RESEARCH

Refinement and Validation of the Student Perceptions of Physician-Pharmacist Interprofessional Clinical Education Instrument

Joseph A. Zorek, PharmD,^a David S. Fike, PhD,^b Jens C. Eickhoff, PhD,^c Jeffrey A. Engle, BS,^a Eric J. MacLaughlin, PharmD,^d Daniel G. Dominguez, PhD, MHA,^e Christine S. Seibert, MD^c

^a University of Wisconsin-Madison, School of Pharmacy, Madison, Wisconsin

^b University of the Incarnate Word, School of Graduate Studies and Research, San Antonio, Texas

^c University of Wisconsin-Madison, School of Medicine and Public Health, Madison, Wisconsin

^d Texas Tech University Health Sciences Center, Schools of Pharmacy and Medicine, Amarillo, Texas

^e University of the Incarnate Word, School of Business and Administration, San Antonio, Texas

Submitted February 7, 2015; accepted April 7, 2015; published April 25, 2016.

Objective. To refine the Student Perceptions of Physician-Pharmacist Interprofessional Clinical Education (SPICE) instrument to address deficiencies observed in previous studies and to demonstrate external validity and reliability of the refined instrument in a broad population of medical and pharmacy students.

Methods. The original SPICE instrument plus four pilot items generated via cognitive interviewing of students was administered to 1708 medical and pharmacy students at five academic institutions. Exploratory factor analysis was used to identify candidate model structures and evaluate their psychometric properties.

Results. An improved version of the instrument was created (SPICE 2) by incorporating three pilot items and removing three original items. Validity and reliability were demonstrated.

Conclusion. The SPICE 2 instrument addresses the limitations observed to date in model structure while increasing its utility. The authors recommend use of the SPICE 2 instrument moving forward.

Keywords: interprofessional education, assessment, instrument validation, exploratory factor analysis

INTRODUCTION

Changes to accreditation standards for medical and pharmacy education highlight the importance of interprofessional education (IPE) and collaborative practice in the United States.^{1,2} The emphasis on IPE within health professions education programs is expected to continue.³⁻⁵ The Interprofessional Education Collaborative's (IPEC) seminal report outlining core competencies for interprofessional collaborative practice, with an explicit focus on patient-centeredness, is the authoritative source for health professions educators charged with revising curricula to meet IPE-related accreditation mandates.⁶ As a result, the importance of valid and reliable IPE measurement instruments that target IPEC competencies is evident.

The Canadian Interprofessional Health Collaborative performed a systematic literature review and developed an inventory of 128 quantitative instruments measuring IPE and collaborative practice focused on six outcomes:

attitudes; knowledge, skills, and abilities; behavior; organizational practices; patient satisfaction; and provider satisfaction.⁷ The National Center for Interprofessional Practice and Education in the United States systematically culled this inventory, targeting readily available instruments with an explicit focus on IPE and collaborative practice.⁸ Twenty-six instruments were selected for the National Center's compilation, representing a variety of options from which health professions educators could choose.⁹ This selection was complicated by the fact that the majority of these instruments were created prior to IPEC's seminal report. As a result, IPEC's core competency domains are dispersed as factors (ie, subscales) throughout the compilation as opposed to consolidated in a single instrument.

The Student Perceptions of Physician-Pharmacist Interprofessional Clinical Education (SPICE) instrument was created in the post-IPEC era, and a detailed description of its development and validation is published.¹⁰ A team of health professions educators generated and validated a pool of 20 items (ie, questions), then administered these items to 179 medical and pharmacy students at

Corresponding Author: Joseph A. Zorek, University of Wisconsin-Madison School of Pharmacy, Pharmacy Practice Division, 777 Highland Ave., Madison, WI 53705-2222. Tel: 608-265-8752. E-mail: joseph.zorek@wisc.edu

a single institution. Factor analysis techniques were employed to identify a suitable model structure for the SPICE instrument, which ultimately contained 10 items with a 5-point Likert-type response scale allocated to three IPEC-inspired factors (interprofessional teamwork and team-based practice, roles/responsibilities for collaborative practice, and patient outcomes from collaborative practice). The SPICE instrument demonstrated validity according to multiple established criteria, and the composite reliability of the overall instrument (ie, all 10 items evaluated together) was high at 0.84. A composite reliability of at least 0.6 is considered acceptable while the desired value (dv) is 0.7 or greater.¹¹ Deficiencies identified for potential improvement were suboptimal reliability of the roles/responsibilities factor and imbalance of item distribution throughout the instrument. The roles/responsibilities factor reliability was marginally below the acceptable threshold at 0.58. In terms of imbalance, 60% (6/10) of items were contained within the teamwork factor while the roles/responsibilities and patient outcomes factors each contained only two items. This was below the recommended minimum of three items per factor.¹² Incorporation of new items into these two factors was identified as a potential mechanism to address both of these deficiencies, while simultaneously improving the utility of the instrument.

The SPICE instrument was subsequently administered to 49 medical and pharmacy students before and after participation in a predefined IPE experience to assess whether it was capable of measuring changes in students' perceptions.¹³ Results demonstrated the SPICE instrument's ability to measure change at the individual item level and at the factor level. Change was significant for all three factors, with large standardized effect sizes observed for the patient outcomes and roles/responsibilities factors ($d=0.71$ and $d=0.68$, respectively), and a moderate standardized effect size for the teamwork factor ($d=0.46$).¹⁴ Significant pre-to-post change was observed in 40% (4/10) of items; 100% (2/2) of items within the roles/responsibilities factor; 50% (1/2) within the patient outcomes factor; and 17% (1/6) within the teamwork factor. Despite its suboptimal reliability at the factor level, the individual roles/responsibilities items proved meaningful. These results also suggested that some items from the large teamwork factor might be removed without negatively impacting its utility or the overall performance of the instrument.

A third study demonstrated the internal construct validity of a revised version of the SPICE instrument, called SPICE-R.¹⁵ In creating the SPICE-R instrument, investigators eliminated profession-specific language so the instrument could be used across all health professions,

as opposed to being limited to just medical and pharmacy student populations. Beyond the broadening of the language, the intent of the items and the overall model structure was unchanged (ie, the SPICE and SPICE-R model structures are identical). Results from the SPICE-R study, therefore, informed the ongoing development of SPICE, including this multi-institutional study. The SPICE-R instrument was administered to 221 students from five health professions (nursing, optometry, pharmacy, physical therapy, and health administration) at a single institution, and similar strengths and weaknesses between SPICE-R and SPICE were observed. Once again, the reliability of the roles/responsibilities factor was below the acceptable threshold at 0.53.

All of our SPICE-related studies to date were performed at single institutions, thus limiting the generalizability of findings. Although investigators recommended use of the SPICE instrument beyond their institutions in an effort to gain insight into its performance in a variety of settings, the external validity of the instrument has yet to be evaluated systematically in a formal study. The objectives of this study, therefore, were to refine the SPICE instrument to address the factor deficiencies, and to demonstrate external validity and reliability of the refined instrument in the context of a broader population of medical and pharmacy students.

METHODS

A national network of medical and pharmacy educators was assembled for the purpose of this study. The SPICE Collaborative was comprised of faculty members at colleges and schools of medicine and pharmacy from eight institutions geographically dispersed throughout the United States. In addition to geographic balance, an explicit goal in the creation of the SPICE Collaborative was to maintain a balanced representation of public and private institutions. In the past two decades, a surge of private pharmacy schools has created greater parity within a student population that was once dominated by public institutions. Investigators sought to ensure that the makeup of the study population reflected this demographic shift.

The introduction of new items to the roles/responsibilities and patient outcomes factors was identified as a mechanism to address the deficiencies described above. Pilot item generation began with one-on-one and focus group interviews with convenience samples of medical and pharmacy students at the University of Wisconsin-Madison (UW-Madison). Sessions were conducted based on principles of cognitive interviewing, an established methodology employed by survey researchers to identify and address problems with survey questions.¹⁶ Two broad

approaches to cognitive interviewing exist: think-aloud and probing. The latter was used in this study, where the interviewer played a proactive role incorporating anticipated probes (ie, scripted questions established prior to the session) and emergent probes (ie, unscripted questions that emerged based on participants' responses) to guide the interviews. Six anticipated probes were employed (Appendix 1) to investigate students' interpretations of items and their relation to the overall model structure, impressions relating to the clarity and relevance of items, and ideas regarding valuable topics related to interprofessional clinical education that seemed to be missing from the instrument (ie, to inform pilot item generation). Emergent probes were used throughout the sessions to explore students' rationale for their responses to anticipated probes. Notes recorded by the interviewer and the students were analyzed for themes, which were subsequently used to generate four pilot items, two for each of the targeted factors.

Investigators within the SPICE Collaborative identified faculty colleagues at their respective institutions' schools of medicine and pharmacy who would be willing to partner to facilitate data collection. Investigators worked with these partners to determine the most appropriate time and venue to distribute data collection forms to second and third year medical and pharmacy students. The determination was made to exclude first-year and fourth-year students. First-year students were excluded because they were in the process of being newly acculturated to their respective profession. Fourth-year students were excluded given the large number and diversity of participating institutions and because these students likely had already been exposed to significant variability in terms of quantity and quality of interprofessional clinical experiences.

Data for six demographic variables were collected, including professional program (ie, medicine vs pharmacy), year in school, sex, race/ethnicity, age, and highest previously earned degree. Secondary to delays in the pilot item generation process and in consideration of scheduling concerns at some institutions within the SPICE Collaborative, the original SPICE instrument plus the four pilot items generated for this study (Table 1) were administered at five institutions within the network (East Tennessee State University, Midwestern University, Texas Tech University Health Sciences Center, University of Maryland, UW-Madison). A total of 2977 students were eligible to participate in the study (1492 medical students, 1485 pharmacy students). To increase response rates, investigators distributed paper versions of the data collection forms following a mandatory lecture or meeting. Students completed the data collection forms anonymously.

Data collection forms not completed according to instructions were discarded (eg, if a student did not provide a response for every item as instructed).

Exploratory factor analysis (EFA) for ordered categorical outcomes was conducted using MPLUS, v7.11 (Muthén & Muthén, Los Angeles, CA) to identify candidate model structures generated by incorporation of pilot items and/or removal of original items demonstrating poor validity. This process was guided by statistical and theoretical principles, beginning with a calculation of eigenvalues to determine the number of potential factors present within the 14 items (ie, the original 10 items from the SPICE instrument plus the four pilot items).^{11,12,17-19} The Guttman-Kaiser criterion was used to determine the number of factors. Varimax rotated loadings were then evaluated to assign items to factors within candidate model structures. Identified candidate models underwent further evaluation to ensure goodness of fit, whereby the compatibility of each model and the data set was determined. Model parameters were estimated using a weighted least squares approach. The following fit indices were evaluated based on Hu and Bentler's recommendations:¹⁹ (1) maximum likelihood-based standardized root mean squared residual (SRMR, dv close to 0.08 or less); (2) comparative fit index (CFI, dv close to 0.95 or greater); and (3) root mean square error of approximation (RMSEA, dv close to 0.06 or less). Finally, the reliability and validity of candidate models demonstrating appropriate goodness of fit were determined using established criteria. Specifically, Cronbach alpha and composite reliabilities were calculated to determine overall instrument and factor-specific reliabilities, respectively ($dv > 0.7$). Correlation coefficients for factors ($dv < 0.85$) and regression weights for items ($dv > 0.7$) were calculated to evaluate relationships between variables within the instrument.

The Education and Social/Behavioral Science Institutional Review Board (IRB) at UW-Madison approved this multi-institutional validation study. The UW-Madison IRB also provided oversight for East Tennessee State University via an IRB authorization agreement. All other SPICE Collaborative institutions obtained approval for this study directly from their respective IRBs.

RESULTS

A convenience sample of 14 students (nine pharmacy, five medicine) participated in the cognitive interviewing process. According to Beatty and Willis, while there is a lack of consensus regarding appropriate sample sizes for cognitive interviewing, contemporary practices assume that most critical issues can be identified using

Table 1. The Original SPICE Instrument^a (Items 1-10) with Pilot Items (Items 11-14)

No. ^b	Factor ^c	Item ^d
1	T	Working with another discipline of students enhances my education.
2	R	My role within the interdisciplinary team is clearly defined.
3	O	Health outcomes are improved when patients are treated by a team of professionals from different disciplines.
4	O	Patient satisfaction is improved when patients are treated by a team of professionals from different disciplines.
5	T	Participating in educational experiences with another discipline of students enhances my future ability to work on an interdisciplinary team.
6	T	All health professions students should be educated to establish collaborative relationships with members from other disciplines.
7	R	I understand the roles of other professionals within the interdisciplinary team.
8	T	Clinical rotations are the ideal place within their respective curricula for medical and pharmacy students to interact.
9	T	Physicians and pharmacists should collaborate in teams.
10	T	During their education, medical and pharmacy students should be involved in teamwork in order to understand their respective roles.
11	R	I have an understanding of the courses taken by, and training requirements of, both pharmacy and medical students.
12	R	The responsibilities of each team member should be maximized based on his/her level of education and training.
13	O	Health care costs are reduced when patients are treated by a team of professionals from different disciplines.
14	O	Patient-centeredness increases when care is delivered by a team of professionals from different disciplines.

^aSPICE=Student Perceptions of Physician-Pharmacist Interprofessional Clinical Education Instrument

^bItems 1-10 comprise the original SPICE instrument and items 11-14 comprise the additional pilot items tested in this study

^cT=Interprofessional Teamwork and Team-based Practice; R=Roles/responsibilities for Collaborative Practice; O=Patient Outcomes from Collaborative Practice

^dScoring based on 5-point Likert-type response scale whereby 5=strongly agree, 4=agree, 3=neutral, 2=disagree, and 1=strongly agree

small samples.¹⁶ Investigators made the determination a priori to end the cognitive interviewing process once responses became repetitive/redundant. When combined with investigators' impressions and students' and colleagues' input from prior research involving the SPICE instrument, this point of "saturation" was reached quickly.

Several themes emerged from the cognitive interviewing process. First, certain items within the teamwork factor were identified as potentially duplicative or redundant. Items 9 and 10 were most frequently cited as examples of redundancy during follow up with emergent probing. Also, within the teamwork factor, students repeatedly identified having to project beyond their experience level as problematic, citing items 5, 8, and 9 most frequently upon further questioning. No trends emerged when students were asked which items to remove from the teamwork factor. As it related to the roles/responsibilities factor, students pointed to "preparation" as an area worthy of exploration. Specifically, students commented that they lacked knowledge and/or understanding of their

counterparts' academic preparation (ie, to become a physician or pharmacist, respectively) and thus experienced difficulty determining what their counterparts' roles/responsibilities could/should be. The two roles/responsibilities pilot items (Table 1, items 11 and 12) were generated, in part, based on this feedback.

Lack of specification was also highlighted during the cognitive interviewing process. Item 3 relating to "health outcomes" was most frequently targeted, with students citing the seemingly infinite number of potential health outcomes as a source of confusion. Students had difficulty generating potential new items to explore for the patient outcomes factor and no trends were identified in their responses. The two pilot items generated for this factor (Table 1, items 13 and 14) were inspired by the Institute for Healthcare Improvement's Triple Aim Initiative,²⁰ which is also endorsed by the National Center for Interprofessional Practice and Education.

Following analysis and implementation of findings from the cognitive interviewing process, the original 10-item SPICE instrument and four pilot items were

completed by 1708 students at five institutions. The response rate was 57% (1708/2977). Demographic information for study participants is provided in Table 2. The mean age of students was 25 (SD=3.4) years, with a majority reporting white (65%) for race/ethnicity. Most students had a bachelor's degree (70%), and there was equal representation regarding sex and year in school. Pharmacy students comprised more than 60% of the sample. Similarly, 65% of the sample was enrolled in a public institution.

The initial eigenvalue assessment suggested a model structure consisting of either two or three factors. Based on this result, five candidate models (M1-M5) were identified for further consideration via evaluation of varimax rotated loadings. All five candidate models met the SRMR criteria, our initial step in determining goodness-of-fit. The first two candidate models contained two factors and consisted of seven items (M1: Table 1, items 3, 5, 6, 14 [factor 1]; and 7, 8, 11 [factor 2]) and 10 items (M2:

items 3, 4, 5, 6, 9, 10 [factor 1]; and 2, 7, 8, 11 [factor 2]), respectively. These models did not progress to factor analysis because they failed to match the established, IPEC-inspired theoretical framework, and neither demonstrated fit according to both CFI (M1, 0.94; M2, 0.95) and RMSEA (0.11 for both). The remaining candidate models contained three factors and consisted of 10 items (M3: items 1, 5, 6, 10 [factor 1]; 2, 7, 11 [factor 2]; and 4, 13, 14 [factor 3]), 11 items (M4: items 1, 5, 6, 10 [factor 1]; 2, 7, 11 [factor 2]; and 3, 4, 13, 14 [factor 3]), and 12 items (M5: items 1, 5, 6, 10 [factor 1]; 2, 7, 8, 11 [factor 2]; and 3, 4, 13, 14 [factor 3]), respectively. The 10-item model (M3) was the only one to undergo exploratory factor analysis, as it was the only one to align theoretically and demonstrate goodness-of-fit according to both CFI (M3, 0.98; M4, 0.94; M5, 0.96) and RMSEA (M3, 0.06; M4, 0.07; M5, 0.08). While M5 met the CFI threshold, the factor structure that emerged was deemed inappropriate because of the inclusion of item 8 into the factor consisting of items 2, 7, and 11.

Correlation coefficients, regression weights, and percent variance explained (ie, squared multiple correlation coefficients) for the 10-item candidate model, hereafter referred to as SPICE 2 (Table 4), are presented in Table 3. Correlation coefficients were calculated to evaluate the relationships between the three factors in the model. All correlations were positive and below the recommended threshold of 0.85, providing evidence to support the overall theoretical framework for the model. Standardized regression weights for all items were significant, and no modification indices were observed. All item regression weights exceeded the recommended acceptability threshold of 0.6, and 90% (9/10) of item regression weights exceeded the desired threshold of 0.7. Overall instrument reliability as per Cronbach alpha was 0.79. Factor-specific reliabilities for the three factors within the SPICE 2 model were as follows: interprofessional teamwork and team-based practice, 0.85; roles/responsibilities for collaborative practice, 0.68; patient outcomes from collaborative practice, 0.74.

DISCUSSION

The SPICE 2 instrument proposed herein addresses the principal limitations observed to date in terms of model structure. The factors are better balanced and contain the minimum number of recommended items at four (teamwork), three (roles/responsibilities), and three (patient outcomes), as opposed to six, two, and two items in SPICE, respectively. The reliability of the roles/responsibilities factor has been improved. In addition, several important issues with the original version have been addressed. One example involved replacing

Table 2. Demographics of Participants

Characteristic	Value
Area of Study, n (%)	
Medicine	649 (38)
Pharmacy	1059 (62)
Type of Institution, n (%)	
Private	599 (35)
Public	1109 (65)
Year of Study, n (%)	
Second year	896 (52.5)
Third year	812 (47.5)
Gender, n (%)	
Female	994 (58)
Male	714 (42)
Age, mean years (SD)	25.5 (3.4)
Age, n (%)	
20-24 years	764 (44.7)
24-26 years	551 (32.3)
26-30 years	283 (16.6)
>30 years	110 (6.4)
Race, n (%)	
White	1101 (64.5)
Black	64 (3.7)
Hispanic	46 (2.7)
Other	497 (29.1)
Highest Degree Earned, n (%)	
None	301 (17.6)
Associates	67 (3.9)
BA/BS	1194 (69.9)
MA/MS	121 (7.1)
PhD	9 (0.5)
Professional Doctorate	16 (0.9)

Table 3. Exploratory Factor Analysis of SPICE 2 Instrument^a

Factor ^b	Item ^c	Standardized Regression Weight ^d	Squared Multiple Correlation Coefficient ^e
Interprofessional teamwork and team-based practice	1	0.72	0.52
	5	0.85	0.72
	6	0.82	0.67
	10	0.80	0.64
Roles/responsibilities for collaborative practice	2	0.61	0.37
	7	0.79	0.62
	11	0.71	0.50
Patient outcomes from collaborative practice	4	0.74	0.55
	13	0.73	0.53
	14	0.88	0.77

^aSPICE 2=Student Perceptions of Physician-Pharmacist Interprofessional Clinical Education Instrument, Version 2

^bFactor correlations: interprofessional teamwork with roles/responsibilities, $r=0.37$; interprofessional teamwork with patient outcomes, $r=0.73$; roles/responsibilities with patient outcomes, $r=0.42$. All factor correlations were statistically significant ($p<0.05$)

^cItem descriptions are provided in Table 1

^dAll standardized regressions weights were statistically significant at the 0.05 significance level (>0.6 acceptable, >0.7 desired)

^ePercent variance explained by each item (≥ 0.5 desired)

the general health outcomes item (Table 1, item 3) with more specific patient outcomes-related items focused on health care costs and patient-centeredness (Table 1, items 13 and 14). Another example involved the removal of items 8 and 9 from the teamwork factor, which students had identified as problematic and redundant. Importantly, these item-level improvements did not adversely affect the high reliabilities for the teamwork and patient outcomes factors observed in previous single-site studies.

In terms of percent variance explained, 90% (9/10) of items in the SPICE 2 model met the critical desired threshold (ie, ≥ 0.5 , or a regression weight >0.7). Perhaps most importantly, this study was conducted in a large and diverse population of medical and pharmacy students ($N=1708$), thus increasing our confidence in the external validity of the refined SPICE 2 instrument. In addition to demonstrating strong psychometric properties, the three new items also provided greater utility to users. As a result, we suggest that health professional educators at US

Table 4. Final SPICE 2 Instrument^a

No.	Factor ^b	Item ^c
1	T	Working with another discipline of students enhances my education.
2	R	My role within the interdisciplinary team is clearly defined.
3	O	Patient satisfaction is improved when patients are treated by a team of professionals from different disciplines.
4	T	Participating in educational experiences with another discipline of students enhances my future ability to work on an interdisciplinary team.
5	R	I have an understanding of the courses taken by, and training requirements of, both pharmacy and medical students.
6	O	Health care costs are reduced when patients are treated by a team of professionals from different disciplines.
7	T	All health professions students should be educated to establish collaborative relationships with members from other disciplines.
8	R	I understand the roles of other professionals within the interdisciplinary team.
9	O	Patient-centeredness increases when care is delivered by a team of professionals from different disciplines.
10	T	During their education, medical and pharmacy students should be involved in teamwork in order to understand their respective roles.

^aSPICE 2=Student Perceptions of Physician-Pharmacist Interprofessional Clinical Education Instrument, Version 2

^bT=Interprofessional Teamwork and Team-based Practice; R=Roles/responsibilities for Collaborative Practice; O=Patient Outcomes from Collaborative Practice

^cScoring based on 5-point Likert-type response scale whereby 5=strongly agree, 4=agree, 3=neutral, 2=disagree, and 1=strongly agree

schools of medicine and pharmacy use the SPICE 2 instrument within their respective populations to assess students' perceptions of IPE.

Several limitations in this study warrant discussion. First, we were unable to include students from the western region of the United States, and our attempts to recruit a private institution from the northeast were unsuccessful. As a result, these categories of students were not represented in our sample. Furthermore, the majority of our study population were white female students from public schools of pharmacy. A study evaluating subgroup (eg, pharmacy vs medicine, public vs private) response patterns is ongoing and is expected to shed light on potential differences.

Future studies exploring the use of the SPICE 2 instrument before and after students participate in various IPE experiences are necessary to determine its most appropriate use. It is possible, for example, that the instrument might be better suited for specific levels of students (ie, based on year in program), type of IPE experience (eg, didactic, clinical, online, blended, etc.), and/or duration of experience. With increasing accreditation demands related to IPE from both the Liaison Committee for Medical Education and the Accreditation Council for Pharmacy Education, longitudinal studies using SPICE 2 to track changes in students' attitudes throughout medical and pharmacy school may provide valuable assessment data documenting progress in this area. Optimal use of this validated measurement instrument cannot be identified in the absence of such studies.

The evolution of the SPICE family of instruments is also continuing. Using the model structure established in this study, the version of SPICE designed for all health professions students (ie, not just medical and pharmacy students) has been updated from SPICE-R to SPICE-R 2. A single site validation study intended to confirm the validity and reliability of the model structure is currently underway, as well as a single site pre/posttest study evaluating the use of the SPICE-R 2 instrument in the context of an IPE experience involving pharmacy and veterinary medicine students. One important goal in the progression of this line of research is to develop an IPE experience across multiple institutions and to evaluate students' attitudinal outcomes using the SPICE 2 or SPICE-R 2 instrument, depending on the student populations included. Importantly, members of the SPICE Collaborative created for this study have explored formally reconstituting as an IPE research network. A network such as this would be required for a multi-institutional study involving a coordinated IPE intervention. Additional refinements to the model may further improve its utility. For example,

incorporation of factors devoted to interprofessional communication and/or values/ethics for interprofessional practice would align well with the instrument's IPEC-inspired theoretical framework.

CONCLUSION

A multi-institutional network of physician and pharmacist faculty members was assembled to assess the validity and reliability of an improved version of the SPICE instrument in the context of a diverse population of medical and pharmacy students. Cognitive interviewing techniques were used to explore students' interpretations of the original instrument, including perceived issues and potential areas for improvement. Results from this process influenced the generation of four pilot items, which were subsequently administered to 1708 medical and pharmacy students from five institutions in conjunction with the original 10-item SPICE instrument. A new 10-item version of the instrument (SPICE 2) was identified using exploratory factor analysis. The SPICE 2 instrument retains the same 3-factor model structure as the original. However, the factors are now balanced and each contains the minimum recommended number of items. Three pilot items were added to the instrument and three original items were removed. The SPICE 2 instrument demonstrated strong psychometric properties in this study. The authors, therefore, recommend use of the SPICE 2 instrument.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the SPICE Collaborative coinvestigators, whose efforts facilitating IRB approval and data collection made this project possible: Nicholas E. Hagemeyer, PharmD, PhD (East Tennessee State University, Johnson City, TN); Carrie Sincak, PharmD, and Kurt Heinking, DO, (Midwestern University, Downers Grove, IL); S. Scott Wisneski, PharmD, MBA, RPh and Lisa N. Weiss, MD, MEd (Northeast Ohio Medical University, Rootstown, OH); Rebecca Moote, PharmD, MSc, (Regis University, Denver, CO); Rodney B. Young, MD, (Texas Tech University Health Sciences Center, Amarillo, TX); David F. Maize, RPh, PhD (University of the Incarnate Word, San Antonio, TX); and Lisa Lebovitz, JD, Richard N. Dalby, PhD and David B. Mallott, MD (University of Maryland, Baltimore, MD). We would also like to thank Beth A. Martin, PhD, RPh, Betty A. Chewning, PhD, Daniel M. Bolt, PhD, Susan M. Meyer, PhD, and Yvonne M. Hopf, PhD, MSc for the many thoughtful suggestions that strengthened this project and manuscript.

REFERENCES

1. Liaison Committee on Medical Education. Standards, Publications, & Notification Forms. <http://lcme.org/publications/>. Accessed April 1, 2016.
2. Accreditation Council for Pharmacy Education. Accreditation standards and key elements for the professional program in pharmacy leading to the doctor of pharmacy degree. <https://www.acpe-accredit.org/pdf/Standards2016FINAL.pdf>. Accessed March 20, 2015.
3. Zellmer WA, Beardsley RS, Vlasses PH. Charting accreditation's future: recommendations for the next generation of accreditation standards for doctor of pharmacy education. *Am J Pharm Educ*. 2013;77(3):Article 45.
4. Accreditation Council for Pharmacy Education. Accreditation standards and key elements for the professional program in pharmacy leading to the doctor of pharmacy degree: draft standards 2016. <https://www.acpe-accredit.org/pdf/Standards2016DRAFTv60FIRSTRELEASEVERSION.pdf>. Accessed May 19, 2014.
5. Accreditation Council for Pharmacy Education. New health professions accreditors collaborative forms to stimulate interprofessional engagement. https://www.acpe-accredit.org/pdf/HPAC_PressRelease12152014.pdf. Accessed December 18, 2014.
6. Interprofessional Education Collaborative. Core competencies for interprofessional collaborative practice: Report of an expert panel. <http://www.aacn.nche.edu/education-resources/ipcreport.pdf>. Accessed December 10, 2014.
7. Canadian Interprofessional Health Collaborative. An inventory of quantitative tools measuring interprofessional education and collaborative practice outcomes. <http://rerc.brandeis.edu/pdfs/Canadian%20Interprofessional%20Health%20Collaborative%22report.pdf>. Accessed May 20, 2014.
8. National Center for Interprofessional Practice and Education. Assessing IPECP: the selection process for the 2014 National Center's curated collection of measurement tools. <https://nexusipe.org/informing/about-national-center/news/assessing-ipecp-selection-process-2014-national-centers-curated>. Accessed April 1, 2016.
9. National Center for Interprofessional Practice and Education. Measurement instruments. <https://nexusipe.org/measurement-instruments>. Accessed May 20, 2014.
10. Fike DS, Zorek JA, MacLaughlin AA, Samiuddin M, Young RB, MacLaughlin EJ. Development and validation of the student perceptions of physician-pharmacist interprofessional clinical education (SPICE) instrument. *Am J Pharm Educ*. 2013;77(9):Article 190.
11. Bagozzi RP, Youjae Y. On the evaluation of structural equation models. *J Acad Market Sci*. 1988;16(1):74-94.
12. Bollen, KA. *Structural Equations with Latent Variables*. New York, NY: John Wiley & Sons, Inc.; 1989.
13. Zorek JA, MacLaughlin EJ, Fike DS, MacLaughlin AA, Samiuddin M, Young RB. Measuring changes in perception using the student perceptions of physician-pharmacist interprofessional clinical education (SPICE) instrument. *BMC Med Educ*. 2014;14(101).
14. Fritz CO, Morris PE, Richler JJ. Effect size estimates: current use, calculations, and interpretation. *J Exp Psychol: Gen*. 2012;141(1):2-18.
15. Dominguez DG, Fike DS, MacLaughlin EJ, Zorek JA. A comparison of the validity of two instruments assessing health professional student perceptions of interprofessional education and practice. *J Interprof Care*. 2015;29(2):144-149.
16. Beatty PC, Willis GB. Research synthesis: the practice of cognitive interviewing. *Public Opin Q*. 2007;71(2):287-311.
17. Schumacker RE, Lomax RG. *A Beginner's Guide to Structural Equation Modeling*. 3rd Ed. Mahwah, NJ: Lawrence Erlbaum Associates; 2010.
18. Kline RB. *Principles and Practice of Structural Equation Modeling*. 3rd Ed. New York, NY: Guilford Press; 2010.
19. Hu L, Bentler PM. Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal*. 1999;6(1):1-55.
20. Institute for Healthcare Improvement. The IHI Triple Aim. <http://www.ihl.org/engage/initiatives/tripleaim/Pages/default.aspx>. Accessed December 16, 2014.

Appendix 1. Anticipated Probes Used During Cognitive Interviewing Process

Overall Instrument

After completing the Student Perceptions of Physician-Pharmacist Interprofessional Clinical Education (SPICE) instrument, create groups/categories you think the items might belong to, then assign each item to one of those groups/categories.

Interprofessional Teamwork and Team-Based Practice Factor

Items 1, 5, 6, 8, 9, and 10 belong to the "Interprofessional Teamwork and Team-Based Practice" group. Please read each item carefully, then rank them in descending order based on clarity and relevance. You should create two ranked lists, one for clarity and another for relevance. Which two items from this group would you remove from the instrument and why?

Roles/Responsibilities for Collaborative Practice Factor

Items 2 and 7 belong to the "Roles/responsibilities for Collaborative Practice" group. In previous studies, students' responses to these items have not trended together strongly—why do you think this might be? Can you think of any other topics related to this group that are important to you, or that strike you as "missing" from this group?

Patient Outcomes from Collaborative Practice Factor

Items 3 and 4 belong to the "Patient Outcomes from Collaborative Practice" group. What comes to mind when you read each of these items? Can you think of any other topics related to this group that are important to you, or that strike you as "missing" from this group?