

An Integration of Liberal and Professional Learning:
the Case of Constitutional History and
Spreadsheet Date Arithmetic

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Abstract

In an effort to avoid the “silos” that often characterize higher education curricula, the authors propose a method of integrating the History and Information Systems curricula. Using the date arithmetic functionality of common spreadsheets, they analyze the pattern of ratification of two amendments to the U.S. Constitution that occurred since 1900. Then, an approximating algorithm is proposed for dates prior to 1900, as date arithmetic functionality does not exist prior to that date. Using the resulting data, further analysis is performed on three amendments proposed prior to 1900. These analyses are proposed not as substantive analysis of the topic but rather to demonstrate that the History curriculum (and, by extension, other Liberal Arts subjects) can benefit by integrating the Information Systems technology and skills students learn elsewhere in their education.

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1. INTRODUCTION

All too often, institutions of higher education form “silos”, which academic communities work within limited horizons.. These can be across Schools, and Departments but even more common are silos grounded in academic disciplines. It is recognized that this is detrimental to higher education, and many institutions have made attempts to diminish its impact. The real solution, we propose, lies with individual faculty members, from different disciplines, coming together in ways that complement both curriculums.

Many Liberal Arts disciplines have a numerical analysis component, and among these is History. Examples include economic analyses, population and migration studies, and the analysis of military campaigns, to name a few.

Simultaneously, many Information Systems programs offer curriculum focusing on common computing productivity tools. Those taken by a broad range of students typically focus on productivity tools like word processors, spreadsheets, database management system, presentation tools, and the like.

The problem is: the History professor often does not use these tools for curriculum support, while the Information Systems professor often uses unrealistic and contrived applications to which students cannot relate. In short, there has been a “disconnect” between the Information Systems and Liberal Arts Students.

Our objective here is to propose a possible solution: an integration of the History and Information Systems curricula, in which:

1. the study of History is streamlined and enhanced through the use of productivity tools; and
1. the students’ skills in productivity tools is enhanced and extended through the use of more esoteric aspects of tools in support of their History course.

How this integration is to be achieved operationally can vary between institutions and between instructors. Some ideas include:

1. “Cohorting students into a History and an Information Systems section that will run in parallel, with a good deal of cooperation between the professors;
2. A less structured agreement between the History and Information Systems professors in which the IS professor will present analysis techniques just prior to points when they would be useful in the History course;
3. Use by the History professor alone, assuming a degree of comfort with both IS technology and statistical analysis derived from earlier coursework; or

4. Use as an example by the Information Systems professor alone.

By way of example, we will demonstrate a link between the study of History, specifically American Constitutional History, and the study of Information Systems, specifically the use of spreadsheet date arithmetic technology.

We will do so by examining the seventeen amendments to the United States Constitution. We will examine the period between the amendment’s proposal to the States (that is, after approval by both houses of Congress) and the time it is declared in effect by the federal officer then charged with confirming ratification. Between these two dates, we record the date each state took action on the proposed amendment (either ratification, rejection, reconsideration or retraction). We then use the date arithmetic capability of the spreadsheet when we can but, as will be seen, more complex procedures will be necessary for dates in the eighteenth and nineteenth centuries.

From the perspective of the History professor, this analysis will address the timing of the consideration of proposed amendments by the several States: from this can be detected chronological and geographical patterns of interest. The analysis can also compare the patterns of ratification or rejection across similar and dissimilar proposed amendments.

From the perspective of the Information Systems professor, this analysis permits expanded coverage of date arithmetic, a topic often slighted or ignored in the standard curriculum. It will also permit consideration of text manipulation, numeric conversion and logical operations in computation, all topics frequently slighted.

More particularly, the proposed integration will allow coverage of:

1. date arithmetic for amendments proposed after 1 Jan 1900;
2. more complex date arithmetic for amendments proposed before 1 Jan 1900, and for those whose entire consideration occurred in the eighteenth and nineteenth centuries;
3. the use of more complex date arithmetic for amendments whose consideration straddled the eighteenth, nineteenth and twentieth centuries.
4. the use of comparative charts to make clear the time between the establishment of the Constitution and the time each amendment was proposed or ratified/rejected;
5. the use of comparative charts to illustrate the elapsed time between proposal and ratification of an amendment;
6. the use of date arithmetic to compare and analyze the time between ratification of a

- specific Amendment by the several States; and
7. the use of comparative charts to compare the ratification process of several similar or dissimilar proposed amendments.

2. BACKGROUND INFORMATION ON DATE ARITHMETIC

Microsoft Excel, which we will use here for demonstration purposes, has a serial date numbering system that begins with serial number 1 on 1 January 1900. The serial number increments each day, so that any date has its unique serial number. For example, 1 November 2002 has serial number 37561. Arithmetic based on these serial numbers is at the heart of date arithmetic, and is fairly straightforward. The result will always be expressed in days, which in turn must be manipulated to re-express the results in months or years.

However, more complex date arithmetic is required for dates before 1 January 1900 and for time periods which straddle the 1800's and 1900's. This will involve textual manipulation and value comparison prior to performing date arithmetic. Again, the result, expressed in days, must be manipulated to re-express the results in months or years.

3. A PRIMER ON THE RATIFICATION OF AN AMENDMENT TO THE CONSTITUTION

Article V of the United States Constitution sets forth the general procedure for amending the United States Constitution. An amendment must be proposed in one of the houses of Congress, and must pass both houses by a two-thirds margin. Following passage, the amendment is proposed to the States. When three-fourths of the States then extant ratify the proposed Amendment, the Amendment becomes, in the words of Article V, "valid to all intents and purposes, as part of this Constitution".

Over time, however, the specific procedure to be followed has varied, most often in the designation of an officer of the government charged with declaring the Amendment has been adopted and is integral with the Constitution. Under the procedure currently in effect, the National Archivist holds this responsibility.

4. THE USE OF DATE ARITHMETIC FOR AMENDMENTS PROPOSED AFTER 1 JAN 1900

Since Excel's date arithmetic functionality begins on 1 January 1900, the use of date arithmetic to analyze the Sixteenth (proposed in July 1909) through the Twenty-Sixth (proposed in March 1971) Amendments is straightforward. We will proceed directly to a demonstration.

Let us suppose that an American Studies professor wishes to contrast the Eighteenth Amendment, which established Prohibition:

*After one year from the ratification of this article the manufacture, sale, or transportation of intoxicating liquors within, the importation thereof into, or the exportation thereof from the United States and all territory subject to the jurisdiction thereof for beverage purposes is hereby prohibited.*³

with that of the Twenty-First Amendment which repealed Prohibition:

*The eighteenth article of amendment to the Constitution of the United States is hereby repealed.*⁴

At the time of these Amendments there were forty-eight states; ratification of each amendment required thirty-six states. The point of the analysis is to examine the behavior of the states in the ratification of these two Amendments. The variable being studied is the number of intervening days between ratification of one State to the next State. The amendments took 394 and 288 days, respectively, to be ratified.

In Figure 1 below notice that the X-axis represents individual states (since the order in which they took action is different, the names of the states have been deleted from the X-axis label area), while the Y-axis represents the number of days that intervened since the previous state ratified the amendment. The data supporting Figure 1 and all subsequent analyses in this paper are available from the authors.

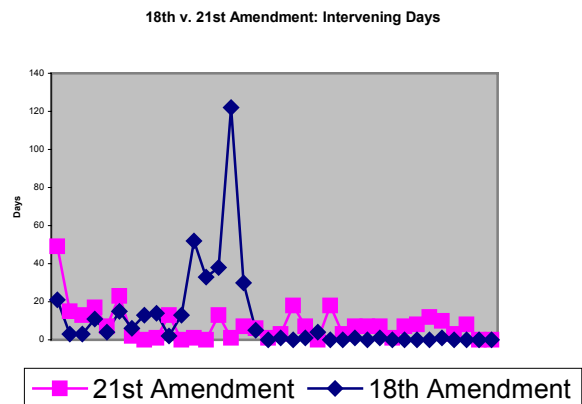
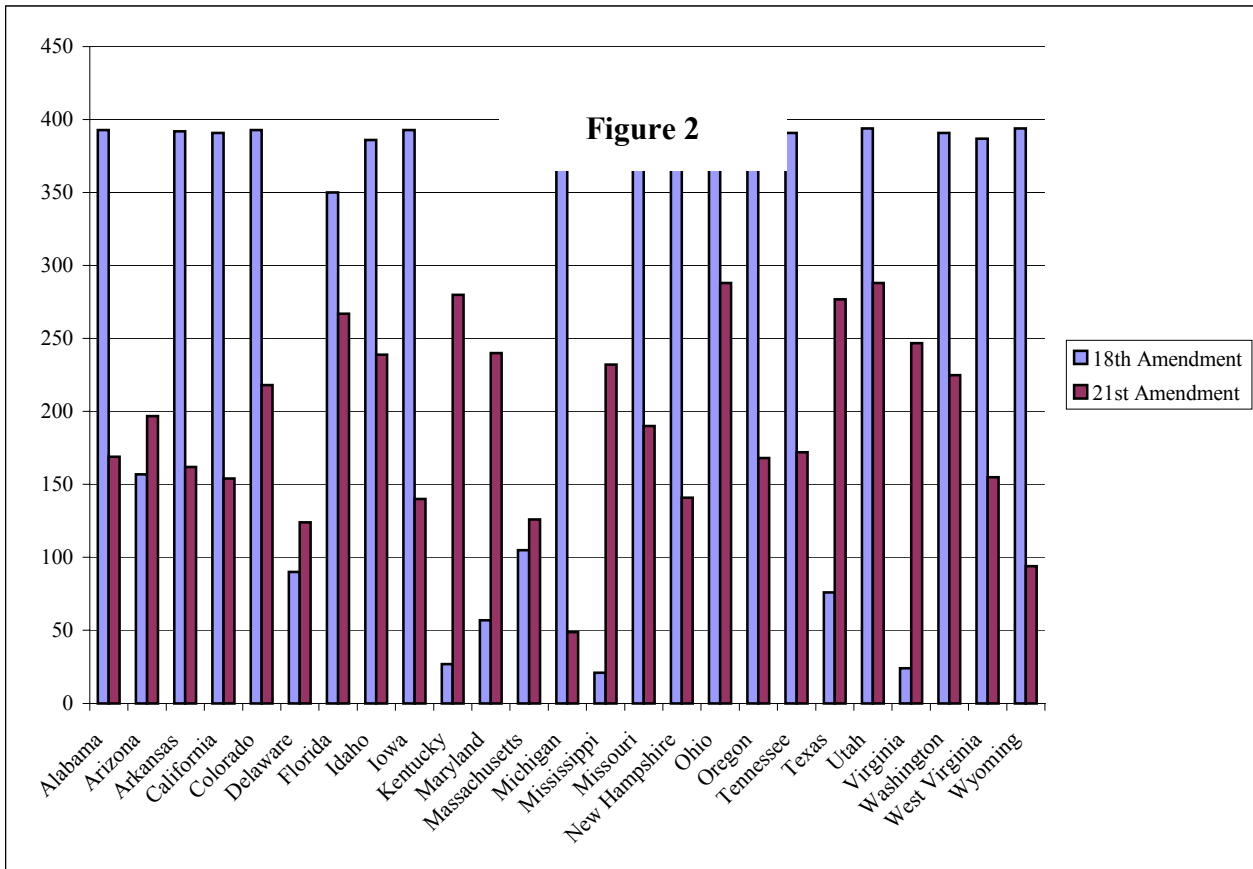


Figure 1

As can be seen, the Eighteenth Amendment was acted on quickly by ten states, and then it "stalled" in the eleventh through sixteen states, reaching a maximum

³ Constitution of the United States of America, Eighteenth Amendment, Section One

⁴ Constitution of the United States of America, Twenty-First Amendment, Section One



gap of 122 intervening days for the fifteenth state. After that, the states acted quickly, often on the same day, as seen in the data points resting on the X-axis. In contrast, the Twenty-First Amendment took a considerably longer time to be considered by the first state (49 days v. 21), but once the ratification process started, the States ratified the Amendment in an orderly fashion, with a maximum of 23 intervening days between ratifications.

Another way to display these data is to consider just the states that approved *both* the Eighteenth and Twenty-first amendments and consider the number of days from the date the amendment was proposed to the date the state approved it. These data are shown Figure 2.

Armed with these data and the analysis made possible by Excel, the professor would then contrast the ratification of the Eighteenth Amendment to the Twenty-First Amendment. Note that there does not appear to be a relationship between those states that ratified the two Amendments early in the process v. those that ratified toward the end of the process.

From this analysis, in conjunction with other course material, the History professor could generate a discussion along several lines, for example:

1. Is there a “roller-coaster” effect, in which the arguments for and against an amendment are aired in the states taking action early, thus speeding up consideration of the amendment in

- later states? If so, what is the “critical mass” of states needed to start the roller coaster effect?
2. Why did the Eighteenth Amendment take longer to ratify than the Twenty-First?
3. For the Eighteen Amendment, the long delay of 122 days, which ended on 3 December 1918, coincided with the end of World War I on 11 November 1918. Is there a connection?
4. For the Twenty-First Amendment, the ratification process started on 10 April 1933, shortly after the inauguration of President Franklin Roosevelt on 4 March 1933. The entire ratification process occurred in 1933, during Roosevelt’s eventful first year in office. Is there a connection?

The data-focused analysis above can be enhanced by use of statistical analysis. Since we are addressing categorical data, non-parametric tools must be used. We will first utilize the Spearman Rank-Correlation procedure, followed by the Wilcoxon Rank-Sum Test.

Spearman Rank-Correlation Procedure:

The Spearman coefficient of rank correlation is a particularly useful nonparametric test as it is straightforward and easy to apply. It assesses the association of two variables based solely on their rank order. Although this is one of the oldest nonparametric tools, it is almost as powerful as its parametric counterpart, the Pearson Product-Moment Correlation. However, this tool is not a function in Excel and, as a result, students will have to use their computational skills to perform this analysis.

The analysis begins by assigning to each state its rank order. The first state to ratify each amendment is assigned rank “1”, the second rank “2” and so forth. When states are equal in their rank order (that is, two or more states ratified an Amendment on the same day), the average of their ranks is assigned. Critical to the Spearman correlation is that we compare *pairs* on the same variables. In this context, the variables are simply the rank order in which the States ratified both the Eighteenth and Twenty-First Amendments. There were several states that ratified one Amendment and not the other; these were eliminated and subsequent ranks decremented. This left (n = 25) states, as seen in Table 1.. The following is the result of this data preparation.

	Eighteenth Amendment	Twenty-First Amendment
Alabama	20	12
Arizona	8	15
Arkansas	17	10
California	15	8
Colorado	20	16
Delaware	5	3
Florida	9	21
Idaho	12	18
Iowa	20	4.5
Kentucky	2	6
Maryland	3	23
Massachusetts	7	19
Michigan	10	4.5
Missouri	24	1
New Hampshire	20	14
Ohio	11	7
Oregon	20	24.5
South Dakota	6	11
Tennessee	15	13
Texas	4	22
Utah	24	24.5
Virginia		20
Washington		17
West Virginia	13	9
Wyoming	24	2

The Spearman rank correlation posits that if observations (in this case, a State) generally share the same rank in both variables (in this case, the Amendments), then there is a direct relationship between them, represented by a positive value of the coefficient. Conversely a negative value of the coefficient would suggest inverse relationship between the variables.

The computation proceeds as follows: first a rank difference score is computed for each record. Here, that is generated as: $d = \text{Rank}_{18\text{th}} - \text{Rank}_{21\text{st}}$. Student would then construct a spreadsheet model to compute the Spearman rank coefficient, r_s , as:

$$r_s = 1 - \frac{6 \sum_{i=1}^n d_{R_i}^2}{n(n^2 - 1)}$$

Here, $d^2 = 3061$ and $n = 25$. The computation results in $r_s = -0.177$, $\alpha = 0.19$, indicating no relationship in the order of ratification for the twenty five states which ratified both the Eighteenth and Twenty-First Amendments .

Wilcoxon Rank-Sum Test:

Another way to analyze to compare the ratification of the Eighteenth Amendment with that of the Twenty-First amendment is to compare the mean or median number of days it took for the states to approve the amendment. The summary statistics are shown below:

<u># Days- 18th amendment</u>		<u># Days - 21st Amendment</u>	
Mean	271.1389	Mean	182.5833
Median	385.5	Median	170.5
Mode	393	Mode	288
Standard Deviation	154.66	Standard Deviation	67.99932
Range	373	Range	239
Minimum	21	Minimum	49
Maximum	394	Maximum	288
Count	36	Count	36

A look at the histogram of each of these data sets shows that they are not normally distributed and thus we cannot use a parametric test to compare the mean number of days. However, the Wilcoxon rank sum test can be used, as it is a powerful nonparametric procedure for testing the differences between the medians of two non-normally distributed populations.

To perform the Wilcoxon rank sum test, we replace the observations in the two samples, each of size $n_1 = n_2 = 36$, with their combined ranks. In the case of ties, the average rank is used. The test statistic is:

Given:

$$\mu_{T1} = \frac{(n_1(n+1))}{2}$$

$$\sigma_{T1} = \sqrt{\frac{n_1 n_2 (n+1)}{12}}$$

$$n = n_1 + n_2 = 72$$

$$Z = \frac{(T_1 - \mu_{T_1})}{\sigma_{T_1}} = \frac{(1532.5 - 1332)}{88.79} = 0.15$$

where T_1 = the sum of the ranks of the Eighteenth Amendment and μ_{T_1} and σ_{T_1} are the mean and standard deviation of T_1 respectively.

Clearly the null hypothesis of equal medians can not be rejected with this Z value, and the analysis of the Twenty-First Amendment indicates similar results. We conclude that the median number of days for the states to ratify each of these amendments is not different.

5. THE USE OF DATE ARITHMETIC FOR AMENDMENTS PROPOSED BEFORE 1 JANUARY 1900

Because the date arithmetic functionality of Excel and similar tools apply only to dates after 1 January 1900, we propose here an approximating algorithm to mimic the functionality of date arithmetic for dates before 1 January 1900. The algorithm will apply to time periods that straddle the 1 January 1900 date. This is necessary as, by way of example, we explore the chronology of the Eleventh through the Fifteenth Amendments. Note that Thirteenth through Fifteen Amendments had approval dates well into the 1900's, and for consistency we will apply the same procedure to these dates as we will to dates before 1900⁵.

The approximating algorithm has high accuracy overall, with an average error of .0027 days ($S = 0.733$ days, $p \approx 1$). Moreover, discrepancies do not appear to be concentrated in any single Amendment, as an ANOVA test indicates ($F = 0.115$, $p \approx 0.99$).

Date arithmetic in Excel always generates a result expressed in days. This result may then be manipulated to be expressed in other units of time. We will follow the same procedure here: the approximating algorithm will generate a result in days. It is only in the computational complexity of date arithmetic that computations before and after 1900 differ.

Americans use highly non-standard time and date notational forms. Here, we will express dates according to the ISO 8601:2000 format⁶. This date format expresses dates in the following format:

YYYY-MM-DD

where:

1. YYYY is the full year (e.g., 2002);

⁵ This situation also applies to the Twenty-Seventh Amendment, which was proposed the States on 25 September 1789 but not declared to be ratified until 12 May 1992, more than 202 years later.

⁶ This is available at [the ISO Publications office](http://www.iso.org/iso/publications)

2. MM is the *two*-digit month with a leading zero if necessary (e.g., January would be 01) with a range from 01 to 12; and
3. DD is the *two*-digit day of the month with a leading zero if necessary, with a range from 01 up to 31 depending on the month/year.

For example, November 1, 2002 would be expressed as:

2002-11-01

Validation of the correct values of the data (e.g., avoiding 2003-02-31) is a function of the software utilizing the date, not the standard itself. In practice, hyphens are often dispensed with, resulting in an eight-digit number, without commas. The dates used in this analysis follow that practice. Either way, there are always eight digits present. Either practice (assuming it is followed consistently) results in date values that always increase over time.

One has an option of entering ISO-formatted date as a text string or as a numeric value⁷. When data is taken from public sources, it is almost always in text. Take, for instance, the date on which the Eleventh Amendment was proposed: March 4, 1794. The first state to ratify the proposed Amendment, New York, did so on March 27, 1794. These are presented in ISO format (but without hyphens) below:

17940304
17940327

From this, it can easily be seen that the computation of the intervening days is simply subtraction, $27 - 4 = 23$ days.

Here, we will assume that dates have been sorted in increasing order. The algorithm proceeds as follows: the ISO formatted date will be have its components extracted and converted to numeric values. Say, for example, the ISO date is in text format, without hyphens, in cell L10. The numeric values for year, month and date are to be extracted, respectively, to cells M10:O10. This is done as follows.

[M10]: =VALUE (LEFT, L10, 4)
[N10]: =VALUE (MID, L10, 5, 2)
[O10]: =VALUE (RIGHT, L10, 2)

The computation demonstrated here is the computation of the intervening days between the ratification of an amendment by the several States. Thus, if the dates are in sequential order, we are always comparing the date values on one row with those one row immediately above.

We begin by comparing year values in column M. As sorted data, each year value will be equal to or greater than the value immediately above it. If the year being considered is greater than the year before, we will add 365.25 days for each year. We always assign a

⁷ In practice, text strings are preferred to preserve the leading zeroes in the month and day positions when using substrings.

minimum value of 365.25 (but see the next step). This step of the computation appears as:

`=IF (M10>=M9, (M10-M9)*365.25, 365.25)`

Note that if the years are equal, the result of the computation is still 365.25. A complication arises, however, when we “look ahead” and compare the month values located in column N. If the present line’s month value is less than that of the line above, then clearly we’re dealing with less than a full year. In this case, we must subtract 365.25 days from the year-based computation just determined and depend on the month calculation to find the proper number of days. This is done by adding a “look ahead” comparison, shown in bold, as follows:

`=IF (M10>=M9, (M10-M9)*365.25, 365.25)
+ IF (N10<N9, -365.25, 0)`

The computation for days based on intervening months follows a similar logic, but substitutes a month value of 30.4375⁸. Note that if the month number exceeds the previous row, then a full month has passed. What is new here is the need to compute a partial month, whenever the month number of the more recent date is less than the less recent date. This accounts for the need to subtract the absolute value of the difference in month dates from twelve before multiplying the by value for days in a month, 30.4375, as seen in bold:

`=IF (N10>=N9,
(N10-N9)*30.4375,
(12-ABS (N10-N9)) *30.4375)
+ IF (O10<O9, -30.4375, 0)`

The computation of days comes last. The only challenge here is the determination of the number of days when the day value of the present row is less than that of the previous record. This is addressed through the use of subtract the absolute value of the difference from 30.4375, as seen in bold:

`=IF (O10>=O9,
(O10-O9),
30.4375-ABS (O10-O9))`

These individual computations are then integrated into a single SUM statement as follows:

`=SUM (
(IF (M10>=M9,
(M10-M9)*365.25,
365.25)
+ IF (N10<N9, -365.25, 0)),
(IF (N10>=N9,
(N10-N9)*30.4375,
(12-ABS (N10-N9)) *30.4375)
+IF (O10<O9, -30.4375, 0)),
IF (O10>=O9,
(O10-O9),
30.4375-ABS (O10-O9)))`

Application of this algorithm derives the approximate number of days between any two dates before 1

⁸ This value is the weighted average number of days in a month. It is computed as:
[31+(28*.75)+(29*.25)+31+30+31+30+31+31+30+31+30+31]/12

January, 1900, or between a date before and a date after 1 January, 1900. Once calculated, the same types of date analysis can be applied to these dates as to dates covered by the date arithmetic function of Excel and similar tools.

By way of demonstration, we will compare the time it took the States to ratify the “Civil War” amendments, the Thirteenth through Fifteenth. The Thirteenth Amendment ended slavery⁹:

Neither slavery nor involuntary servitude, except as a punishment for crime whereof the party shall have been duly convicted, shall exist within the United States, or any place subject to their jurisdiction.

The Fourteenth Amendment,

*All persons born or naturalized in the United States, and subject to the jurisdiction thereof, are citizens of the United States and of the State wherein they reside. No State shall make or enforce any law which shall abridge the privileges or immunities of citizens of the United States; nor shall any State deprive any person of life, liberty, or property, without due process of law; nor deny to any person within its jurisdiction the equal protection of the laws.*¹⁰

established former slaves as citizen and ensured equal protection under the law.

The Fifteenth Amendment,

*The right of citizens of the United States to vote shall not be denied or abridged by the United States or by any State on account of race, color, or previous condition of servitude.*¹¹

established enfranchisement for citizens, and particularly persons who formerly were slaves.

We will demonstrate the use of these data using rank-focused non-parametric test of median and ANOVA.

Median Analysis:

Here we analyze the ranks of the Confederate (“CSA”) and Union States (“USA”) in their ratification of Amendments Thirteen through Fifteen. Our approach to look at the difference in behavior between the States based on the median time it took each group to accomplish ratification. By “Confederate States” we mean those states that seceded from the Union namely: Alabama, Arkansas, Florida, Georgia,

⁹ Thirteenth Amendment to the United States Constitution, Article One

¹⁰ Fourteenth Amendment to the United States Constitution, Article One

¹¹ Fifteenth Amendment to the United States Constitution, Article One

Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Texas and Virginia.

Once again the Wilcoxon rank sum test can be used to test the hypothesis that the median number of days to ratify the amendment is the same for the North and the South versus the alternative hypothesis that the medians are different.

H₀: Median # days for Union States =
 Median # days for Confederate States
 H_A: Medians are different

The results are shown below:

	Thirteenth Amendment	Fourteenth Amendment	Fifteenth Amendment
Sample size - USA	27	26	26
Sample size - CSA	11	11	11
Sum of Ranks - USA	420	437	497
Sum of Ranks- CSA	246	266	169
Z value	1.92	2.6	-.72
p-value	.055	.009	.24
Significant difference?	Yes, at the 0.10 level	Yes	No

Clearly the behavior of the Confederate States was different from the Union States in approving Amendments Thirteen and Fourteen but not Amendment Fifteen. This should lead to interesting discussion of the reasons why this might be the case. Also, it should be noted that many of the Confederate States which originally rejected these amendments much later (in some cases almost 100 years later), approved the amendment

Analysis of Variance:

We will contrast the average time a state took to ratify the respective Amendments v. whether or not the State was a former member of the Confederacy. To do so, we will rearrange our data so that the states of the Confederacy are listed first while those of the Union are listed last. Next, we will recalculate the “intervening days” data to represent days since the respective Amendments were proposed, not the days that passed since the previous state took action. States that were not admitted to the Union during this period are excluded from consideration.

After accounting for such factors as states that rejected an Amendment without subsequently approving it, those which took no action at all, and excluding states which approved an amendment after it was already part of the Constitution. Successive use of the single-factor ANOVA tool generates the following results:

	Thirteenth Amendment	Fourteenth Amendment	Fifteenth Amendment
CSA mean =	173	478	124
CSA n =	8	6	9
Union	22	73	58
USA n =	19	22	19
F =	19.13	40.78	2.17
p =	≈0	≈0	0.15

It can thus be seen that for each Amendment the states of the former Confederacy took much more time to ratify the “Civil War” Amendments than did their northern counterparts. The History professor could use this analysis to springboard into a discussion of the readmission of Confederate States into the union (thus regaining their privilege to ratify amendments), the role of military occupation in the politics of these States, the brief flowering of governments in which African-Americans played prominent roles, and the role of northern “carpet-baggers”.

6. CONCLUSION

Noting that academic curricula often form “silos”, we have argued for a method of integrating the Liberal Arts study of History with the use of Information Technology skills learned elsewhere in the curriculum. We have offered several suggestions regarding methods to achieve this integration. We posit that both disciplines benefit: History through the placement of powerful analysis tools in the hands of students, and Information Systems be incorporating new material and reinforcing prior skills.

To demonstrate our point, we have provided several examples using date arithmetic in the study of American Constitutional History. History, by its very nature, is concerned with dates less recent than 1900 and for that reason we have proposed an approximating algorithm to perform date-based analysis in previous centuries. The use of several analysis tools on these data is also demonstrated.