3		
	CHEM 4333, Advanced Inorganic Chemistry	3		
	CHEM 3653, Introduction to Biochemistry	3		
	TOTAL CREDIT HOURS	**15**	**TOTAL CREDIT HOURS**	**12**

Bachelor's degrees require a minimum of 40 hours of upper-division (3000-4000) coursework.
Additional credit hours may be required in the same college-level foreign language. Teacher candidates must demonstrate conversational skills at a novice-high level in a language other than English.
This plan of study should not be used in lieu of academic advisement.

CERTIFICATION AND DEGREE REQUIREMENTS

ADMISSION REQUIREMENTS—JEANNINE RAINBOLT COLLEGE OF EDUCATION
Students are eligible for admission to the Jeannine Rainbolt College of Education with:

a. a minimum of 24 semester hours earned from an accredited institution of higher learning;
b. a minimum of 2.75 combined retention grade point average on all coursework attempted;
c. a declared major in education.

FULL ADMISSION REQUIREMENTS—TEACHER EDUCATION AND PROFESSIONAL STUDIES PROGRAMS
Students are eligible for admission to Teacher Education with:

a. a minimum of 30 semester hours from an accredited institution of higher learning to include the following 24 hours as defined by the Oklahoma State Regents for Higher Education with a grade of C or better: English (Composition and Literature)-6 hours; MATH, Gen. Ed. Core I -3 hours; American History-3 hours; American Government-3 hours; Humanities to include Artistic Forms, Western Civilization, Non-Western Culture, World Language, or other adviser-approved Gen. Ed. course -3 hours; Social and Behavioral Sciences-3 hours; Natural Sciences-3 hours.
b. a minimum of 2.75 grade point average (OU retention and combined retention) on all coursework attempted;
c. successful completion of the OGET (Oklahoma General Education Test) or PPST (Pre Professional Skills Test) The OGET Exam requires a minimum score of 240. All three portions of the PPST must be passed with minimum cut scores of MATH 171, WRITING 172, and READING 173.

Admission to a teaching program requires submission of an application, essay, background check, and an interview with the admission committee prior to enrollment in the first education course.

RETENTION REQUIREMENTS—JEANNINE RAINBOLT COLLEGE OF EDUCATION

a. Students must maintain a minimum 2.75 grade point average (OU retention and combined retention) in all **undergraduate** coursework and a minimum 3.00 grade point average in all **graduate** coursework attempted.
b. Students must maintain a minimum of 2.75 **undergraduate** grade point average in both professional education courses and in specialized education courses with no grade less than a **C** and must maintain a minimum of 3.00 grade point average in **graduate** professional and specialized education courses, with no grade less than a **B**.
c. Students must earn a C or better in Communication 1113 or Communication 2613.
d. Students whose OU retention or combined retention grade point averages at the **undergraduate** level fall below 2.75 will be subject to dismissal from the college. At the **graduate** level, students must meet Graduate College requirements.
e. Students who have not earned OU retention and combined retention grade point averages of 2.75 after the completion of 60 semester hours will be dismissed from the College.
f. Because one college level math course is a requirement for full admission into both the college and the teacher preparation program, declared Education majors must complete at least one college-level Math within the first four semesters of enrollment at OU. Transfer students who have not completed a college level Math course will have two semesters to complete the requirement. Students who fail to meet the requirement within the time limits specified will be subject to dismissal from the College.
g. Coursework more than 10 years old in the teaching specialization and professional education may not be credited toward the completion of a teacher education degree and/or certificate program. However, coursework over 10 years old may be reviewed by the appropriate certificate committee for possible credit toward the completion of a teacher education degree and/or certificate program.
h. A student has 6 years to complete a teacher education degree and/or certificate program after full admission. After the 6-year period, a student must seek readmission to that program and meet the catalog requirements in effect at the time of readmission.
i. Students **will be** withdrawn from courses for failing to observe prerequisites and corequisites. Continued disregard of prerequisites and corequisites is grounds for dismissal from the College.

FIELD EXPERIENCES: Transfer students without appropriate field experiences may be required to enroll in EDUC 2400.
PASS/NO PASS ENROLLMENT: Only general education electives may be taken under the pass/no pass option.
RESIDENCE REQUIREMENTS: Students must complete either the last 30 hours or 45 of the last 60 hours after being fully admitted to a teacher education program to satisfy this requirement.
REQUIREMENTS TO BE COMPLETED TO BE ELIGIBLE FOR STUDENT TEACHING INTERNSHIP: Students must be in good standing and have completed **all** baccalaureate degree requirements with the excep tions of EDUC 4060 and EDSC 4533.
JUNIOR COLLEGE TRANSFER STUDENTS: Students transferring from a junior college may use the transferred credit to meet certain lower-division course requirements only; that is, freshman and sophomore-level courses.
DEGREE COMPLETION RESPONSIBILITY: Although the Dean's Office checks each student's records, **the responsibility for meeting degree requirements lies with the student** and not with the adviser or the Dean. Each student should obtain a copy of his or her requirements for graduation and check it regularly as he or she completes his or her degree program.
GRADUATION APPLICATION: The final step to be completed by the student before graduation is the filing of an official Application for Graduation. The Application for Graduation should be filled out online by October 1 for fall graduation, March 1 for spring graduation, and July 1 for summer graduation. **The student's degree will not be conferred, nor any completion statement entered on his or her transcript, until the required application is filed.**

APPENDIX J: List of Schools That Were Sent Chemistry Survey

KANSAS	KANSAS	MISSOURI	MISSOURI	OKLAHOMA	OKLAHOMA
COUNTY	*HIGH SCHOOL*	*COUNTY*	*HIGH SCHOOL*	*COUNTY*	*HIGH SCHOOL*
Cherokee	Baxter Springs - USD 508	Barry	Cassville R-IV (005-123)	Craig	Ketchum
Cherokee	Columbus - USD 493	Barry	Exeter R-VI (005-122)	Craig	Welch
Cherokee	Galena - USD 499	Barry	Monett R-I (005-128)	Craig	Bluejacket
Cherokee	Riverton - USD 404	Barry	Purdy R-II (005-124)	Craig	Vinita
Crawford	Cherokee - USD 247	Barry	Southwest R-V (005-121)	Deleware	Jay
Crawford	Frontenac Public Schools - USD 249	Barry	Wheaton R-III (005-120)	Deleware	Grove
Crawford	Girard - USD 248	Jasper	Carl Junction R-I (049-132)	Deleware	Kansas
Crawford	Northeast - USD 246	Jasper	Carthage R-IX (049-142)	Deleware	Colcord
Crawford	Pittsburg - USD 250	Jasper	Jasper Co. R-V (049-137)	Deleware	Oaks-Mission
Labette	Chetopa-St. Paul - USD 505	Jasper	Joplin Schools (049-148)	Mayes	Pryor
Labette	Labette County - USD 506	Jasper	Sarcoxie R-II (049-140)	Mayes	Adair
Labette	Oswego - USD 504	Jasper	Webb City R-VII (049-144)	Mayes	Salina
Labette	Parsons - USD 503	Lawrence	Aurora R-VIII (055-110)	Mayes	Locust Grove
Bourbon	Fort Scott - USD 234	Lawrence	Marionville R-IX (055-106)	Mayes	Chouteau-Maize
Bourbon	Uniontown - USD 235	Lawrence	Miller R-II (055-104)	Nowata	Oklahoma Union
Nieosho	Chanute Public Schools - USD 413	Lawrence	Mt. Vernon R-V (055-108)	Nowata	Nowata
Nieosho	Erie-Galesburg - USD 101	Lawrence	Pierce City R-VI (055-105)	Nowata	South Coffeyville
Montgomery	Caney Valley - USD 436	Lawrence	Verona R-VII (055-111)	Ottawa	Wyandotte
Montgomery	Cherryvale - USD 447	McDonald	McDonald Co. R-I (060-077)	Ottawa	Quapaw
Montgomery	Coffeyville - USD 445	Newton	Diamond R-IV (073-102)	Ottawa	Commerce
Montgomery	Independence - USD 446	Newton	East Newton Co. R-VI (073-099)	Ottawa	Miami
Wilson	Fredonia - USD 484	Newton	Neosho School District (073-108)	Ottawa	Afton
Wilson	Neodesha - USD 461	Newton	Seneca R-VII (073-106)	Ottawa	Fairland
Allen	Humboldt - USD 258	Newton	Westview C-6 (073-105)	Rogers	Claremore
Allen	Iola - USD 257	Barton	Lamar R-I (006-104)	Rogers	Catoosa
Allen	Marmaton Valley - USD 256	Barton	Liberal R-II (006-101)	Rogers	Chelsea
Woodson	Woodson - USD 366	Barton	Cedar	Rogers	Oologah Talala
Chautauqua	Cedar Vale - USD 285	Barton	El Dorado Springs R-II (020-002)	Rogers	Inola
Chautauqua	Chautauqua Co Community - USD 286	Barton	Stockton R-I (020-001)	Rogers	Sequoyah
Elk	Elk Valley - USD 283	Dade	Dadeville R-II (029-002)	Rogers	Foyil
Elk	West Elk - USD 282	Dade	Greenfield R-IV (029-004)	Rogers	Verdigris
Greenwood	Eureka - USD 389	Dade	Lockwood R-I (029-001)		
Greenwood	Madison-Virgil - USD 386				