Longitudinal interprofessional education in a graduate physiology course

Lisa M. Harrison-Bernard,1 Mihran V. Naljayan,2 Donald E. Mercante,3 Tina Patel Gunaldo,4 and Scott Edwards1

1Department of Physiology, Louisiana State University Health Sciences Center–New Orleans School of Medicine, New Orleans, Louisiana; 2Section of Nephrology and Hypertension, Louisiana State University Health Sciences Center–New Orleans School of Medicine, New Orleans, Louisiana; 3Department of Biostatistics, Louisiana State University Health Sciences Center–New Orleans School of Public Health, New Orleans, Louisiana; and 4Center for Interprofessional Education and Collaborative Practice, Louisiana State University Health Sciences Center–New Orleans, New Orleans, Louisiana

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INTRODUCTION

Training students in team-based behaviors or interprofessional collaborative practice skills is a developing evidence-based practice in health education. Many health educational accreditation organizations have required the integration of interprofessional education (IPE) in accreditation standards. IPE is defined as, “When students from two or more professions learn about, from and with each other to enable effective collaboration and improve health outcomes” (7). In the United States, faculty use the four Interprofessional Education Collaborative (IPEC) competencies (values/ethics, roles/responsibilities, interprofessional communication, and teams and teamwork) and respective 39 subcompetencies when developing IPE experiences for health professional students (8).

In 2015, the Louisiana State University Health Sciences Center-New Orleans (LSUHSC-NO) established a centralized office, the Center for Interprofessional Education and Collaborative Practice (CIPECP), to support faculty training and student learning in IPE. A goal of the CIPECP was to increase interprofessional learning for all students enrolled in all six schools (Allied Health Professions, Dentistry, Graduate Studies, Medicine, Nursing, and Public Health) by assisting faculty in the development and implementation of meaningful IPE experiences.

Two LSUHSC-NO physiology faculty members involved in a graduate course that enrolls multiple healthcare disciplines, basic science graduate students enrolled in the School of Graduate Studies, and physical therapy (PT) and physician assistant (PA) students from the School of Allied Health Professions, independently developed IPE experiences for the endocrine (2, 3) and renal (5) blocks of the course in 2016 and 2017, respectively. Edwards, et al. (2, 3) and Harrison-Bernard et al. (5) reported positive changes in student IPE perceptions after case-based physiology IPE sessions. The outcome from the studies supported interprofessional learning within multidisciplinary basic science courses. Both faculty members decided it was important to determine the impact on student learning from consecutive IPE experiences within the same semester. Therefore, in 2018, the faculty members collaborated to develop an IPE assessment tool representative of questions from previous years and containing mutual student learning objectives.

IPE researchers commonly use the Kirkpatrick Model to evaluate the effectiveness of IPE learning activities. The Kirkpatrick Model includes four levels: 1) reaction, 2) learning, 3) behavior, and 4) results (8). In 2000, Barr, et al. (1) expanded the original four-level model to include six categories when evaluating IPE. Specific to this research study, the authors assessed levels 1: reaction; 2a: learning—modification of attitudes/perceptions; and 2b: learning—acquisition of knowl-
Questions 5–7 are the results of the number of correct responses to open-ended questions.

| Question No. | Renewal Level | Type | Question | Survey Type |
|--------------|---------------|------|----------|-------------|
| 1            | 2a            | Likert scale | I am able to communicate my roles and responsibilities clearly to other healthcare professional students. | Pre and Post |
| 2            | 2a            | Likert scale | I am able to explain the roles and responsibilities of a physical therapist. | Pre and Post |
| 3            | 2a            | Likert scale | I am able to explain the roles and responsibilities of a physician assistant. | Pre and Post |
| 4            | 2a            | Likert scale | I am able to explain the roles and responsibilities of a science researcher. | Pre and Post |
| 5            | 2b            | Open-ended | The role and responsibilities of a basic research scientist include . . . | Pre and Post |
| 6            | 2b            | Open-ended | The role and responsibilities of a physical therapist include . . . | Pre and Post |
| 7            | 2b            | Open-ended | The role and responsibilities of a physician assistant include . . . | Pre and Post |
| 8            | 2b            | Open-ended | My role on an interprofessional team is . . . | Pre and Post |
| 9            | 1             | Likert scale | I encouraged other team members to share their ideas and opinions as related to the case. | Post |
| 10           | 1             | Likert scale | Everyone on the team contributed to the discussion. | Post |
| 11           | 1             | Likert scale | There was sufficient time dedicated to the IPE case-based learning experience. | Post |
| 12           | 1             | Open-ended | Do you have any suggestions for improving this class session? | Post |

IPE, interprofessional education; Pre, presurvey; Post, postsurvey.

e edge/skills (1). The reaction and learning levels are most commonly assessed in IPE environments.

The students were asked to apply foundational renal physiology or endocrine physiology knowledge to a patient case and then engage in interprofessional discussions focused on the following IPEC subcompetencies:

- Roles/responsibilities (RR1): Students should be able to communicate their roles and responsibilities clearly to other health care professionals.
- Roles/responsibilities (RR4): Students should be able to explain the roles and responsibilities of other care providers and how the team works together to provide care.

METHODS

Participants. Second-semester Doctoral (n = 7) and Master’s (n = 2) degree students from the School of Graduate Studies (SGS), third-semester Doctoral students in PT (n = 35), and first semester Master’s students in PA (n = 30) programs in the School of Allied Health Professions participated in both the renal and endocrine IPE learning experiences.

Students were organized into nine small groups of eight to nine members. Each small group included at least one representative from all three professions. One SGS student was a member of each group. The student group members remained the same over the two IPE sessions.

Study design. The renal IPE learning experience was held in February and was 120 min in length, whereas the endocrine IPE learning experience followed 6 wk later in March and was 60 min in length. One week before the experiences, faculty posted IPE session documents to the university’s electronic educational platform for students to review. Both IPE experiences presented patient cases, but the renal case was delivered through an electronic quiz format, requiring students to type in answers before proceeding to the next question, whereas the endocrine case did not require written answers to discussion questions. The order of the IPE experience was as follows: 1) presurvey, 2) clinical case, 3) small group discussion, 4) write answers on large poster notes, 5) entire class discussion, and 6) postsurvey. Class time was provided to complete an IPE pre- and postsurvey using a personal laptop computer, if the student consented to participation. The research portion was anonymous and was approved by the institutional review board at LSUHSC-NO (no. 9260).

The details of the acute kidney injury case (5) and female athlete triad (2, 3) have been previously described. Faculty facilitators were available throughout both sessions and moved freely among the student groups. After students completed small-group discussions, student groups were asked to write on large poster notes displayed in the classroom. Teams responded to questions about the role of a PT, PA, and science researcher. As an entire class, student responses were confirmed and/or modified by faculty representing the profession.

Data collection and analysis. The outcomes of the two IPE experiences during the 2018 spring semester were quantitatively assessed and included a comparison of the students’ perceived abilities to communicate their roles and responsibilities clearly to other health care professional students; explain the roles and responsibilities of a science researcher, PT, and PA; and explain how a team works together to provide care as related to acute kidney injury and the female athlete triad, both before and after the IPE experience. Student written responses describing the roles of a science researcher, PT, and/or PA were also assessed pre- and postexperiences. Students evaluated the IPE activity and responded to one open-ended question regarding their suggestions for improving the IPE experience. Student responses to the renal presurvey were compared with the endocrine presurvey responses, as well as the renal postsurvey responses compared with the endocrine postsurvey responses. These comparisons were performed to determine whether there were significant improvements in student perceptions and knowledge of the roles and respons-

Table 2. Renal and endocrine pre- and postsurvey results

| Question No. | Renal Presurvey | n | Renal Postsurvey | n | Endocrine Presurvey | n | Endocrine Postsurvey | n |
|--------------|-----------------|---|-----------------|---|---------------------|---|---------------------|---|
| 1            | 3.92 (0.89)     | 51 | 4.42 (0.54)    | 43 | 3.89 (0.99)        | 53 | 4.41 (0.66)        | 44 |
| 2            | 2.90 (1.05)     | 29 | 4.15 (0.78)    | 26 | 3.45 (0.96)        | 31 | 4.32 (0.72)        | 28 |
| 3            | 2.42 (0.81)     | 26 | 3.96 (0.88)    | 23 | 3.36 (1.16)        | 28 | 4.43 (0.51)        | 21 |
| 4            | 2.91 (1.02)     | 45 | 4.19 (0.66)    | 37 | 2.94 (1.15)        | 47 | 4.21 (0.62)        | 38 |
| 5            | 1.04 (0.59)     | 25 | 2.42 (1.06)    | 26 | 1.03 (0.61)        | 36 | 1.37 (0.58)        | 27 |
| 6            | 1.16 (0.60)     | 19 | 2.00 (0.74)    | 20 | 1.41 (0.55)        | 28 | 1.68 (0.75)        | 22 |
| 7            | 1.50 (0.87)     | 18 | 2.58 (1.07)    | 18 | 1.45 (0.95)        | 22 | 1.83 (1.17)        | 12 |

Values are means (SD); n, no. of responses. Questions 1–4 are the results of the Likert scale (1–5; strongly disagree, disagree, neutral, agree, strongly agree). Questions 5–7 are the results of the number of correct responses to open-ended questions.

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sibilities of the other health professional students when exposed to multiple IPEs in a single graduate physiology course.

The presurvey included a total of 9 questions, and the postsurvey included 13 questions. Both pre- and postsurveys included three anonymous identifier questions. Based on the students’ declared profession, the logic of the subsequent IPEC sub-competency questions changed. For example, if students declared their profession as a PT, they were asked to rate their ability to explain the role of a basic science researcher and PA. All students answered question 1 (Q1), students only answered two questions in the Q2–Q4 groups, and students only answered two questions in the Q5–Q7 group.

Table 1 provides an overview of the survey questions (not including demographic questions), Kirkpatrick assessment level, and measurement type. The pre/post-paired comparisons were carried out using the Wilcoxon signed-rank test. P value of < 0.05 indicates statistical significance.

Students evaluated the IPE activities and responded to one open-ended question regarding their suggestions for improving the IPE experience. Student responses to the renal presurvey were compared with the endocrine presurvey responses, and the renal postsurvey responses were compared with the endocrine postsurvey responses. These comparisons were performed to determine whether there were significant improvements in student knowledge of the roles and responsibilities of the other healthcare students when exposed to multiple IPEs in a single graduate physiology course.

Student responses indicated on large poster notes were used to compare answers provided by students for Q5–Q7. Factual roles of the professions were noted from poster notes and used as answers when analyzing Q5–Q7. The responses to these three questions were analyzed by L.M.H.B. or S.E. (authors), and the number of correct responses for the roles of the healthcare students was quantified by both L.M.H.B. and S.E. in a blinded fashion. The average values were obtained and used for statistical comparisons. Quantitative analyses were performed using the Statistical Analysis System (version 9.4).

RESULTS

Fifty-four percent of the students enrolled in the physiology course participated in both the pre- and postsurvey for the renal IPE experience, whereas 58% participated in both the pre- and postsurvey for the endocrine IPE experience. There was a potential of 54 paired data sets across both IPE experiences. However, there were missing data elements noted in student surveys. We collected paired data from 26 PA, 22 PT, and 6 SGS students. Table 2 includes descriptive statistics from the renal and endocrine pre- and postsurvey results.

Table 3 provides a summary of the data analysis for the renal presurvey responses. There was a statistically significant increase from the pre- to postsurvey for the renal IPE activity. There was no significant change in the knowledge gained on the roles of the basic science researcher, PT, and PA increased significantly from the pre- to postsurvey for the renal IPE activity.

Table 4 provides a summary of the data analysis for the endocrine activity. There was a statistically significant increase from pre- to postsurvey scores for Q1–Q4 for all students. There was no significant change in the knowledge gained on the roles of the basic science researcher, PT, and PA as reflected in the presurvey and postsurvey responses.

Table 5 provides a summary of the renal and endocrine presurvey responses. There was a significant increase in the presurvey responses compared with the prerenal responses for the ability to explain the roles and responsibilities of a PT and PA, but not for the science researcher.

Table 6 summarizes the scored correct responses for the renal and endocrine experiences. The data for the renal and endocrine presurveys were combined, as was the data for the postsurveys. The top responses for each question are noted in Table 6.

Table 7 summarizes the results for the renal and endocrine postsurveys. There was a significant increase in the mean Likert scores for the renal compared with the endocrine postsurveys for Q10, indicating that there was an increased participation by the team members on the second IPE experience.

Finally, we assessed whether students could describe their roles within the context of an interprofessional team in the pre- and postsurveys for both exercises. This question was specifically designed to assess how students could communicate their team-oriented roles as an extension of the previous knowledge questions that surveyed their understanding of individual roles. For example, an individual PT role that was communicated was “assess function and mobility and provide treatment if necessary.”

Table 3. Renal pre- and postsurvey results

| Question No. | Presurvey | Postsurvey | Postsurvey vs. Presurvey | n  | P Value |
|--------------|-----------|------------|--------------------------|----|---------|
| 1            | 3.93 (0.89) | 4.45 (0.55) | 0.52 (0.91) | 40  | 0.0002* |
| 2            | 2.87 (1.06) | 4.30 (0.47) | 1.43 (0.99) | 23  | <0.0001*|
| 3            | 2.52 (0.81) | 4.09 (0.62) | 1.57 (1.03) | 21  | <0.0001*|
| 4            | 2.94 (0.98) | 4.20 (0.69) | 1.26 (0.83) | 34  | <0.0001*|
| 5            | 1.06 (0.66) | 2.56 (1.01) | 1.50 (1.13) | 16  | 0.0004* |
| 6            | 1.07 (0.59) | 2.10 (0.71) | 1.03 (0.99) | 15  | 0.0005* |
| 7            | 1.50 (0.97) | 2.59 (0.74) | 1.09 (1.02) | 11  | 0.008*  |

Values are means (SD); n, no. of responses. Questions 1–4 are the results of the Likert scale (1–5; strongly disagree, disagree, neutral, agree, strongly agree). Questions 5–7 are the results of the number of correct responses to open-ended questions. *Statistical significance.

Table 4. Endocrine pre- and postsurvey results

| Question No. | Presurvey | Postsurvey | Postsurvey vs. Presurvey | n  | P Value |
|--------------|-----------|------------|--------------------------|----|---------|
| 1            | 4.05 (0.87) | 4.47 (0.55) | 0.42 (0.76) | 43  | 0.0002* |
| 2            | 3.52 (0.94) | 4.41 (0.57) | 0.89 (0.97) | 27  | <0.0001*|
| 3            | 3.28 (1.15) | 4.43 (0.51) | 1.14 (0.91) | 21  | <0.0001*|
| 4            | 3.00 (1.11) | 4.22 (0.63) | 1.22 (1.08) | 37  | <0.0001*|
| 5            | 1.22 (0.53) | 1.40 (0.60) | 0.18 (0.61) | 25  | 0.20    |
| 6            | 1.50 (0.49) | 1.68 (0.75) | 0.18 (0.73) | 22  | 0.28    |
| 7            | 1.73 (1.08) | 1.91 (1.20) | 0.18 (1.08) | 11  | 0.60    |

Values are means (SD); n, no. of responses. Questions 1–4 are the results of the Likert scale (1–5; strongly disagree, disagree, neutral, agree, strongly agree). Questions 5–7 are the results of the number of correct responses to open-ended questions. *Statistical significance.

Table 5. Renal and endocrine presurvey results

| Question No. | Renal Presurvey | Endocrine Presurvey | Endocrine vs. Renal Presurvey | P Value |
|--------------|----------------|---------------------|-----------------------------|---------|
| 1            | 3.92 (0.89)    | 3.89 (0.99)         | −0.04 (1.12)                | 0.81    |
| 2            | 2.90 (1.05)    | 3.45 (0.96)         | 0.57 (1.37)                 | 0.03*   |
| 3            | 2.42 (0.81)    | 3.36 (1.16)         | 0.96 (1.48)                 | 0.002*  |
| 4            | 2.91 (1.02)    | 2.94 (1.15)         | 0.23 (1.34)                 | 0.80    |
| 5            | 1.04 (0.59)    | 1.03 (0.61)         | 0.068 (0.85)                | 0.75    |
| 6            | 1.16 (0.60)    | 1.41 (0.55)         | 0.44 (0.75)                 | 0.04*   |
| 7            | 1.50 (0.87)    | 1.45 (0.95)         | −0.07 (1.02)                | 0.57    |

Values are means (SD); n, no. of responses. Questions 1–4 are the results of the Likert scale (1–5; strongly disagree, disagree, neutral, agree, strongly agree). Questions 5–7 are the results of the number of correct responses to open-ended questions. *Statistical significance.
Postsurveys

Question No. Renal

Table 7. Likert scale results for renal and endocrine postsurveys

| Question No. | Renal   | Endocrine | P Value |
|-------------|---------|-----------|---------|
| 9           | 4.40 (0.70) | 4.43 (0.66) | 0.40    |
| 10          | 4.19 (0.85) | 4.55 (0.59) | 0.01*   |
| 11          | 4.19 (1.07) | 4.45 (0.59) | 0.07    |

Values are means (SD); n, no. of responses. *Statistical significance.

necessary,” whereas an interprofessional role communicated by a PT student was “keep the patient mobile and help maintain their strength and range of motion and coordinate timing and method of treatment with other healthcare professionals on the team.” When initially examined during the renal presurvey, 16.7% of PT students, 5.9% of PA students, and 0% of GS students who responded were able to specifically communicate IPE team-oriented roles, whereas percentages tended to increase for PA students following both exercises. When responses were aggregated over the four surveys, these numbers rose to 25.7% of PT students, 25.9% of PA students, and 12.5% of GS students, suggesting some improvement over the course of the exercises. Student feedback on the exercises was generally positive. One student suggested that different groups could be constructed for the two IPE activities, and another student wished for dedicated time together for teams to discuss their roles and viewpoints before reviewing the cases.

DISCUSSION

The IPE literature continues to grow nationally and internationally. A systematic review of the IPE literature in 2007 noted only nine studies reported Kirkpatrick level 1 and 2 outcomes (4). In a 2016 systematic review, the number of studies increased to 32, 26, and 26 for level 1, 2a, and 2b, respectively (6). However, the majority of studies reporting level 2b outcomes are through self-assessment reports, which can be an inaccurate measure (6). Unique to this study is the measurement of three Kirkpatrick levels with a direct measurement of student knowledge regarding the roles of other health team members.

As noted in Tables 2 and 3, student perceptions statistically (P < 0.05) improved from pre-to postsurvey after each activity. Although positive learning occurred, student knowledge of the role of other team members (Q5–Q7) was not statistically significant (P = 0.20–0.60) after the endocrine experience (Table 3). The idea of providing a written answer to questions could have contributed to enhanced student learning, compared with verbal discussion alone.

This study also reports on the longitudinal impact of IPE. The results noted in Tables 4 and 5 provide a perspective of the impact over a period of 6 wk. The students’ perception of their ability to explain the role of a PT and PA increased over time (Q2–Q3). Even though the pre-mean for the endocrine experience was lower than the post-mean for the previous renal experience, there was a statistically significant difference when comparing the pre-mean surveys (Table 4). In addition, the endocrine post-mean score was higher than the renal post-mean score. Via survey results, students demonstrated their comfort in explaining the roles of others after one IPE experience. In regards to the measurement of knowledge, student knowledge of a PT significantly increased over time as well.

In regards to the students’ perception of being able to communicate their role over time, mean scores increased after each IPE experience, but the pre-mean scores and post-mean scores between the two experiences remained relatively the same (Table 4). A temporary increase in mean scores may indicate a lack of confidence in articulating one’s role. The students enrolled in the physiology course were relatively new learners in their respective program. Being able to communicate one’s professional role requires experience, which can boost confidence.

This study was conducted on early learners who have more information on the roles of their own professions than on the skills necessary to work as a part of an interdisciplinary team.

Table 6. Scored correct responses for open-ended questions of the renal and endocrine pre- and postsurveys

| Question/Responses                                      | %       | n       |
|--------------------------------------------------------|---------|---------|
| Q5. The roles and responsibilities of a science research include: |         |         |
| Perform research to advance science                     | 25      | 27      |
| Perform laboratory tests                                 | 20      | 41      |
| Interpret laboratory results                             | 19      | 40      |
| Develop treatment plan                                   | 9       | 19      |
| Educate patients/scientific community                   | 6       | 13      |
| Don’t know                                              | 6       | 13      |
| Q6. The roles and responsibilities of a physical therapist include: |         |         |
| Improve mobility                                        | 19      | 29      |
| Educate patient                                         | 18      | 28      |
| Develop treatment plan                                   | 13      | 20      |
| Provide strengthening training                           | 10      | 15      |
| Assess function                                         | 5       | 8       |
| Rehabilitation                                          | 5       | 7       |
| Q7. The roles and responsibilities of a physician assistant include: |         |         |
| Diagnose patient                                        | 24      | 46      |
| Treat patient/treatment plan                             | 23      | 45      |
| Educate patient                                         | 13      | 26      |
| Assess patient                                          | 10      | 19      |
| Prescribing medications                                 | 5       | 10      |

Values are percentage of correct responses with n, no. of respondents. Q5–Q7, questions 5–7.
The renal IPE experience was the first for the graduate students and PA students. However, the PT students had participated in three prior IPE experiences. The prior experiences of the PT group appeared to be reflected in the renal presurvey, as a higher percentage of PT students were able to communicate their roles within the context of an interprofessional team compared with PA and GS students.

There was a statistically significant increase in the quantity of correctly identified roles by the GS and PA students concerning the roles of a PT in the presurvey for the endocrine compared with the presurvey of the renal IPE (Table 5, Q6). There was no change in the presurvey scores for the role of the GS and PA in the endocrine compared with the renal IPE. These data suggest that the students retained knowledge during the 6-wk interval.

In three previous research studies, the authors had analyzed responses by programs, although the relatively low number of enrolled GS students has limited demonstrations of between-group differences in IPE learning outcomes. Even though this study was focused more on the longitudinal effects, the low number of GS student participants remains a limitation to analyzing results by program.

We are in the process of discovering the appropriate number of IPE experiences in a single course that results in the optimal interprofessional learning. We plan to add a third IPE experience in the graduate physiology course related to the cardiovascular system. Our study provides insight regarding the increased or maintained perceptions and knowledge of roles of healthcare professions during two longitudinal IPE experiences.

Conclusion. Consecutive classroom IPE activities in early learners engaged in a multidisciplinary basic science course have a positive impact on student perceptions of their ability to explain the roles of other team members. Additional longitudinal studies are needed to determine optimal learning factors.

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DISCLAIMERS

The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

DISCLOSURES

No conflicts of interest, financial or otherwise, are declared by the authors.

AUTHOR CONTRIBUTIONS

L.M.H.-B., M.V.N., and SE conceived and designed research; L.M.H.-B. and SE performed experiments; L.M.H.-B., D.E.M., T.P.G., and SE analyzed data; L.M.H.-B., T.P.G., and SE interpreted results of experiments; L.M.H.-B. prepared figures; L.M.H.-B. drafted manuscript; L.M.H.-B., M.V.N., T.P.G., and SE edited and revised manuscript; L.M.H.-B., M.V.N., D.E.M., T.P.G., and SE approved final version of manuscript.

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