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Restructuring of an evidence-based practice curriculum and assessment with structural mapping by course outcome verb

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Objective: An evidence-based clinical practice (EBCP) subcurriculum within a chiropractic curriculum was restructured to distribute EBCP topics to courses throughout the curriculum. We posited that this would enhance student learning through early exposure, repetition, and the use of progressively more difficult levels of learning. In this paper we describe how we determined if Bloom's verb level trended upward from the beginning of the curriculum to the end and if there were any gaps in presentation of topics periodically in the curriculum. We describe how we determined if the restructured subcurriculum provided adequate integration of topics.
Methods: EBCP committee chairs created templates of the new structure, solicited feedback from the faculty, and faculty members volunteered to assimilate topics into courses. Support for the faculty included comprehensive PowerPoint production and in-service training. Assessment for trends and gaps was performed of the resultant learning outcomes by mapping 13 quarters against 6 Bloom's verb levels for 19 topics.
Results: Fourteen of the topics had increasing linear model trends indicating verb progression. Decreased attention to EBCP topics was identified in some quarters.
Conclusion: The graphical mapping process seemed useful to find EBCP topics that did not show progression of Bloom's verb difficulty and gaps in topics in the restructured subcurriculum.

Key Indexing Terms: Chiropractic; Education; Curriculum; Evidence-Based Medicine

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INTRODUCTION

This paper describes how we restructured an evidence-based clinical practice (EBCP) subcurriculum within our overall doctor of chiropractic (DC) training program. Our program is an integrated curriculum. In this curriculum, some courses are a combination of related disciplines instead of covering a discrete discipline. For example, anatomy, physiology, diagnosis, patient management, and philosophy are integrated within most courses for the entire 13 quarter-based curriculum. Our program also has subcurricula, which are main themes (eg, communication or diagnosis) that are weaved throughout the integrated curriculum. Sometimes these themes combine into 1 outcome such as, "The student is able to communicate the diagnosis and treatment to a mock patient using EBCP terms such as absolute risk ratios in a report of findings."

At the time of the revision of the EBCP subcurriculum it was not fully meshed within the integrated curriculum. The EBCP subcurriculum was limited to the outcomes in a first quarter course. Some professors who were early adopters of EBCP covered related topics in other courses; although, there was not an accounting of those EBCP outcomes. Clinic faculty members had started to integrate EBCP in their teaching as well, yet there was not a known curricular structure where the EBCP topics were intentionally integrated in the curriculum. Given the integrated curriculum, it was a challenge to match discrete subjects with EBCP topics. For example, all classes about diagnostic procedures (eg, physical examination) should have included diagnostic validity (likelihood ratios) and reliability (κ, interclass correlation coefficients) in related course outcomes.

We had to develop a strategy that would provide a basic structural goal, reveal where professors were already teaching EBCP topics, determine where we needed volunteers to teach the topics, and solicit volunteers to teach the material in courses that related to the topics and were not already laden with content. In addition, we had to provide resources for those who were unfamiliar with EBCP topics. The challenges of the integrated curriculum resulted in what we believe is an innovative model for the incorporation of EBCP outcome measures into a health care provider curriculum.

Different outcome verbs carry different "depth of processing" levels. For example, "After this course, the student will be able to define evidence-based clinical practice." The verb "define" means that the student will memorize the definition, although the outcome does not require critical analysis of the definition. The various depth of processing levels were developed by Benjamin Bloom around 1956. Mary Allen listed the following ordinal Bloom's verb levels: knowledge, comprehension, application, analysis, synthesis, and evaluation and included a table of "relevant verbs" that are related to these levels.[1] The verbs can be used to take a student from memorization of a concept, to application, to critical analysis throughout an entire curriculum. The verbs can also be used to encourage a teacher to assess deeper levels of processing. Thus, students must master the content in order to apply it to their patient's benefit and further the development of the profession through critical analysis. The ability for professionals to question established protocols and taboos enables them to think through nonscripted situations in practice and improve patient management skills.

The background of EBCP has been described by many authors in the past and should be a familiar topic to chiropractic educators. Therefore, we defer to other sources for details on EBCP.[2,3] Basic implementation of EBCP can be achieved by using the 5 As (Ask, Acquire/Access, Appraise, Apply, Assess) model adapted from Sackett.[4] Basically, a clinician asks a clinically relevant question. The main terms in that question are used in a database search to acquire related articles. The clinician appraises the article for quality and applicability to the clinical situation. If applicable, the article's recommendations are applied to the patient and then an assessment is made to see if the intervention helped. The applicability of mentioning this model in this paper is 3-fold: (1) because the 5 As parallel critical thinking constructs,[5] then using the process demonstrates critical thinking in student learning with respect to patient care; (2) helps to delineate topics for outcome measures for an evidence-informed curriculum; and (3) provides a descriptive overview for those who are new to developing an EBCP curriculum.

There are many stated benefits to EBCP and the importance to stakeholders (patients,[6,7] students,[8–10] clinician[11], other health professions,[12,13] and accreditors[6,14]) is evident. These benefits include improved patient outcomes, common ground, and meeting accrediting requirements. The benefits of EBCP make it a worthy inclusion into the content of educational programs for physicians. Generally, content should be assessed for its usefulness to stakeholders, especially patients. Otherwise, the content becomes a waste of time to teach, manage, and assess for the teacher and an unnecessary barrier for the student to learn more applicable concepts.

Significant barriers exist to the integration of EBCP into curricula, into the practice of EBCP in clinical training settings, and into practice. The following barriers are prominent themes in the literature: time constraints,[2,4,6,7,15,16] confidence,[9,17] a lack of adequately trained faculty,[7,15,16,18] teaching methods,[6,19–24] clinical challenges,[7,8,12,18,25,26] negative attitudes toward EBCP,[4,7,8,18] and the belief that EBCP might degenerate into "cook-book" clinical practice.[4]

Given the above, the overreaching research question during our process was, "How does an educational institution prepare students for their intended profession?" More specifically, we questioned "How do we reevaluate curricula and determine if curriculum design promotes student learning to the benefit of their patients?" We also wanted to know the specific criteria that should be present in the curricular structure. To determine the degree of student learning, we wanted to know the level of depth that content was being taught and the assessment scores compared with the threshold. Finally, we wanted to identify if the content was necessary for students to perform their intended profession. For this project, we concentrated on the connection between the structure and level of student learning.

Because the subcurriculum was complex, visual representation of the way the EBCP topics progressed was desired to avoid gaps and a lack of Bloom's verb progression. We designed a graphical analysis of the curriculum to provide the visual representation. Therefore, our aims with this paper were to (1) describe the process we used to recreate our EBCP subcurriculum; (2) identify if the Bloom's verb level seemed to progress upward from the beginning of the curriculum to the end; (3) using the same plot, determine if there were gaps where a topic was not addressed periodically during the curriculum for learning reinforcement; and (4) determine if our approach to restructuring the EBCP subcurriculum provided adequate integration.

METHODS

Addressing Barriers

The barriers pointed out earlier had to be lowered to reach our goal of revising the EBCP subcurriculum. Our solutions to these barriers included resources and training. We informed the faculty of various resources, such as clinical practice guidelines. One helpful resource was the Canadian Chiropractic Association's clinical practice guideline Initiative (https://www.chiropractic.ca/guidelines-best-practice/practitioners/). This site has clinical practice guideline for headaches, neck pain, mid back pain, upper and lower extremity disorders, and other conditions.[27,28]

It seems that many of the barriers noted above were partially overcome by training in EBCP provided to our faculty over several years. Faculty members were given opportunities to participate in intensive EBCP training series provided by different schools, including Northwestern States University, Palmer College of Chiropractic, University of Iowa, and McMaster's University. This training was possible through a R-25 grant from the National Institutes of Health.

Implementation

Based upon the levels of training of our faculty in EBCP through the R-25 grant, an EBCP faculty committee was formed comprising clinical and academic faculty. An EBCP topics list was created with proposed sequencing

Table 1 - Sample of Actual Evidence-Based Clinical Practice Curricular Map Including 2 Topics, Faculty Assigned to Instructional Topics, and Corresponding Learning Outcomes

Topic	Introduction	First Reinforcement	Second Reinforcement	Clinical QE	Learning Outcomes
Confidence intervals	Dr A Class 101 (term 1)	Dr B Class 301 (term 3)	Dr C Class 401 (term 4)	Dr D Class 901 (term 9)	K. Describe confidence intervals. K. Interpret confidence intervals when appraising a study.
Odds ratio	Dr A Class 101 (term 1)	Dr E Class 501 (term 5)	Dr F Class 601 (term 6)	Dr D Class 901 (term 9)	K. Describe odds ratios. K. Interpret odds ratios when appraising a study.

throughout the curriculum by 2 to 3 topic experts who formed an initial curriculum map. EBCP topics were determined by categorizing content into similar topics. Sequencing was based on where topics related to outcomes in the courses. EBCP committee faculty were asked to review the map and provide feedback. Changes were made based upon this feedback.

Committee members were then asked what EBCP topics they already taught and were willing to teach to complete the proposed sequencing. Learning outcomes were assigned based upon the sequencing and committee faculty feedback. Competencies and learning outcomes were created for each of the evidence-based topics by content experts. Most topics were intended to be introduced in quarter 1. Inclusion of 1 to 3 new EBCP learning outcomes in 1 class per quarter was implemented with reinforcement of each learning outcome in a later quarter. Evidence-based competencies were placed sequentially in courses so that the competency was introduced in first quarter, covered in greater depth in a subsequent quarter and reinforced in a later quarter as exemplified in Table 1. These sequential competencies were added to existing course syllabi as learning outcomes from first to 13th quarter. Learning outcomes were debated, refined, and approved by a learning outcomes committee and then approved by a faculty and administration level curriculum management committee and administrative committee. This project was authorized by the academic dean and granted exemption by the Palmer College of Chiropractic institutional review board (# N2018-10-1-M).

Table 2 - List of EBCP Topics

Topic Number	Topic Content
T01	Basics: Definitions, Pillars
T02	Critical Thinking: 5 As, Logic, Creativity
T03	Scientific Method
T04	Ethics
T05	Reliability, Validity General
T06	Ask: Background, Foreground (PICO)
T07	Access/Acquire: Pyramid, Databases (PubMed: MeSH, DynaMed)
T08	Appraisal: General Stats: Data Types, Distributions, Measures of Central Tendency, Dispersion
T09	Appraisal: Stat Selection: Data Types, Parametric, Skew, Kurtosis
T10	Appraisal: Significance, Confidence Intervals, alpha level, *P*-value, Statistical significance
T11	Appraisal: ABCDFix: Allocation (Randomization, concealment), Blinding, Comparison, Drop-out, Follow-up, Intention to Treat, X-tra factors.
T12	Appraisal: Formal Tools
T13	Appraisal: Correlation, Regression
T14	Appraisal: Diagnostic Reliability: κ, ICC mean absolute deviation
T15	Appraisal: Diagnostic Validity: Sensitivity, Specificity, Likelihood ratio
T16	Appraisal: Treatment (Surrogate End Points, Effect size, Difference in Means Tests), Meta-analysis (Forrest Plot, Heterogeneity, Funnel plot)
T17	Appraisal: Risk/Prevention: Odds Ratio, Adjusted Relative Risk, Numbers Needed to Treat
T18	Apply: Clinical significance, Effect size, Minimally Clinically Important Difference
T19	Assess: Outcome Assessment Tools, Specific Activities of daily living

EBCP: evidence-based clinical practice; T, topic.

Assessment (Structure)

A frequency analysis of the use of Bloom's verbs served as a starting point that we synthesized with statistics software to make a graphical representation. First, the outcomes from the syllabi were paired with relevant EBCP topics. Table 2 lists the EBCP topics and corresponding content. Most outcomes covered multiple EBCP topics. Some of the outcomes were at 2 Bloom's levels in 1 course, although most were at 1 level. Some courses had projects that often incorporated multiple topics and levels of understanding. Microsoft Excel (Microsoft Corp; Redmond, WA) was used to prepare data for analysis (Table 3).

Our structural analysis involved creating graphs of the topics that plotted Bloom's verbs on the y-axis and the quarter on the x-axis. Assessments were structural or learning performance focused. Structural assessments included determining aspects of sequencing, repetition, and level of rigor (Bloom's verb level). Learning performance assessments involved determining the grades achieved and whether they demonstrated clinically meaningful learning.

We used the ggplot2 (Wickham, Hadley; Switzerland) graphics program of R (version 3.4.3, R Foundation for Statistical Computing, Vienna, Austria) to plot our subcurriculum.[29] Structural analysis methodologies used

Table 3 - Example of Spreadsheet Preparation for Data Analysis in R

Quarter	Bloom Lvl	Topic_Num	Topic_Num	Topic
1	3	106	6	T06 Ask
1	3	107	7	T07 Access
2	3	106	6	T06 Ask
2	3	107	7	T07 Access
3	3	106	6	T06 Ask
3	3	107	7	T07 Access
4	3	106	6	T06 Ask
4	3	107	7	T07 Access
9	3	107	7	T07 Access
10	2	102	2	T02 CritThink
10	2	117	17	T17 App Risk
1	6	110	10	T10 App SignP
1	6	111	11	T11 App ABCDFix
1	6	112	12	T12 App Formal
1	6	113	13	T13 App Cor Reg
1	6	114	14	T14 App Dx Rel
1	6	115	15	T15 App Dx Val

Only columns "Quarter," "Bloom Lvl," and "Topic_Num" were used in the data analysis. ABCDFix: Allocation (Randomization, concealment), Blinding, Comparison, Drop-out, Follow-up, Intention to Treat, X-tra factors. App = Apply. SignP = Statistical significance using p value. Cor Reg = Correlation and Regression. Dx Rel = Diagnostic Reliability. Dx Val = Diagnostic validity.

by other researchers include Academic Analytics, Walktrap algorithm[30] and Bloom's verb based Frequency Analysis.[22] In our analysis, the quarter was assigned to the x-axis, Bloom's level to the y-axis, and the topic number to functions called color and faceting. Figure 1 shows the ggplot2 script.

Support

The EBCP task force supported the faculty by creating teaching tools, including detailed PowerPoint presentations (Microsoft Corp) with a standardized format, for each competency. The teaching resources were then compiled into a single resource for all faculty members to assure consistency in the information being provided. We also implemented a continuing education program about EBCP for all faculty members. During these periodic in-service meetings, concepts that have been identified and that need to be emphasized and taught to students are reinforced.

RESULTS

The mapping of the curriculum quarters versus Bloom's verb level is presented in Figure 2. The value for Bloom's verb should increase as the student goes through the curriculum, showing a progression from memorization to critical analysis. Another feature was the ability to find gaps. A gap in the quarter on the x-axis shows that the topic is not being reinforced during that quarter. This could be an issue or not depending upon how much reinforcement is needed for that topic. A gap in the Bloom's verb level means that the topic is not being assessed at that level. These gaps showed that the outcome depth of processing did not have foundation, mid-level building blocks, or a cap stone, higher level exposure.

Table 3 and Figure 2 were used to determine the amount of EBCP topics per quarter and where they are more concentrated. Table 4 showed that 14 of the 19 topics had increasing linear model trends, 5 had short linear trends, and 1 had no trend. Decreasing, short trends were found in 3 topics. Quarters 5–8 showed decreased attention to EBCP topics, especially quarter 5.

DISCUSSION

The 14 of 19 increasing linear model trends were preferred patterns because they represent topics assessed at higher levels as the quarters progressed. The 5 short linear trends represent topics that are not assessed later in the curriculum. The 1 topic with no trend showed that the topic is taught only once. The 3 decreasing short trends represent topics that were developed at a higher level in the beginning but at a lower level later in the program. This is not a preferred trend. This structural analysis of the EBCP subcurriculum was helpful for us to detect trends and gaps for further refining of the curriculum. In our assessment plan, we have addressed building a curricular structure that includes early, frequent, repetitive, progressive development of EBCP topics. Based on our analysis, further development of the structure is planned.

Our future plans involve tracking the EBCP competencies tied with the learning outcomes within the courses. We will need to overcome some barriers to assessment, such as the compilation and analysis of data from all the courses into an easily understandable product. As well, it

```
jpeg("ResCurBW.jpeg", units="in", width=7, height=5, res=300) #Print at 300dpi
ggplot(d1, aes(Quarter,`Bloom Lvl`, group=Topic))+ #Set up x, y and groups
  geom_smooth(method="lm",col="Black")+  #Black, grey and white format
  geom_point(pch=1)+ #point appearance
  xlim(0,13)+ #Limit of x axis
  ylim(0,6)+ #Limit of y axis
  facet_wrap(~Topic)+ #Create facets of different Topics
  annotation_logticks(2)+ #Create aesthetically pleasing axis
  labs(x="Quarter", # Set x-axis label
       y="Bloom's Verb")+ # Set y-axis label
  theme(legend.position = "none") #Turn off legend
dev.off()
```

Figure 1 - The ggplot2 script used after converting the topic number to a factor variable.

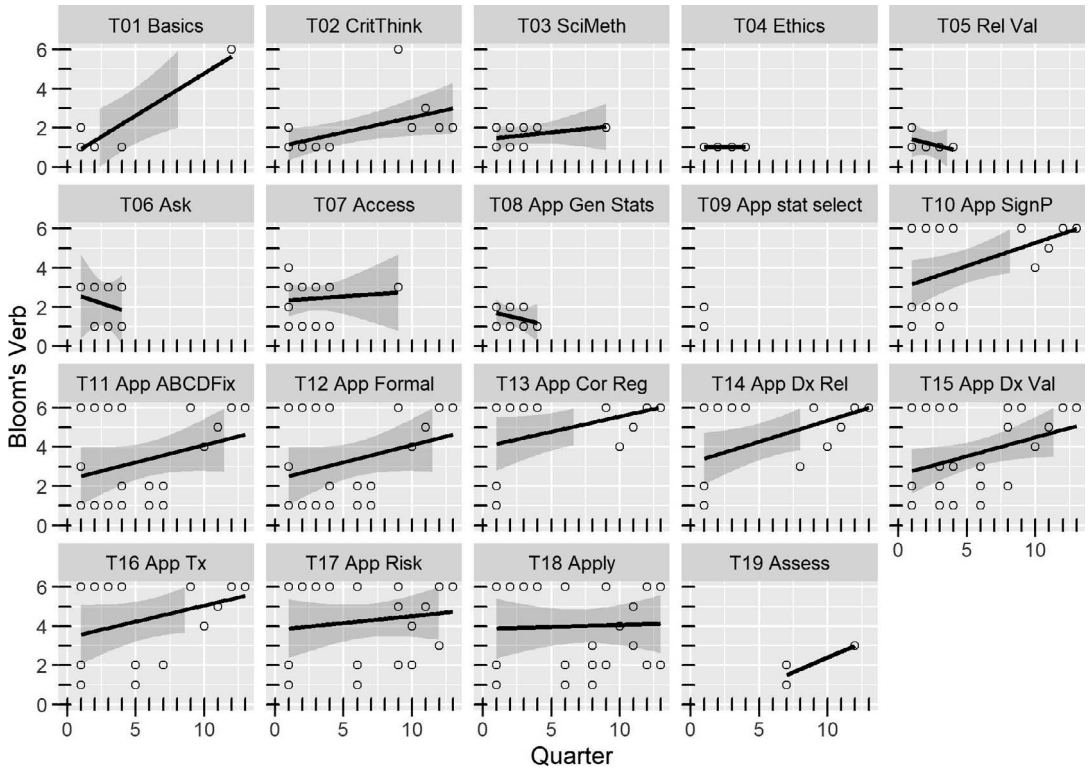

Figure 2 - Bloom's based curriculum maps facetted by topic name. Each Topic (T) is given its own graph (T01 through T19). The Bloom's verb level on the y-axis indicates the level of difficulty of the course outcome. The quarter is on the x-axis and represents the passage of time as the student proceeds through the curriculum. The linear regression for that topic shows if the topic outcome verbs start tightly at a lower level and get more complex. The shaded area represents the confidence interval of the data, which show if the outcome verbs are closer to the same level and how many are at that level. Notice T07 where the topic "Access" or how to use databases to do literature searches starts with many outcomes lower to mid-level, which makes the CI tight. Then only a single point represented a scant increase in the average verb level causing a wide confidence interval.

will be important to limit the changing of course outcomes contrary to an adequate process of revision (ie, curricular drift).[31] It will also be important to identify outcomes that are not sufficiently demonstrated by students if they are intentionally doing well enough on other content to receive a passing grade. For example, a student could do well on the easier topics and not the harder topics.

Specific structural changes may be needed to address shortcomings identified with the structural analysis. We also plan to gather information about the students' mastery of EBCP topics through programmatic assessments. To assess our students' ability to apply EBCP principles to patient care, we can review data on our interns in quarters 9 through 12.

We believe that 1 of the unique aspects of our project was the goal of EBCP outcomes being introduced early, frequent, repetitively, and progressively throughout the entire curriculum. As stated by Bussieres et al[7] in 2016, "academic programs should incorporate EBCP content early in a program of study and 'weave' it throughout the 4–5 years of professional education." We look forward to performing our learning assessment following this "weaving" concept. Our desired end goal is to assure a progression from knowledge to comprehension to application in all topics and lead to successful clinical integration of EBCP by our students. As noted by Nkangieneme[33]:

> "In the traditional pre-clinical years cognition by students is mostly at the knowledge and comprehension levels. In the first clinical year it moves to the application and analysis levels with expansion of the knowledge base and reduction of comprehension time. By the final year, students should be functioning mostly at the analysis and synthesis levels with occasional evaluation level processing to effectively solve the clinical problems that they are likely to encounter."

It is of particular interest to note that students have been found to value higher order learning opportunities for EBCP; as noted by Thomas et al[34] in 2017, "Students believe that application of EBCP in the clinical context is of utmost importance and that the academic program should design opportunities for this to happen as often as possible."

Comparison with another method by Whillier et al[31] is presented in Table 5. We are interested in their more open format, research stream to increase research capacity, and inclusion of recent graduates and chiropractic clinicians in noncollege-related practice.

Table 4 - Structural Analysis Guide and Results

Check List Items	Positives	Areas of Interest	Solutions
Trends: Are all Bloom's verbs trending up over time?	14/19 increasing linear model trends	Some not visually linear with drop in middle of terms, 3/19 decreasing, short linear trend, 1/19 flat trend (104 Ethics), 1/19 no trend (109 stat selection)	Create learning outcomes with more details to provide data points for improved trends, capture other data points from other learning outcomes that are not designated as EBCP learning outcomes
Bloom gaps: Are all Bloom's levels represented?	19/19 lower Bloom's levels represented in all topics	8/19 high-level (Lvl 5–6) gaps, 7/19 mid-level (Lvl 3–4) gaps or sparse	Determine which of the 8/19 require higher and mid-level verbs to be assessed
Course load: Are all quarters equal in amount of outcomes except those with dedicated courses?		Some spread is needed between courses with 2 nondedicated courses taking unequal load	Create upper term dedicated course or spread out the learning outcomes to courses that can logically relate to the topics.
Density/repetition: Are all topics equally stressed with repetition? Is equality desired?		Many trends without increasing overlapping repetition.	Consider which topics require more repetition base upon assessment data (test results)
Term gaps: Any large breaks between addressing topic?		12/19 mid-term gaps especially quarter 5, short trends in 5/19	Spread to fill gaps
Clinic gaps: Does this outcome become addressed in clinic (clinically relevant)?	Articles used in clinical cases in many clinic courses (Quarters 9–13)	8/19 gaps	Consider how to incorporate more specific use of some topics taking into consideration that articles related to patient do not cover all topics
Overwhelm: Are the higher level verbs spread out so big projects do not overwhelm students or professors?		Overwhelm in many student cohorts with quarter 1 EBCP dedicated course. EBCP break in middle of terms needs to be spread out. Although appraisal needs to be started early, it skews the analysis since it is a level 6/6 Bloom's verb.	Consider mid curriculum dedicated course for mid-level EBCP outcomes. Spread outcomes to appropriate classes. Change appraisal verb to lower level verbs such as "explain" in the lower quarters and progress to 6/6 verb such as "defend". Although remember that this education is at a graduate level college and students should be able to progress to higher level verbs faster even on new material.

EBCP: evidence-based clinical practice.

Limitations

There were several limitations to this study. There was no learning assessment as part of this project. We did not ask each professor whether any EBCP topics were embedded in their course without an outcome. We also did not address the issue of subjectivity across the level of Bloom's taxonomy. Such that, "appraisal" can be done at a beginner level where the student can "identify" or at an expert level where they "criticize."[35]

CONCLUSION

The graphical verb-based, structural analysis seemed useful to identify progression of intended learning complexity and gaps in presentations of topics in our EBCP subcurriculum. Fourteen of the topics had increasing linear model trends indicating verb progression. Insufficient attention to EBCP topics was identified in some quarters. We hope that our experience incorporating

Table 5 - Comparison Between Methods

Issue	Our method	Whillier et al[31]
Demographics: Country	USA	Australia
Demographics: Program	Prerequisite BS degree, 5-y professional doctorate consolidated to 3.3 y	3-y BS, 2-y MS
Type of Curriculum change	Incorporation	Overhaul
Goals	1 stream (practicing clinician) with Bloom's verb progression, frequency and repetition	3 streams (professional, clinical science, research) with program learning outcome mapping
Process: Initial sketch of curriculum	Created and refined by 2–3 content experts	Created by writing on bulletin boards by many faculty
Process: Further refining	Committee with >10 faculty to review proposal	Many faculty
Members: Faculty	Expert group and those interested	All invited
Members: Student Representative involvement	Yes	Unknown
Members: Recent graduate included	No	Yes
Members: Clinic rep	Yes	Yes
Assessment: Curriculum map	Written; Graphic, structural, Bloom's verb based analysis	Written
Future: Drift	Faculty informed to go through process to change	Allowed to change outcomes

EBCP into an integrated curriculum may be helpful to others.

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