

Acid/Base Chemistry- Concept or Gateway?

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A large thank you to Professor Flynn for her encouraging words and insightful ideas. Any questions regarding the future of the acid/base chemistry project or for more information please visit the website:

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Introduction

Acid base chemistry is a fundamental concept and utilized in almost every reaction learned in undergraduate organic chemistry studies. It is a threshold concept, defined as a portal or gateway that opens up previously inaccessible knowledge. If this concept is so vital to our understanding of organic reactions, there should be minimal variation in the concepts taught between organic chemistry textbooks, whether they be introductory or advanced. As part of a program studying acid/base reactions as a threshold concept in organic chemistry, the extensity and quality of coverage in undergraduate organic chemistry textbooks was assessed with two research questions (RQ) in mind:

RQ1- What acid/base chemistry knowledge is required to solve more advanced problems/reactions?

RQ2- What do organic chemistry textbooks currently teach/cover and to what depth?

Methods

Phase 1

Initially an extensive chart was created to account for the presence of acid/base chemistry in 24 key reactions (e.g., S_N2 , E2, Grignards). Reactions were coded for what kind of skill set and knowledge was needed to make certain decisions regarding protonating and deprotonating in the mechanisms, work up, or neutralization steps of these reactions. Source data was obtained from Wade 8th edition, an introductory textbook, and Clayden 2nd Edition, an advanced textbook and prevalence of acid/base chemistry steps are shown in **Figure 1**.

Phase 2

Seven introductory and four advanced organic chemistry textbooks were examined with the learning objectives and skill set developed in phase one in mind. The textbooks were coded according to how extensive their coverage was regarding acid base chemistry. The textbooks were scrutinized critically with a focus on many different factors. The quality and quantity of knowledge in these textbooks was evaluated by examining indicators such as in-text and end of chapter questions, real life examples, factors predicting acid/base strength and stability and many other concepts crucial to the understanding of this critical topic. These factors were chosen based on learning objectives that are seen as essential to success in organic chemistry.

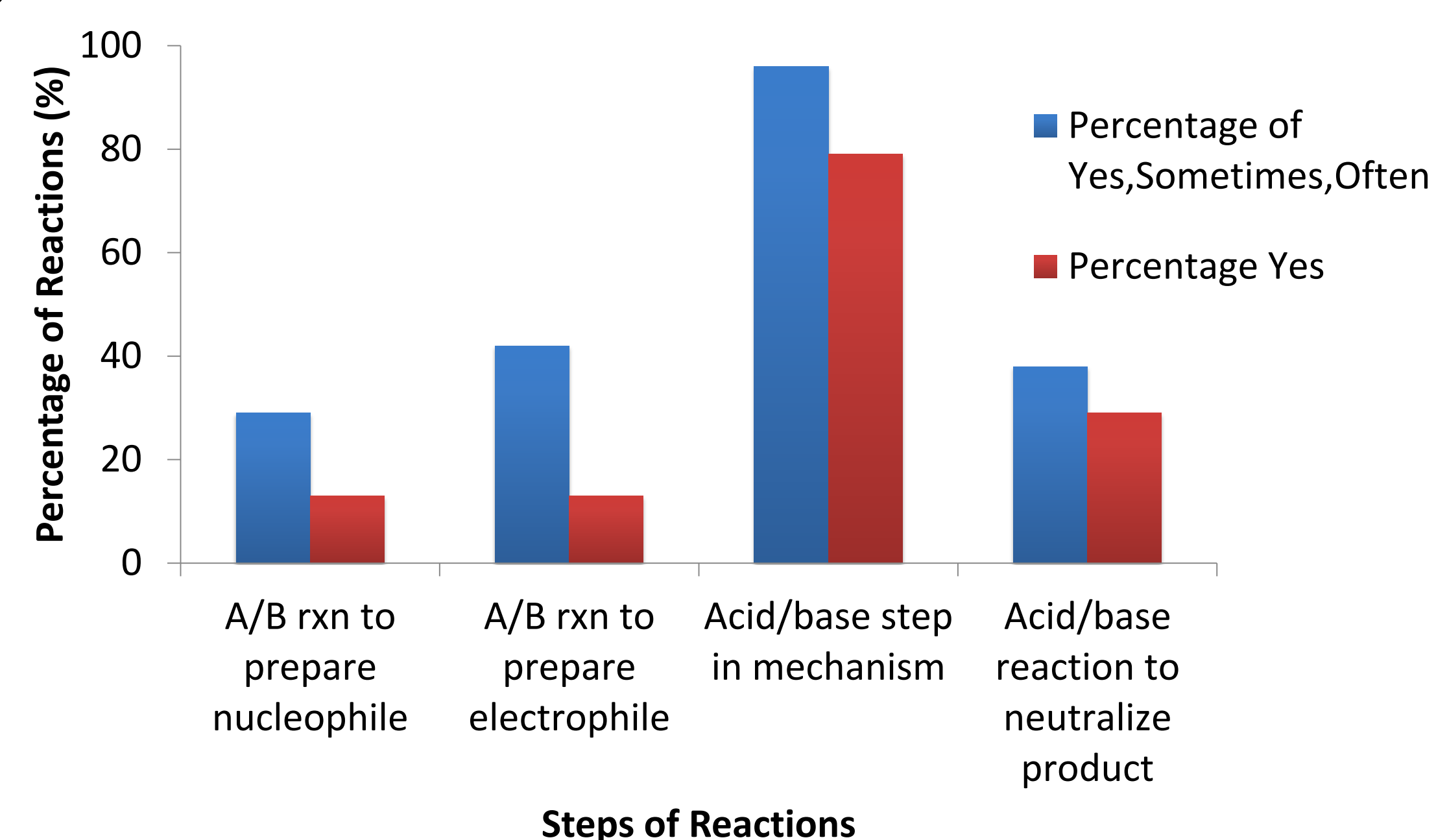


Figure 1. Reactions studied in undergraduate organic chemistry (n=24) were coded based on whether or not acid/base chemistry was needed to complete certain steps in the reaction.

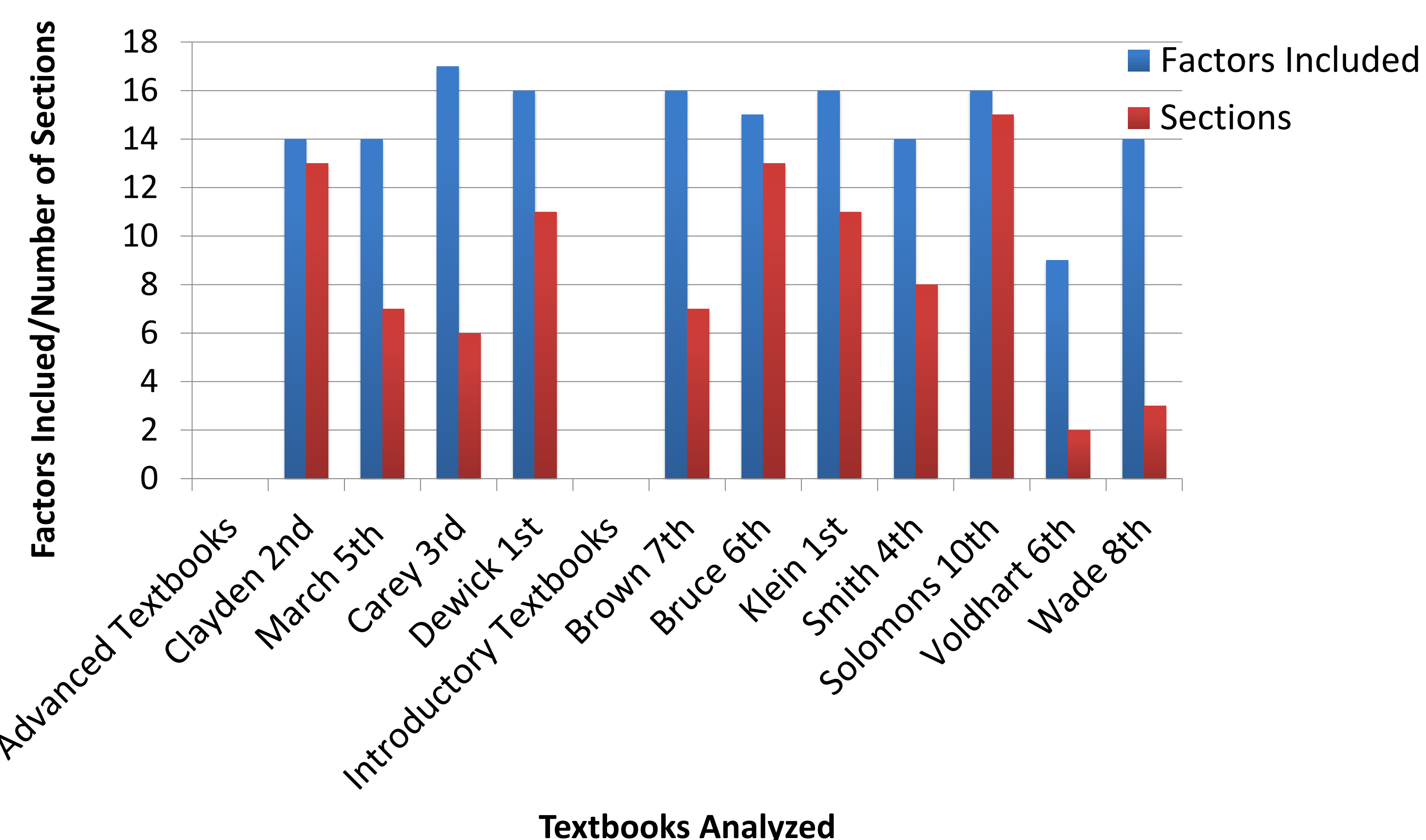


Figure 2. Comparison of organic chemistry textbooks with the number of acid/base concepts they cover and the number of sections pertaining to acid/base chemistry

Results

- Extreme variation existed across introductory and advanced textbooks.
- Of the eleven texts studied, four did not have a chapter devoted to acid/base chemistry forcing the reader on a search for the information.
- **Figure 2**; illustrates that certain textbooks had a very holistic approach to acid/base chemistry and covered all of the factors in depth and efficiently whereas others were greatly lacking.
- By comparing the number of factors to the number of sections related to acid/base chemistry the, at times, gaping difference between the two is evident.
- One may conclude that the presence of the factor alone is not revealing about the quality and extensity of the explanation.
- To determine the most important of the factors from the criteria in used in phase 2 a pilot survey with a small sample size (n=7) was used to assess what professors and graduate students deemed important and to identify any potential missing items.
- **Figure 3**; was created from this data to show the prevalence of the topics deemed important in the textbooks studied.
- Examination of in-text and end of chapter problems revealed significant variances in terms of difficulty, applicability and pertinence to what was taught in the chapter.
- Number of problems also varied ranging from 45 end of chapter questions (Smith) to 0 (March).



Figure 3. Number of textbooks that contained themes deemed critical.

Conclusions

Organic chemistry can be seen as quite abstract to the unassuming first year student. Acid/base chemistry is a fundamental threshold concept needed to succeed in this vast new mechanistic world. This study has revealed that there is not clear agreement within the community (as represented by textbooks) as to what should be taught. It is imperative that the lessons taught in these textbooks are clear, concise and effective at arming the students with the tools needed to accomplish the learning objectives. This research is one part of a large study on acid/base chemistry education.

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