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Proposal to develop a set of inquiry-based science content courses

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Many elementary education majors report having enjoyed science as a child in elementary school, but they were later turned off by a dry, memorization-heavy, lecture-based science course in high school or college. As a result, many become science-phobic or dread teaching science themselves. It is difficult to impossible to overcome their low level of confidence and efficacy in our current curriculum, in which there is a single course, SCED 322 Science Education in the Elementary School, where we have the opportunity to foster their development as a science teacher for their future students.

A number of institutions have effectively responded to this situation by offering a series of science content courses designed primarily for pre-service teachers, taught in smaller sections that make use of the same investigative, inquiry-based, and group-learning techniques that we want to encourage them to apply in their own classroom in the future (e.g. Bianchini and Colburn, 2000; Cervato et al., 2013; Choi and Ramsey, 2009; Liang and Gabel, 2005; Linneman, 2011; Pedersen and McCurdy, 1992; Sanger, 2007). Within the state of Washington, both Western Washington University and Eastern Washington University have developed curricula and adopted this model, along with several of the two-year colleges from which students transfer to WWU and EWU.

We seek to develop a similar set of inquiry-based science content courses here at CWU. The end result will be a set of four courses in physics, chemistry, biology, and geology, geared specifically to elementary education majors. The primary goal of these courses is to allow students to fulfill their general education requirements in natural sciences in a way that facilitates the development of skills they need as future teachers.

This proposal describes:

- The goals of developing a new set of courses
- Who will develop and teach the courses
- Who will take the courses
- Proposed distribution of WLUs, FTEs, and lab fees
- The resources needed to achieve our goals
- Impacts
- Appendices (WLU data and department chair signatures)

Goals

The primary goals of developing a new set of introductory science courses are:

1. To utilize best practices derived from research on learning (e.g. Bransford et al., 1999; National Research Council, 2012) in designing introductory science courses;
2. To provide opportunities for future teachers to fulfill their natural science general education requirements through courses that build their content knowledge, their ability to engage in inquiry, and their confidence in teaching science;
3. To build a community of faculty who are engaged in teaching science using high-impact practices (Kuh, 2008).

In order to achieve these goals, we propose to develop three new courses:

BIOL 106 Life Science Inquiry
CHEM 106 Chemistry Inquiry
GEOL 106 Earth Science Inquiry

These courses will be modeled on PHYS 106 Physics Inquiry, first offered in 2009 and taught every fall since then. PHYS 106 may be modified in the development of the three courses listed above in order to make explicit connections between disciplines and to develop common themes.

These courses will share the following components:

- The content will focus on the Washington state competencies for elementary and middle-level and teachers as they are tested in the WEST-E.
- Lecture and lab will be integrated in a 5-credit course that meets for 3 2-hour (or 4 1.5-hour) session per week.
- The teaching style will be grounded in student-centered, activity-based learning techniques and will integrate pedagogical content knowledge.
- Class size will be limited to 24 (with one instructor) or 48 (with two instructors).
- Courses will fulfill student learner outcomes for the three components of the natural sciences breadth requirement in CWU's general education program.

Some of the content in these courses will overlap with current offerings (specifically BIOL 101, CHEM 111 and 111LAB, GEOL 101 and 101LAB). These courses differ, however, because they cover fewer concepts in greater depth using a constructivist approach that models the style of teaching that we hope to cultivate in future teachers. In addition, they may cover some concepts that are part of the WEST-E competencies but are not currently part of the introductory curricula (e.g. the human body, basic environmental chemistry, and weather). As such, we do not envision these courses as replacing existing offerings within the departments, but adding to them.

It is important that these courses are listed in the respective disciplinary departments and not as Science Education courses. First, these really are science content courses. For all existing courses listed in SCED, the content is pedagogical methods, the teaching community, etc.—not science content. So the content of the courses is more aligned with what is being offered in the disciplinary departments (BIOL, CHEM, GEOL, PHYS) than what is being offered in SCED. In addition, it is important for the students to have these on their transcripts as science content courses, which would not be clear if they had SCED prefixes. Particularly for students who choose to take the whole series through the Science Education K-8 minor, we want it to be clear to principals doing the hiring that these graduates are highly qualified in science.

Who will develop and teach the courses?

We propose that teams of faculty work together to develop each course. Each team will include at least one faculty member from Science Education and 1-2 others from the disciplinary departments. Science Education faculty will coordinate to assure that similar themes are being addressed throughout the series. Tentatively, these development groups are:

Biology	Chemistry	Geology	Physics
Jennifer Dechaine	Martha Kurtz	Anne Egger	Bruce Palmquist
Ian Quitadamo	Bob Rittenhouse	Walter Szeliga	Mike Jackson
Lucy Bottcher	Tim Sorey	Keegan Fengler	Mike Braunstein

By developing the courses as a group, we will draw on a variety of expertises and cultivate a cohort of faculty that can teach these courses effectively. We plan to draw from materials that were designed by a cohort of faculty at WWU (Debari et al., 2008; Fackler-Adams et al., 2009) based on the highly effective Physics and Everyday Thinking (PET) curriculum (Goldberg et al., 2010; Otero and Gray, 2008). These curricula use high-impact educational practices including collaborative assignments and projects and learning communities (Kuh, 2008).

Once the courses are developed, we propose a co-teaching model that will continue to allow for professional development and getting new faculty involved in teaching these courses in a mentored fashion. In the team-teaching model, each course would be taught by two faculty members: one from Science Education who would be teaching outside of their discipline and one from the disciplinary department. For example, Bruce Palmquist (SCED and PHYS) would teach GEOL 106 with Walter Szeliga (GEOL). To accommodate this model, we would double the ideal class size from 24 to 48.

Who will take the courses?

We will submit the courses to the General Education for approval to fulfill the natural sciences breadth requirement, and thus the courses will be open to anyone. However, they will be geared specifically towards elementary education majors, and be appropriate for middle-level science teaching majors as well. There are approximately 100 elementary and early childhood education majors on the Ellensburg campus per year who could take as many as three of these courses if they fulfill general education requirements.

Students in General Science Teaching major – Middle-level Designated Endorsement (currently under development) will be required to take two of these courses; students in the Science Education K-8 minor (currently Science Education – Elementary Education minor) will be required to take all four courses. While elementary education majors would make up the majority of students in the classes, we anticipate these two programs together could contribute 10-20 students per year.

Currently, PHYS 106 enrolls about 15-20 education majors (out of 24 enrolled students) per quarter that it is offered (fall only 2009-2013; in 2013-14 the number of courses offered increased to two). We anticipate the approximately the same ratios in the newly developed

courses. It is likely that these courses will grow well beyond their initial target audience, once students outside of the education majors become aware of their existence.

In order to fully accommodate the students who would need to take these courses (~120 students taking 2-4 courses per year), we would need to offer 8 courses per year (assuming enrollment caps of 48), potentially with the following schedule (we will work with departments, including TEACH, to determine the best distribution, which may include summer):

	Aut	Win	Spr
PHYS 106	1 (48)	1 (48)	
CHEM 106			1 (48)
GEOL 106	1 (48)		1 (48)
BIOL 106	1 (48)	1 (48)	1 (48)
	3 (144)	2 (96)	3 (144)

It is important to note that the majority of these students currently take existing offerings in the science departments, typically GEOL 101, 107, or 108, CHEM 101 or 111, BIOL 101, and PHYS 106. So although we are proposing new courses, it is not likely to add significant numbers of students to the total number enrolled in each department's 100-level offerings.

How will FTEs, WLUs, and lab fees be distributed?

One of the primary concerns expressed by faculty in SCED and chairs of all of the departments is the equitable distribution of FTEs and WLUs, especially given current budget scenarios in which resource distribution is heavily dependent on FTEs. We've attempted to address these concerns here.

FTEs: As described above, it is important to list these courses in their disciplinary departments so that these courses appear on student transcripts as science content courses. However, most students in these courses will be coming from Science Education and other education majors, and half of the faculty teaching these courses will be from Science Education. For those reasons, we propose a 50-50 split of FTEs between the disciplinary science department and Science Education.

WLUs: In our co-teaching model, we pair faculty but also double the class size. For that reason, we propose that each faculty member should receive the full 6 WLUs for teaching a 5-credit course. Appendix I details the current distribution of WLUs for introductory courses in each department and the effect that adding these courses would have. By replacing one or more existing introductory courses with a 106 course, the number of WLUs does not change significantly in any of the disciplinary departments, but there is a significant increase in SCED (see below).

Lab fees: Since most (if not all) of the materials used in the labs will come through the departments and stockrooms, we propose that all lab fees remain in the disciplinary departments.

What resources are needed?

Despite the abundance of research that suggests that teaching science in smaller, investigation-based courses is more effective than a traditional lecture-lab format, there are barriers to adoption. One barrier is cost: smaller classes require more faculty time, appropriate classrooms, and additional materials.

Faculty: Based on the analysis of WLUs in Appendix I, we anticipate needing one additional full-time instructor or tenure-track faculty member, ideally appointed in Science Education who could also serve as coordinator for the entire set.

Classrooms: We are fortunate that the new Science Phase II building is designed specifically to allow for teaching this kind of course. Several classrooms have movable tables and accommodate 20-50 students in a collaborative learning environment. We anticipate making full use of these facilities, but these will not accommodate all of the offerings, and we may need to modify classrooms in Science I.

Materials: Lab fees will support the purchase of materials for courses once they are running, but new lab materials will likely need to be purchased, since this model of teaching requires enough samples/manipulatives for all students to be able to have their hands on at the same time – a departure from some of the current lab-based courses. In addition, we anticipate purchasing some materials that could be used in all courses, such as sets of portable whiteboards and reference materials.

Impacts

Washington state recently adopted the Next Generation Science Standards (National Research Council, 2013). The knowledge, skills, and attitudes embodied in the NGSS reflect several big changes from the current standards, and will require significant changes in the ways that we prepare teachers at all levels to teach science. Giving future teachers the opportunity to learn science in the way that we expect them to teach it is a critical component of effective teacher preparation, and the most significant impact of this proposal will be felt well beyond CWU – in the classrooms across the region where these students are hired.

In addition, faculty professional development is a significant positive factor in offering these new courses. We anticipate that one impact of professional development will be the spread of highly effective teaching practices to the other courses that those instructors teach.

Approximately half of the elementary education majors that graduate from CWU transfer in having completed their general education requirements elsewhere. In future years, we hope to work with faculty at the institutions students transfer from in order to be able to offer these courses beyond CWU. We see this as an opportunity to build a community of science educators across the state and offer professional development opportunities.

References

Bianchini, J. A., and Colburn, A., 2000, Teaching the Nature of Science through Inquiry to Prospective Elementary Teachers: A Tale of Two Researchers: Journal of Research in Science Teaching, v. 37, no. 2, p. 177-209.

Bransford, J. D., Brown, A. L., and Cocking, R. R., 1999, How People Learn: Brain, Mind, Experience, and School, *in* Education, C. o. B. a. S. S. a., ed.: Washington, D.C., National Academies Press, p. 346.

Cervato, C., Kerton, C., Peer, A., Hassall, L., and Schmidt, A., 2013, The Big Crunch: A Hybrid Solution to Earth and Space Science Instruction for Elementary Education Majors: Journal of Geoscience Education, v. 61, no. 2, p. 173-186.

Choi, S., and Ramsey, J., 2009, Constructing Elementary Teachers' Beliefs, Attitudes, and Practical Knowledge Through an Inquiry-Based Elementary Science Course: School Science and Mathematics, v. 109, no. 6, p. 313-324.

Debari, S. M., Bachman, J., Dougan, B., Fackler-Adams, B., Kratz, R., Linneman, S. R., Plake, T., and Smith, B., 2008, Using 'How People Learn' as a Blueprint for Developing Teaching Strategies in an Introductory Geology Course: EOS Transations, v. 89, no. Fall Meeting Supplement, p. Abstract ED41B-06.

Fackler-Adams, B., Debari, S. M., Dougan, B., Kratz, R., Linneman, S. R., Plake, T., and Smith, B., 2009, Using metacognition to promote robust learing in a module-based introductory geology course: Geological Society of America Abstracts with Programs, v. 41, no. 7, p. 714.

Goldberg, F., Otero, V., and Robinson, S., 2010, Design principles for effective physics instruction: A case from physics and everyday thinking: American Journal of Physics, v. 78, no. 12, p. 1265-1277.

Kuh, G. D., 2008, High-impact educational practices: What they are, who has access to them, and why they matter, Association of American Colleges and Universities, 44 p.:

Liang, L. L., and Gabel, D. L., 2005, Effectiveness of a Constructivist Approach to Science Instruction for Prospective Elementary Teachers: International Journal of Science Education, v. 27, no. 10, p. 1143-1162.

Linneman, S. R., 2011, Geology and Everyday Thinking: A metacognitive learning experience designed to insprie future elementary teachers to teacher Earth science: Geological Society of America Abstracts with Programs, v. 43, no. 5, p. 406.

National Research Council, 2012, Discipline-Based Education Research: Understanding and Improving Learning in Undergraduate Science and Engineering, Washington, D.C., The National Academies Press.

-, 2013, Next Generation Science Standards, Washington, D.C., The National Academies Press, 324 p.:

Otero, V. K., and Gray, K. E., 2008, Attitudinal gains across multiple universities using the Physics and Everyday Thinking curriculum: Physical Review Special Topics - Physics Education Research, v. 4, no. 2, p. 020104.

Pedersen, J. E., and McCurdy, D. W., 1992, The effects of hands-on, minds-on teaching experiences on attitudes of preservice elementary teachers: Science Education, v. 76, no. 2, p. 141-146.

Sanger, M. J., 2007, The Effects of Inquiry-Based Instruction on Elementary Teaching Majors' Chemistry Content Knowledge: Journal of Chemical Education, v. 84, no. 6, p. 1035.

Appendix I: Analysis of WLUs

Current offerings

Table 1 uses actual enrollment data from Fall 2013, Winter 2013 (except PHYS 106 is Winter 2014), and Spring 2013. For each quarter the table shows: number of courses offered, WLU, enrolled/capacity/wait list.

Table 1.

Fall	WLU	#S/WL	Winter	WLU	#S/WL	Spring	WLU	#S/WL
BIOL 101	8	71/72/2	BIOL 101	8	72/72/1	BIOL 101	8	74/72/0
BIOL 101	8	70/72/5	BIOL 101	8	73/72/2	BIOL 101	8	72/72/2
BIOL 101	6	48/48/0	BIOL 101	6	49/48/1	BIOL 101	6	46/48/0
	20	**189**/192/7		**20**	**194**/192/4		**20**	**192**/192/2
			CHEM 101	6	66/72/1	CHEM 101	6	44/72/0
CHEM 111	6	67/72/0	CHEM 111	6	76/72/1	CHEM 111	6	64/72/1
CHEM 111	6	72/72/0	CHEM 111	6	66/72/1			
CHEM 111	6	71/72/0						
	18	**210**/216/0		**18**	**208**/216/3		**18**	**108**/144/1
GEOL 101	4	63/65/0	GEOL 101	4	62/60/0	GEOL 101	4	61/60/0
GEOL 101	4	64/65/0	GEOL 101	4	60/60/0	GEOL 101	4	60/60/1
GEOL 101	4	61/65/0	GEOL 103	6	53/60/0	GEOL 103	6	38/60/0
GEOL 103	6	44/65/0	GEOL 107	5	65/65/0	GEOL 107	5	64/65/0
GEOL 107	5	37/70/0	GEOL 107	5	55/65/0	GEOL 107E	5	17/20/7
GEOL 107	5	35/70/0	GEOL 107	5	41/65/0	GEOL 108	5	49/65/0
GEOL 107	5	20/70/0	GEOL 108	5	48/65/0	GEOL 108	5	37/65/0
GEOL 107E	5	24/25/6						
GEOL 108	5	35/70/0						
GEOL 108	5	32/70/0						
	48	**416**/635/6		**34**	**395**/440/0		**34**	**326**/395/7
PHYS 106	6	25/24/0	PHYS 106	6	22/30/0			
PHYS 111	6	45/40/0						
PHYS 111	6	44/40/0						
	18	114/104/0		**6**	22/30/0			

Proposed Steady State

If new courses are co-taught with one SCED and one discipline and have 48 students per section, the effect (shown in Table 2) would be to:

Replace one BIOL 101 (48) with one BIOL 106 (48) each quarter

Impact: no change in workload for BIOL + 18 additional WLU for SCED

Add one CHEM 106 (48)

Impact: 6 additional WLU for CHEM + 6 additional WLU for SCED

Replace one GEOL 107 (70) and one GEOL 108 (65) with two GEOL 106 (96)

Impact: 2 additional WLU for GEOL + 12 additional WLU for SCED

Increase two PHYS 106 (24) to two PHYS 106 (48)

Impact: no change in workload for PHYS + 12 additional WLU for SCED

Table 2.

Fall	WLU	#S/WL	Winter	WLU	#S/WL	Spring	WLU	#S/WL
BIOL 101	8	72	BIOL 101	8	72	BIOL 101	8	72
BIOL 101	8	72	BIOL 101	8	72	BIOL 101	8	72
BIOL 106	6	48	BIOL 106	6	48	BIOL 106	6	48
	20	**192**		**20**	**192**		**20**	**192**
CHEM 101	6	72	CHEM 101	6	72	CHEM 106	6	48
CHEM 111	6	72	CHEM 111	6	72	CHEM 111	6	72
CHEM 111	6	72	CHEM 111	6	72			
CHEM 111	6	72						
	24	**284**		**18**	**216**		**18**	**120**
GEOL 101	4	65	GEOL 101	4	60	GEOL 101	4	60
GEOL 101	4	65	GEOL 101	4	60	GEOL 101	4	60
GEOL 101	4	65	GEOL 103	6	60	GEOL 103	6	60
GEOL 103	6	65	GEOL 107	5	65	GEOL 107	5	65
GEOL 106	6	48	GEOL 107	5	65	GEOL 107E	5	20
GEOL 107	5	70	GEOL 107	5	65	GEOL 106	6	48
GEOL 107	5	70	GEOL 108	5	65	GEOL 108	5	65
GEOL 107E	5	25						
GEOL 108	5	70						
GEOL 108	5	70						
	49	**613**		**34**	**440**		**35**	**378**
PHYS 106	6	48	PHYS 106	6	48			
PHYS 111	6	40						
PHYS 111	6	40						
	18	**128**		**6**	**48**			

Table 3. Comparison of Faculty Workload and Student Capacity

	Faculty WLU New	Faculty WLU Current	Students Served New	Students Enrolled Current
Biology	60	60	576	575
Chemistry	60	54	600	526
Geology	118	116	1431	1137
Physics	24	24	176	136
Science Ed	48	0		

Appendix II: Signatures

This proposal has been discussed with all of the department chairs and curriculum committees of the relevant departments. Their signatures below indicate approval.

Approval	Signature	Printed name	Date
SCED Chair		Martha Kurtz	
BIOL Chair		Tom Cottrell	
CHEM Chair		Levente Fabry-Asztalos	
EDEL Chair		Keith Salyer	
GEOL Chair		Carey Gazis	
PHYS Chair		Andy Piascek	
COTS Dean		Kirk Johnson	