



# The Impact of Experiential Learning in Host-Pathogen Research on Medical Students' Interests and Attitudes towards Microbiology and Immunology

Jorge Cervantes<sup>a</sup> and Bo-Young Hong<sup>b</sup>

<sup>a</sup>Paul L. Foster School of Medicine, Texas Tech University Health Sciences Center, El Paso, Texas, USA

<sup>b</sup>Jackson Laboratory for Genomic Medicine, Farmington, Connecticut, USA

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## INTRODUCTION

There is a shortage of residents in the infectious diseases (IDs) specialty due to a lack of interest in this field. If the choice of an ID subspecialty is linked to medical school experiences, then how we teach microbiology and immunology could be a factor in the declining interest in the field. We sought to determine whether experiential learning activities on host-pathogen research might improve students' interests and attitudes toward medical microbiology and immunology.

### Shortage of infectious disease specialists

Over the past decade, there has been a steady decline in the number of internal medicine residents applying for fellowship positions in infectious diseases (IDs) (1, 2). The declining interest in ID subspecialization has left many in the field concerned for the sustainability of the discipline and its ability to meet the service needs of the public. Since ID had already acquired the distinction of routinely dealing with new diseases (3), a lack of ID specialists proves to be even more crucial in a scenario such as the current coronavirus pandemic or the continuous emergence of antibiotic-resistant microbes.

Only 40 to 42% of internal medicine residents consider ID, while 53 to 61% are uninterested (4, 5). Of those who considered ID, 73% changed their mind in their second and third postgraduate years, citing salary (22%), lack of procedures (18%), and training length (18%) as primary deterrents to choosing ID (4).

## Improve ID teaching

Almost 3/4 of residents who selected ID as a career became interested in their chosen field before or during medical school (5). If the choice of an ID subspecialty is linked to medical school experiences, then how we teach microbiology, antibiotic therapy, and the management of ID could be a factor in the declining interest in the field. The majority of undergraduate medical education (UME) learners report relying on memorization, rather than more-effective techniques when learning ID and microbiology. Interestingly, those who experienced nonmemorization and case-based learning have an increased likelihood of selecting a career in ID (6).

Many possible solutions to this shortage of ID applicants have been proposed (2). Among these is the need to improve ID experience among internal medicine residents, with increased research interests, support and mentoring, involvement of medical students and residents in ID societies, and encouragement of presentations at meetings.

Methods of teaching basic science in medical schools are rapidly changing (7). Since scholarship activities are mandatory in our medical school curriculum, we here aimed to determine whether experiential learning activities on host-pathogen research might improve students' interests and attitudes toward medical microbiology and immunology.

## METHODS

We sought to identify the impact and benefits that experiential learning through microbiology-immunology research could have on specific areas of motivation, learning, career, and social niche. A survey was conducted on 16 medical students from Texas Tech University Health Sciences Center at El Paso, Paul L. Foster School of Medicine, who undertook their Scholarship and Research Program (SARP) project on a topic related to host-pathogen interaction between 2017 and 2019. SARP is a mandatory, highly dynamic, active-learning core curriculum, which

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Address correspondence to Paul L. Foster School of Medicine, Texas Tech University Health Sciences Center, El Paso, Texas, USA. E-mail: [jorge.cervantes@ttuhsc.edu](mailto:jorge.cervantes@ttuhsc.edu).

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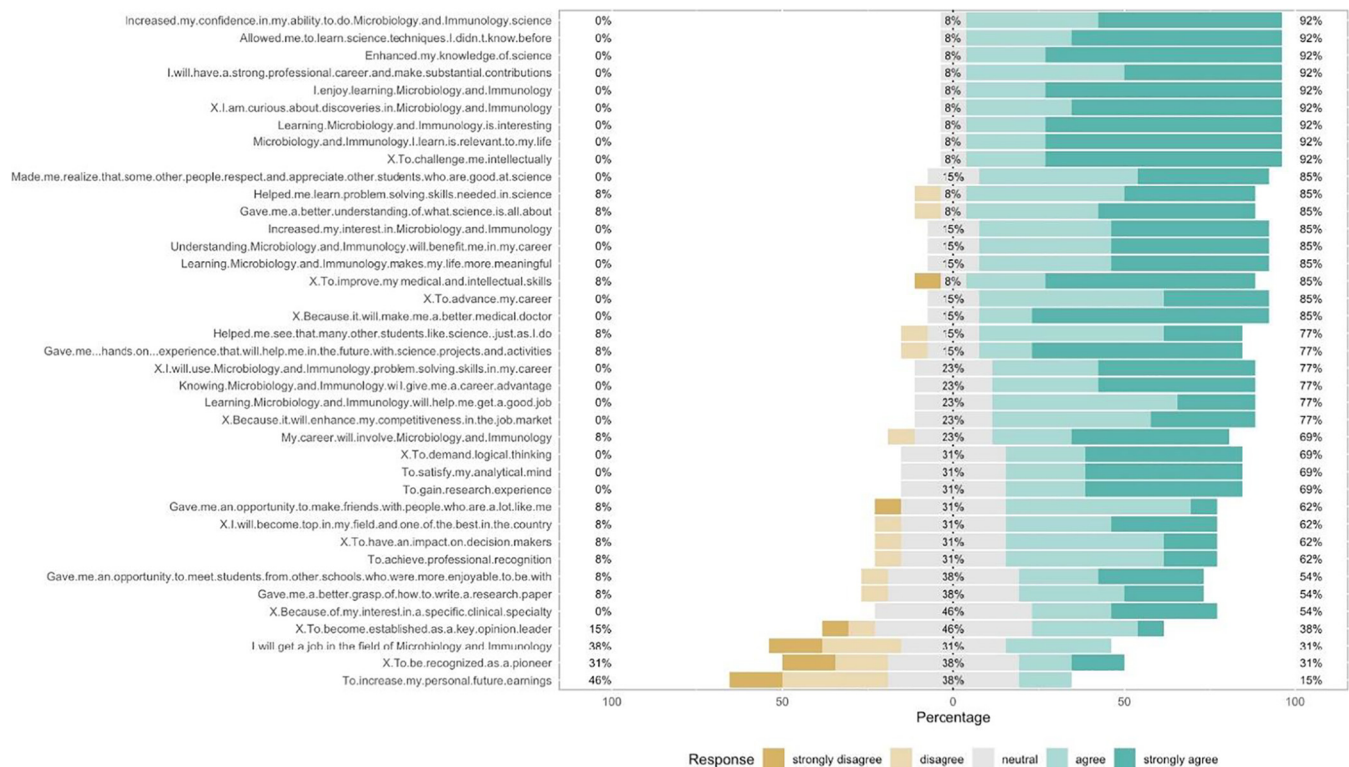


FIG 1. Top survey items showing a positive response. A graph shows survey items arranged in decreasing order of their percentages of positive responses (i.e., agree and strongly agree) on the right (green).

requires the students to identify a mentor and develop an independent research project early in their training (8). The program allows students to be exposed to research in any field, with any mentor, on any topic of their interest. The scope of this study focused on students who opted to develop scholarship projects related to hosts and pathogens. The course entailed development of a research question or project theme, a literature search to identify previous knowledge and theory that provides the context and relevance for the project, the development of a rationale for their project along with specific aims, a plan for the execution, laboratory experimentation for the acquisition and analysis of data, and the development of communication skills in the presentation of their project at a SARP symposium. Sixteen students performed a host-pathogen project which included projects evaluating human cells interaction with microbes, bacterial recognition, antimicrobial action, phagocytosis, and the effect of high glucose in the response to pathogens (9–11). Most projects were carried within a 3.5- to 4-month period, with a few being developed though a year.

The project met the criteria for exemption from formal IRB review in accordance with Code of Federal Regulations Title 45 CFR 46.104(d) (1): research, conducted in established or commonly accepted educational settings, that specifically involves normal educational practices that are not likely to adversely impact students' opportunity to learn required educational content or the assessment of educators who provide instruction. The survey was anonymous,

delivered via an online platform, and consisted of items selected from previously published surveys, and evaluated medical students' attitude and motivation in pursuing the mentioned research project (12), power and cognitive motivations (13), intrinsic motivation, career motivation (14), and future career self, as well as subjective attitude change after the experiential learning (i.e., increased science motivation, confidence, and knowledge) and developing of a new social niche (15).

Responses were recorded on a 5-point Likert scale, on which 1 represented "strongly disagree," and 5 represented "strongly agree." Data were analyzed with R using the sjPlot-package for *Data Visualization for Statistics in Social Science*. A principal-component analysis (PCA) was performed to identify sources of variation across the survey items.

## RESULTS

Of 16 students, 14 responded to the survey (87.5% response rate). Overall, 32 survey items showed more than 60% of their responses as positive (i.e., agree and strongly agree) (Fig. 1). The majority of participants stated that the main reasons to carry out their research in host-pathogen interactions were to gain research experience (71.4%), to enhance competitiveness in the job market (71.5%), and because it will make them better medical doctors (85.7%).

Performing research in host-pathogen interactions was

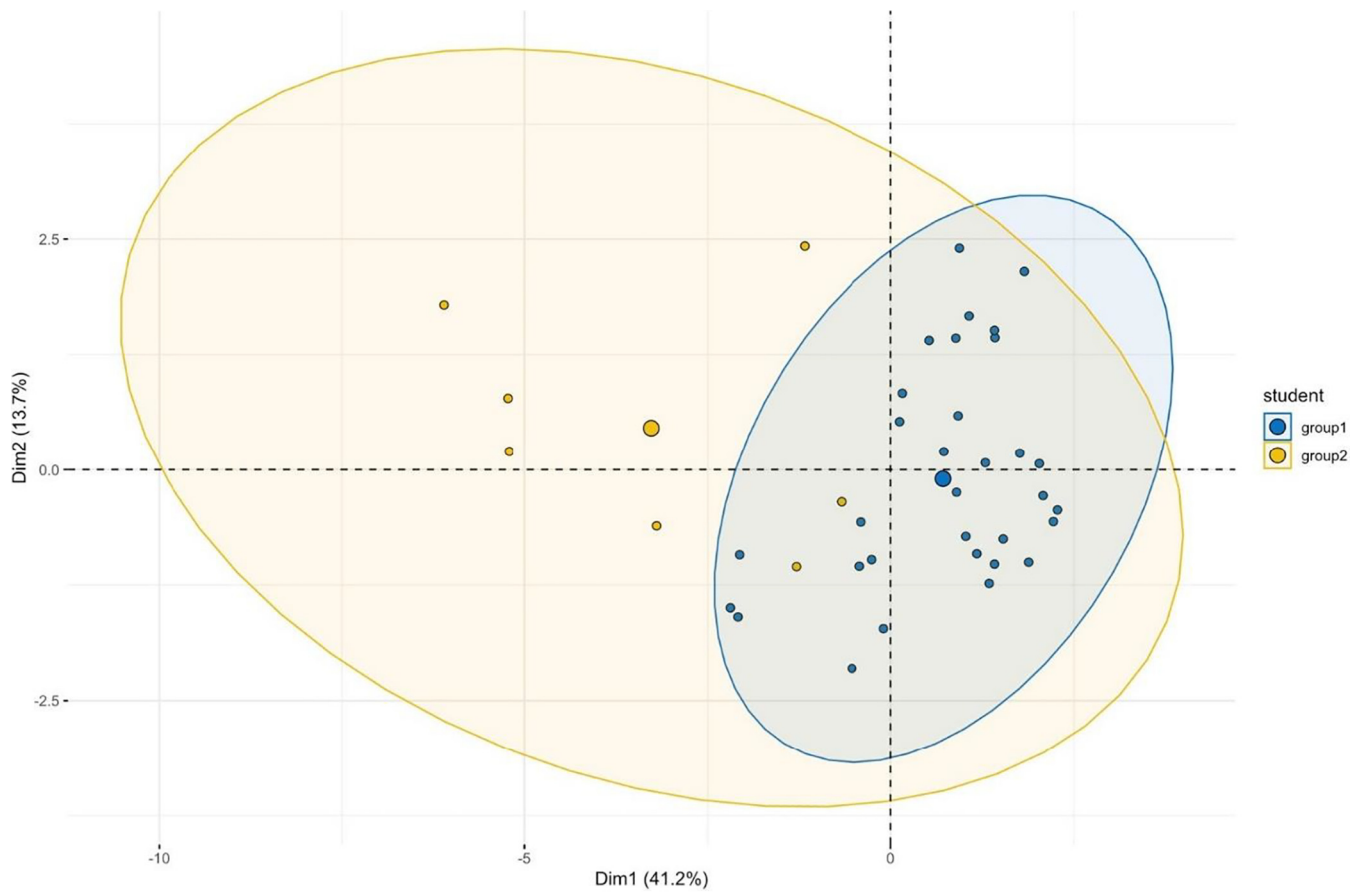


FIG 2. Clustering of positive versus negative responses. A PCA plot shows the clustering of items with >60% positive responses (blue) versus those that had <60% positive responses (yellow).

perceived as an advancement in their career (78.6%) and having an impact on decision making (71.5%). Cognitively, it was perceived as satisfying the analytical mind (71.4%), intellectually challenging (92.8%), a way to improve medical and intellectual skills (85.7%), and a demand in logical thinking (71.4%). Motivationally, most of the stated that learning microbiology and immunology was relevant to their lives (92.8%), interesting (92.8%), made their lives more meaningful (78.6%), enjoyable (92.8%), and made them curious about discoveries in those fields (92.9%).

When exploring career motivation, most of the participants felt that learning microbiology and immunology will help them get a good job (78.5%), would give them a career advantage (78.6%), and benefit their career (85.8%). The majority answered that their career will involve Microbiology and Immunology (64.3%), and will use microbiology and immunology problem-solving skills in my career (71.5%).

Regarding future career self, a great proportion of the responses showed that the participants will have a strong professional career and make substantial contributions (92.9%). A great number of the participants considered their experience in developing a project in host-pathogen interactions to have increased their interest in microbiology and immunology (85.8%), as well as their confidence in their ability to do

microbiology and immunology science (92.9%), enhanced their knowledge of science (92.8%), and allowed them to learn science techniques (92.9%), giving them “hands-on” experience that will help me in their future science projects and activities (78.5%). It also gave them a better understanding of what science is all about (85.7%) and helped them learn problem-solving skills needed in science (85.7%).

The research experience also had an impact in their new social niche, helping participants to see that many other students like science, just as them (78.5%), and that some other people respect and appreciate other students who are good at science (85.7%).

Inversely, items exploring interest in becoming a key opinion leader, getting a job in the field of microbiology and immunology, being recognized as a pioneer, or increasing personal future earnings had less than 50% positive responses (Fig. 1).

A PCA showed clustering of those items >60% positive responses versus those that had <60% positive responses (Fig. 2).

## DISCUSSION

SARP is a three-credit, mentor-guided, hands-on research

experience completed while in medical school (8). It provides medical students with an opportunity to design and execute independent scholarship or research projects under the guidance of faculty mentors. The course allows for a project to be tailored to a student background and interests. Improving the teaching of preclinical microbiology and infectious diseases can utilize a new approach that emphasizes active learning (16). Authentic learning with examples of research-led teaching can be presented via a science platform with a microbiological focus (17), along with teaching support from university research laboratories (18). Applying principles from bioengineering can also improve microbiology learning (19). Here, we show that experiential learning of medical students undertaking research project on microbiology and immunology leads to subjective attitude changes (i.e., increased science motivation, confidence, and knowledge) and development of a new social niche. As projects were developed in the same laboratory, with lab meeting, and preparations for result presentations, students were in fact immersed in a new social niche where they could interact with other students who were also interested in science, sometimes from other universities. This gave them the opportunity to make friends with people who think alike or shared the same interests. It also let students learn new scientific techniques and use novel technological devices, which also have an impact in the experiential learning of basic sciences such as microbiology and immunology (20). It was also apparent that students were not interested in aspiring to notoriety, self-boasting, or financial success, since the aspects of becoming a key opinion leader, being recognized as a pioneer, or increasing future earnings had less than 50% positive responses.

Experiential learning that is aligned with organizational goals can also help achieve improvements in quality and safety at the clinical level while also improving the education and competency of trainees (21). This is particularly important since microbiology and immunology are taught in the preclerkship years.

Although the majority of the participants had a background in science, the extent of the impact in developing a larger population of physician-scientists goes beyond the promotion of ID as a subspecialty. Physician-scientists, independent of their research focus, serve a number of key roles (22). Furthermore, they promote scholarship and excellence in research with potential impact not only within their field but globally among other disciplines. They also contribute significantly to the training experiences of ID fellows, internal medicine residents, and students, by providing evidence-based medicine patient care and through the pursuit of research questions enrich the scholarly environment providing the foundation for translational medicine (22).

## APPENDIX

### Questionnaire

I decided to carry out research in host-pathogen interactions:

A1—to gain research experience

A2—because of my interest in a specific clinical specialty  
A3—because it will enhance my competitiveness in the job market

A4—because it will make me a better medical doctor

Performing research in host-pathogen interactions will:

P1 . . . achieve professional recognition.

P2 . . . advance my career.

P3 . . . established me as a key opinion leader.

P4 . . . have an impact on decision makers.

P5 . . . increase my personal future earnings.

P6 . . . lead to my being recognized as a pioneer.

Performing research in host-pathogen interactions will:

C1 . . . satisfy my analytical mind.

C2 . . . challenge me intellectually.

C3 . . . improve my medical and intellectual skills.

C4 . . . demand logical thinking.

Regarding microbiology and immunology:

Q1. The microbiology and immunology I learn is relevant to my life.

Q2. Learning microbiology and immunology is interesting.

Q3. Learning microbiology and immunology makes my life more meaningful.

Q4. I am curious about discoveries in microbiology and immunology.

Q5. I enjoy learning microbiology and immunology.

Q6. Learning microbiology and immunology will help me get a good job.

Q7. Knowing microbiology and immunology will give me a career advantage.

Q8. Understanding microbiology and immunology will benefit me in my career.

Q9. My career will involve microbiology and immunology.

Q10. I will use microbiology and immunology problem-solving skills in my career.

Regarding your future self-career:

F1. I will get a job in the field of microbiology and immunology.

F2. I will have a strong professional career and make substantial contributions.

F3. I will become top in my field and one of the best in the country.

My experience in developing a project in host-pathogen interactions:

S1. Increased my interest in microbiology and immunology.

S2. Increased my confidence in my ability to do microbiology and immunology science.

S3. Enhanced my knowledge of science.

S4. Allowed me to learn new science techniques.

S5. Gave me “hands-on” experience that will help me in the future with science projects and activities.



S6. Gave me a better understanding of what science is all about.

S7. Gave me a better grasp of how to write a research paper.

S8. Helped me learn problem-solving skills needed in science.

My experiences in the research project:

SOC1. Helped me see that many other students like science, just as I do.

SOC2. Made me realize that some other people respect and appreciate other students who are good at science.

SOC3. Gave me an opportunity to meet students from other schools who were more enjoyable to be with.

SOC4. Gave me an opportunity to make friends with people who are a lot like me.

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