High school biology preparation: Do students feel they have been adequately prepared for introductory college biology?

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Recommended Citation
Neitzel, Mara () "High school biology preparation: Do students feel they have been adequately prepared for introductory college biology?," Empowering Research for Educators: Vol. 3 : Iss. 1 , Article 2.
Available at: https://openprairie.sdstate.edu/ere/vol3/iss1/2

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High schools in South Dakota can drastically differ in size, facilities, and funding. However, each school is required to meet the same state standards. This study focuses on high school biology courses, which have standards designed to: “Ensure graduates of South Dakota’s public schools have the knowledge, skills, and competencies essential to be college, career, and life ready” (South Dakota Department of Education, 2018). Depending on the resources available to a high school, the success of teaching to these standards may vary. Analyzing the effects of high school biology preparation on postsecondary success is important because success in high school STEM courses is directly related to success in college science courses (Hinojosa et al., 2016). The goals of this study are to determine whether high school students in South Dakota feel they have been prepared for introductory college biology courses and why.

**Literature Review**

An important component of a student’s success in college is academic confidence. Academic confidence is a student’s belief in his or her ability to meet the academic and social demands of college. A student’s success in introductory college classes is related to academic confidence (Bickerstaff, Barragan, Rucks-Ahidiana, 2017). Thus, academic confidence is important because success in introductory college courses impacts whether or not a student stays in the class, their current major, or the university all together. In addition, a student’s academic confidence influences his or her self-efficacy. Low academic confidence leads to a student feeling unmotivated, while high academic confidence causes a student to strive for high achievement (Kirikkanat, B. & Soyer, M. K., 2017).
Sander and Sanders (2006) determined that academic confidence is primarily derived from a student’s previous academic experiences and social interactions. A positive experience in high school science courses, for example, increases the likelihood that a student will develop high academic confidence. However, academic confidence is a multifaceted component of a person’s psyche and cannot be directly linked to an exact source. One can only speculate based on current research and personal experiences pertaining to a particular student (Sander & Sanders, 2006). In other words, a person’s academic confidence in college is related to high school preparation, but there are many other contributing factors.

High school environment is another component relating to a student’s success in college. Factors that influence a high school’s environment include: Available resources, funding, quality of school buildings, and quality of staff (Beaulieu et al., 2005). Schools lacking in any of these areas are at risk of negatively impacting student achievement. For example, schools that are underfunded typically have lower achievement than schools with proper funding (Kansas Association of School Boards, 2014). Beaulieu (2005) posited that partnerships between schools, parents, and communities foster an environment conducive to academic achievement. When parents and the community partner with high schools, students receive support. Financial backing for the school is easier to obtain in highly engaged communities. Thus, the schools are better equipped to support and promote academic achievement in students.

Maintaining a high school environment conducive to academic achievement is often difficult in rural schools. The National Science Foundation (NSF) worked to
address this by funding Rural Systematic Initiative (RSI) projects from 1994 to 2008. RSIs were designed to: “[E]nsure that all students in some of rural America’s most impoverished communities are prepared for the 21st century as citizens and workers with a quality education in mathematics and science” (Harmon, Smith, & Edvantia, 2007, p. 3). The RSI projects improved math and science education in rural communities by providing workshops for teachers to expand teaching methods. For example, one RSI workshop emphasized the importance of student investigation and analysis of science questions. The NSF found significant improvements in student achievement after the implementation of RSI across the country (Harmon, Smith, & Edvantia, 2007).

In addition to academic confidence and high school environment, another major factor relating to student success in introductory college classes is whether or not a student has taken Advanced Placement (AP) classes. Students who have taken AP classes in high school have a significant advantage over those who have not. This advantage is present because AP classes allow students to learn college level material before entering introductory college classes (Gagnon & Mattingly, 2016). However, Sadler and Tai (2007) argue that half of the reason AP students are more successful in introductory college courses is due to verbal and mathematical skills obtained independently of AP classes. Thus, AP classes often benefit students that would have been successful in introductory college classes anyway.

Although part of the benefit of AP classes is due to innate student skills, students still benefit from learning college material in high school – given the high school provides access to advanced science courses. However, rural schools often do
not have the resources to provide AP classes or other advanced science courses. Purdue University took action to equip rural schools with resources. They provided funding for support in the form of education, finances, and/or equipment. Indiana state schools began helping teachers with a program called “STEM Goes Rural.” The program description states, “STEM Goes Rural seeks to attract talented, committed individuals with backgrounds in the STEM fields – science, technology, engineering, and mathematics – into teaching in high-need rural Indiana high schools” (Purdue University, 2018). Teachers in this program receive training and a stipend of $30,000. However, there is a 3-year teaching requirement in rural, Indiana schools (Huchel, 2016). The motivation behind STEM Goes Rural is to enhance rural science education through teacher education and support.

Academic confidence, high school environment, and access to advanced science courses are all factors that influence a student’s success in introductory college courses. Since South Dakota produces high school students from rural schools and urban schools, the most prevalent cause of success or lack of success in introductory college biology courses is unknown. The following methods were used to determine if students in South Dakota believe they have been adequately prepared for college biology courses. Additionally, we explored potential reasons as to why students think they were prepared or not.

**Methodology**

A mixed methods survey was designed and administered to freshman students at South Dakota State University. Specifically, these students had
completed either General or Honors Biology 151 in the fall of 2017. The professors of General and Honors Biology 151 distributed the survey link to students in the spring semester of 2018. A mixed methods approach best suited this research question because the qualitative data provided an explanation to trends found in the quantitative data. Mertens (2005) explained the intent of a mixed methods approach: “[T]o seek a common understanding through triangulating data from multiple methods, or to use multiple lenses simultaneously to achieve alternative perspectives that are not reduced to a single understanding” (p. 293).

**Survey Development.** The survey was carefully developed to ensure each question was interpreted reliably by every survey respondent. Dillman (2007) developed a set of criteria to evaluate survey questions. This set of criteria was used to evaluate the survey. Katherine Bertolini, Ph.D, and the Institutional Review Board (IRB) approved the survey. (Appendix A). The survey was left open for one month, and student responses were kept anonymous and confidential.

**Quantitative Data.** The quantitative questions were designed to obtain information about the students such as the number of biology courses taken in high school and grades received in high school and college biology. The survey (Appendix B) contained 22 quantitative questions. Some questions were designed with an ordinal scale. This allowed students to give an accurate response based on prior experiences. An example of a survey question using an ordinal scale is given below.

How would you rate the difficulty of your high school biology course(s)?

- Very Difficult
- Somewhat Difficult
- Neither Difficult nor Easy
In addition, some questions were designed using a scale from 1-10. A score of 10 indicated a student felt strongly positive about the question, while a score of 1 indicated a student felt strongly negative about the question. A score of 5 indicates a neutral response. An example of this type of question is given below.

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<tr>
<td>How well do you feel your high school prepared you for Biology 151?</td>
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<td>6</td>
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<td>9</td>
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The survey was created and responses were analyzed using QuestionPro™. In addition, Statistical Package for the Social Sciences (SPSS)™ sponsored by IBM was used to analyze the survey data. Spearman's rank correlation was the primary statistical test utilized for the ordinal data.

**Qualitative Data.** The qualitative section of the survey was designed to find out how students felt about their high school and college experience and why they felt that way. This section of the survey provided reasoning behind data obtained in the quantitative section. The intent of collecting the qualitative data was to triangulate and humanize the statistical results of the survey. The qualitative questions were analyzed based on common themes. First, the responses were categorized into
positive, neutral, or negative responses. These initial categories varied slightly based on the question. These categories were divided further into subcategories. The subcategories list specific reasons as to why a student responded in a certain way.

**Results**

**Quantitative Data Analysis.** Figure 1-3 show significant findings from the quantitative data. The survey asked students to rate how they felt about the question on a scale of 1-10. A low score indicated a negative response to the question, and a high score indicated a positive response to the question. Students generally felt positive about how well their high schools prepared them for introductory college biology (Figure 1). In addition, 88% of students felt their experience in Biology 151 either did not impact their future goals or had a positive impact (Figure 2). Lastly, most students felt their experience in Biology 151 had no impact or a positive impact on self-confidence (Figure 3).
**Figure 1.** How well do you feel your high school prepared you for Biology 151?

Mean: 6.83

**Figure 2.** Has your experience in Biology 151 impacted your academic or career goals?

Mean: 5.91

**Figure 3.** Has your experience in Biology 151 impacted your self-confidence?

Mean: 5.96
The following quantitative data was analyzed using SPSS™. The statistical test used was Spearman’s rank order correlation. Spearman’s correlation coefficient is appropriate for analyzing ordinal data (Field, 2005, p. 129). Several significant correlations are present in the data.

- Students who attended small schools were more likely to report that an honors and/or AP biology course was not offered at that school.
  Correlation: \(-0.41\) (Honors, p < .01), \(-0.51\) (AP, p < .01)

- Students that rated their high school biology courses as difficult generally rated their experience in Biology 151 as having a positive impact on their academic or career goals. Correlation: 0.33 (p < .01)

- Students that rated their high school biology courses as difficult generally rated their experience in Biology 151 as having a positive impact on their self-confidence. Correlation: 0.36 (p < .01)

- Students that received an A in Biology 151 typically stated their high school prepared them better for college biology compared to their peers.
  Correlation: 0.44 (p < .01)

**Qualitative Data Analysis.** Student responses to the qualitative section of the survey were split into groups based on whether the response was positive, indifferent, or neutral. Then, these groups were further categorized into groups based on common themes. Table 1 depicts the breakdown of responses to each question.
Table 1. Main categories for qualitative data analysis.

<table>
<thead>
<tr>
<th>Q18. Describe your experience in Biology 151.</th>
<th>Positive</th>
<th>Neutral</th>
<th>Negative</th>
<th>Total</th>
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<tr>
<td></td>
<td>26</td>
<td>23</td>
<td>25</td>
<td>74</td>
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</tbody>
</table>

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<tr>
<th>Q19. How has Biology 151 impacted your future academic and career goals?</th>
<th>Change to Bio</th>
<th>No Change</th>
<th>Change from Bio</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>46</td>
<td>18</td>
<td>10</td>
<td>74</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Q20. How did your experiences in Biology 151 impact your decision for your major?</th>
<th>Change to Bio</th>
<th>No Change</th>
<th>Change from Bio</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>9</td>
<td>52</td>
<td>13</td>
<td>74</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Q21. If you could change anything about your high school preparation for introductory college biology classes, what would you change and why?</th>
<th>Change to Bio</th>
<th>No Change</th>
<th>Change from Bio</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>24</td>
<td>3</td>
<td>47</td>
<td>74</td>
</tr>
</tbody>
</table>

Next, responses were put into representative subcategories. The subcategories were created based on common themes present in the responses. Tables 2-5 highlight the top 3 themes found in each group listed above.

Table 2. Q18. Describe your experience in Biology 151.

Positive
- Learned a lot
- AP bio gave good background knowledge
- Lecture was interactive

Neutral
- The class had a lot of busy work
- The class got easier as it progressed.
- Tutoring and Supplemental Instruction helped

Negative
- Poor class structure
- Lecture was not helpful
- Too large of a class
Table 3. Q19. How has Biology 151 impacted your future academic and career goals?

Positive
- The class was a good foundation for future biology classes
- Class made students want to continue in biology
- Improved work ethic

Neutral
- Career goals have not changed
- Didn’t learn anything new

Negative
- Nervous about future biology courses
- Negatively influenced mental health
- Would not recommend a biology major to other students

Table 4. Q20. How did your experiences in Biology 151 impact your decision for your major?

Change to Bio
- Increased interest in biology
- Increased desire to learn
- Successful experience

No Change
- Major was not impacted
- Already had goals set

Change from Bio
- Did not do well in the course
- Faculty in biology program
- Not as interested in biology as previously thought

Table 5. Q21. If you could change anything about your high school preparation for introductory college biology classes, what would you change and why?

No Change
- High school prepared students well
- High school biology was more rigorous than Biology 151
- Advanced science courses helped

Neutral
- Change in personal attitude

Change
- Take high school biology as a junior or senior instead of freshman or sophomore
- Have more rigorous biology courses
- Access to advanced biology courses
Discussion

The results of this survey have several implications for high schools in South Dakota. Student experiences in Biology 151 differently, Biology 151 impacted students’ academic or career goals, and Biology 151 impacted students’ academic confidence.

As seen in Figure 1, students generally responded positively to questions about high school biology preparation. However, there were students who felt negatively about their experience. Although 80% of students rated their experiences from neutral to positive, the other 20% of students rated their experiences negatively.

Student experiences in Biology 151 directly related to their preparation in high school biology. Students who had access to honors or AP biology classes typically had a more positive experience in Biology 151. Question 18 from the qualitative data analysis demonstrated this. One student reflected on their experience in Biology 151, “It was a great time. It was basically a repeat of AP bio. I knew the material already, so it wasn’t terribly hard.” A different student stated, “I honestly had a difficult time grasping onto concepts because my prior biology knowledge was very simple”.

Student experiences in Biology 151 impacted their academic or career goals (Figure 2). Most students responded to this question neutrally or slightly positively. Based on the qualitative results for question 19 and 20, most students in introductory college biology courses already have career and academic goals set in place before college. Thus, a student’s experience in the course, whether positive or negative, typically did not impact his or her career or academic goals. For example,
one student stated, "My future goals have not changed as a result of this course, but I feel well prepared for the next step in my science education". However, some students decided to change their major or career goals after taking Biology 151. This change does not necessarily indicate a negative experience in the course. One student explained, “[Biology 151] made me less interested in biology”. Some students did change specifically because of the course. One student stated, “Biology 151 made me feel less excited about biology. It wasn’t interactive or informational. I feel neutral towards it and don’t see myself recommending a biology major to anyone”.

Student experiences in Biology 151 impacted their self-confidence (Figure 3). Most students reported a neutral to slightly positive impact. These data were of particular interest as related to academic confidence. Academic confidence describes a student’s belief in his or her ability to meet the academic and social demands of college (Bickerstaff, Barragan, & Rucks-Ahidiana, 2017). 22% of respondents indicated Biology 151 negatively impacted self-confidence (see Figure 3). This is significant because students with low academic confidence are more likely to fail or drop out of introductory science classes or college.

The results from the qualitative data indicated why students feel self-confidence was impacted. One student reported a positive impact on self-confidence. “Because I enjoyed the content, I have decided to continue on with my major and have even considered attending graduate school”. While a student who experienced a negative impact on self-confidence stated, “My mental health took a
beating”. This negative impact on the student may cause him or her to decide to change majors or drop out of school.

The qualitative data obtained from question 21 provided insight to what students would change about their high schools if given the chance. Most answers related to whether or not a student’s high school provided access to advanced biology courses. For example, one student said they wouldn’t change anything about high school biology because, “I had a very good teacher for high school biology and felt I was perfectly prepared for Biology 151”. On the other hand, some students would change their preparation in high school. One student explained, “I really liked my high school bio, but I feel that there needed to be a section for kids going on in a science field, and one for kids who just simply needed it for a graduation requirement. I don’t feel I was pushed as much as I could have been”.

**Conclusion and Implications**

The data indicated that there is not equal access to advanced biology courses in high schools. High schools with a smaller student body are less likely to offer honors or AP biology courses. This may be due to a lack of funding, qualified teaching staff, or student interest in these courses (Gagnon & Mattingly, 2016). Having a more rigorous biology course in high school was found to increase the grade received in college biology. Thus, students who have access to advanced high school biology courses are at an advantage to those who do not.

Further research on specific student success indicators, such as motivation and grit, may help identify why students have different experiences in high school and college biology courses. The amount of student responses is a limitation of this
study. In future studies, students from each grade level and potentially different universities should be surveyed.
References


Appendix A

To: Mara Neitzel and Katherine Bertolini, Department of Teaching, Learning, and Leadership

Date: November 21, 2017

Project Title: High School Biology Preparation: Do Students Feel They Have Been Adequately Prepared for Introductory College Biology?

Approval #: IRB-1711031-EXM

Thank you for bringing your project to the Human Subjects Committee. Your project is approved as exempt from the Common Rule because it fits the following category (from 45 CFR 46.101 (b)):

(2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless:
   (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation.

If there are any unanticipated problems involving risks to subjects or others or changes in procedures during the study, please contact the SDSU Research Compliance Coordinator. Please inform the committee when your project is complete.

If I can be of any assistance, don’t hesitate to let me know.

Sincerely,

Dianne Nagy
Acting IRB Coordinator
Appendix B

Mixed Methods Survey:

Student Demographics:

1. What is your major/minor? ________________

2. What is your age?
   - <18
   - 18
   - 19
   - 20
   - 21
   - 22
   - >22

3. In what state did you attend High School?
   - SD
   - ND
   - MN
   - NE
   - IA
   - MT
   - WI
   - Other (please list) ________________

High School Information:

4. Approximately how many students were in your graduating class?
   - <25
   - 26-50
   - 51-100
   - 101-150
   - 151-200
   - 201-250
   - 251-300
   - >300

5. How many biology courses did you take in high school?
   - 0
   - 1
   - 2
   - 3
   - >3
6. Was an honors biology course offered at your high school?
   o Yes
   o No

   Did you take the honors course?
   o Yes
   o No
   o N/A

7. Was an AP biology course offered at your high school?
   o Yes
   o No

8. Did you take the AP biology course?
   o Yes
   o No
   o N/A

9. How would you rate the difficulty of your high school biology course(s)?
   o Very Difficult
   o Somewhat Difficult
   o Neither Difficult nor Easy
   o Somewhat Easy
   o Very Easy
   o Undecided

10. What grade did you earn in high school biology? (Average grades between multiple classes if applicable).
    o A
    o B
    o C
    o D
    o F

**College Information:**

11. Which Biology 151 course did you take?
    o General Biology 151
    o Honors Biology 151

12. What grade were you when you took Biology 151?
    o Freshman
    o Sophomore
    o Junior
    o Senior
13. What academic year and semester did you take Honors/General Biology 151?
   - Fall 2015
   - Fall 2016
   - Fall 2017
   - Other (please list) _______________

14. What grade did you receive in Biology 151?
   - A
   - B
   - C
   - D
   - F

15. What grade were you hoping to receive in Biology 151?
   - A
   - B
   - C
   - D
   - F

16. Did you attend tutoring or supplemental instruction for Biology 151?
   - Yes
   - No

   17. If yes, how often did you attend tutoring or supplemental instruction?
       - Weekly
       - Every other week
       - Monthly
       - Once
       - N/A

**Open Response**

18. Describe your experience in Biology 151.

19. How has Biology 151 impacted your future academic and career goals? Please explain.

20. How did your experiences in Biology 151 impact your decision for your major? Please explain.

21. If you could change anything about your high school preparation for introductory college biology classes, what would you change and why?
Use the rating scale from 1-10 to answer the next questions. A score of 10 indicates you feel strongly positive about the question. A score of 5 indicates you feel neutral about the question. A score of 1 indicates you feel strongly negative about the question.

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