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Science Education Specialists: Agents of Change

A CRITICAL ELEMENT of the SEI was the use of science education specialists (SESs) that were embedded in the departments. These specialists were experts in the discipline with expertise in teaching the discipline using the most effective research-based methods and principles. The SESs worked collaboratively with individual faculty members to change how courses were taught, and to enhance the teaching expertise of the faculty member in the process. Their work on course transformation focused on three key questions: What *should* students learn? What *are* students learning? and What instructional practices will improve student learning? The SESs played a vital role in the SEI change process and were responsible for much of the success of the SEI, but there was little precedent for such change agents. The SEI largely invented this position and figured out how to make it effective in improving teaching. In this chapter, I describe the SES position, and how SESs were hired, trained, and worked with faculty to improve teaching.

What is an SES? These professionals, called "science teaching fellows" (STFs) at CU and "science teaching and learning fellows" (STLFs) at UBC, offer an unusual combination of expertise in their discipline and knowledge of relevant teaching methods and research on learning. A typical SES was a recent PhD in the relevant science discipline who was keen to improve teaching, and to varying degrees interested in education research. However, there were also a number of excellent SESs with different backgrounds.

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These included people who had been frequent instructors in the department on short-term contracts, an emeritus faculty member, master's degree holders, and graduate students (for limited periods). Whatever their background and whatever the process by which they were selected, all effective SESs combined thorough disciplinary knowledge with good interpersonal skills and a strong interest in teaching.

Since most individuals hired as SESs had limited prior experience with research and research-based teaching methods, new SESs attended a semester-long training program run by SEI Central. SESs also attended ongoing meetings to further develop their skills and to generate a cross-departmental community and learning opportunities.

The primary job of the SES was to collaborate with individual or small groups of faculty to implement course transformation, helping faculty members increase their knowledge of relevant teaching and learning research and supporting the introduction of evidence-based educational practices and measurements of learning. It was important for SESs to be partners and gentle coaches for faculty—and not to be treated as glorified teaching assistants (TAs) who merely develop instructional materials.

The most successful SESs were those who were viewed (and viewed themselves) as *departmental resources*, and therefore continually worked to enhance both their scholarly expertise about teaching and their productive relationships with many faculty members. These SESs acted in a variety of capacities:

- Supporting specific course transformation efforts, as described below, including documenting achievements and archiving materials
- Being a consultant for general faculty questions on effective teaching, or small teaching projects (that is, not a full course transformation)
- Running workshops for faculty and/or TAs on various teaching methods, or bringing in outside experts to do so
- Engaging the department by running seminars or brown-bag luncheon discussions on teaching issues, creating newsletters, and actively seeking out opportunities for informal hallway discussions
- Staying apprised of education research relevant to the discipline, and conveying this to the faculty
- Helping set up training programs for TAs within the department to allow TAs to better support the use of new teaching methods

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Position Description

At both institutions there was an initial difficulty with the formal job title and description for the SES. Existing university job titles allowed for two explicitly distinct types of short-term PhD-level positions: research postdocs and instructors. The formal policies of both universities forbade a non-tenure-track person from doing both teaching and research (including research on teaching and learning). A person who helped with teaching a course, did research on the effectiveness of the teaching in a course, and might choose to publish that work (as SESs were expected to do) was in conflict with some aspect of every official position description. I had to negotiate a change in official position descriptions at both universities in order to make it possible to hire SESs.

SES Candidates

There was little difficulty in finding excellent candidates for SES openings except for in computer science. In the standard model, good candidates were new PhDs in the respective disciplines with people skills and a strong interest in education. In computer science (CS), the model included buying out some of the teaching load of suitable CS instructor-track faculty so that they could serve in the SES role. This worked well.

Selection and Hiring

It was important that the departments have ownership of the SES recruitment and hiring process, although SEI Central always participated in the hiring process and interviews in an advisory capacity. There were variations across the departments as to how hiring was carried out. Usually there was some form of open search for an external candidate, but in some cases the department had internal candidates (recent PhD graduates or sessional instructors) they felt would be well suited. I have no reason to argue for one over the other, as I have seen that both can work out well. Because it took time for an SES to become effective, and it takes time to transform multiple courses, at least a two-year appointment was considered essential and a three-year appointment was preferable.

In departments where educational activities had particularly high public visibility (for example, because of substantial educational research in the

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discipline), the applicant pool for SES positions was quite large (forty to fifty applicants, with approximately half those being worth serious consideration); in other departments, the applicant pool was smaller (ten to twelve). We were pleased with the quality of the top candidates in nearly all cases. In the later years of the SEI, it was increasingly possible to hire postdocs in some disciplines who had both a background in the relevant discipline and science education expertise. Such a background is not sufficient to ensure that an SES is effective, however, as many other skills are also required.

Advertising was done through a wide variety of channels, including disciplinary research, education research, and teaching- and learning-related venues. Disciplinary-specific search channels (for example, advertisements in a professional society journal) did not typically attract many suitable candidates. Advertisements described the position and its duties, which included working with faculty to develop course materials and measures of student learning. A PhD was typically required, as were organizational, interpersonal, and communication skills, with experience in education listed as a plus. Most positions were advertised as one-year renewable appointments. Examples of advertisements are available in Appendix 3.

Departments typically invited the top candidates to visit the campus and give a talk on their research and/or an education-related topic. Interviews often included questions about their interest in the position and relevant expertise (that is, disciplinary knowledge, education, and education research). The most important criteria were whether the applicant's personality and work characteristics were a good fit for the position. For example, candidates were often asked how they might handle a scenario, such as a faculty member who is resistant to change. Red flags would include a candidate who suggested that the faculty member just needed to be convinced of the effectiveness of the change, or who expressed overconfidence about his or her knowledge of science education, rather than an interest in and willingness to collaborate, listen, and learn. Other questions might ask candidates to describe a time when they did not feel adequately supervised or had to deal with a difficult person.

At SEI Central, we participated in the hiring process in several ways. First, when the person who was handling the search did not have experience in the process, we had preliminary discussions with that person about factors that were important in selecting a good SES, and we helped write the advertisement and a brief job description. In some cases we offered suggestions about places to advertise for candidates. We were always involved

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with the interviews, meeting with the candidates and providing our suggestions to the department, but always deferred to the department when it came to making the final decision. (There was never a case of a serious disagreement over the choice.) An early lesson learned was that during the interviews with candidates, we needed to discuss quite explicitly the relationship between SEI Central and the department. This included stressing that the SES would work for the department and have a primary supervisor in the department, but that SEI Central provided the salary money and had a small set of requirements the SES needed to follow: participation in training, reading group, SES meetings every one to two weeks, and submission of progress reports (originally every two weeks, later once a month). We also discussed the resources and assistance we would provide to them.

SES Course Transformation Activities

In this section, I list the major components of the SES role, including lessons learned as to how SESs could be most productive within that role. Since every situation was somewhat different, the relative emphasis of these components differed, and no single SES was likely to be heavily involved in all of the listed activities. SES activities were organized around three separate guiding questions of the SEI model of course transformation: What should students learn? What are students learning? Which instructional practices will improve student learning?

What Should Students Learn?

In order to answer this question, SESs undertake several activities, as described below.

Develop learning goals. Learning goals define operationally what students should be able to *do* as a result of learning about the content.[1] Ideally, the SES would meet with individual faculty members to find out what their overall learning goals were for the class. What were the big ideas that the faculty were looking to get across to students? What did they feel that the course was "about"? Did they have goals that were not content-specific, such as developing critical thinking or improving student interest in the topic? What knowledge and skills were needed for follow-up courses?

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Useful approaches taken by the SESs were:

- Asking the instructors for examples of student work that demonstrated to them where students were and were not achieving the desired understanding
- Going over past exam questions with the instructors and asking them to explain why they included the question and what they felt it was testing
- Asking instructors of subsequent courses in a sequence what they noticed that students could not do that they wished or expected they would be able to (surprisingly, instructors of subsequent courses were often better able to articulate learning goals for the preceding course than was the instructor of that preceding course)
- Providing relevant examples of learning goals
- Working with faculty in facilitated groups to develop learning goals

Below are several SES prompts for use in discussions with faculty that worked well to elicit faculty ideas about their instructional goals and needs:

- After you lecture on this topic, what do you expect a student to be able to do?
- If a student gets this exam question right, then what does it show that the student can do?
- What do the students have the most difficulty with? What would the students do that would show you they got it?
- What are things that students have said or done that indicated to you they did not get it?

As discussed in Chapter 6, developing learning goals is not necessarily the best way to start working with faculty, because it is difficult and does not provide immediate rewards. It is, however, an important step in a course transformation. Learning goals are valuable because they allow the faculty to more effectively target instruction and assessment, and they enable communication with both students and fellow faculty about course expectations. Learning goals were almost always modified and improved after the first iteration of the transformed course.

Facilitate consensus among faculty. The original vision of the SEI was to create faculty working groups, which would collaborate to develop learning goals and review assessments. Such dedicated working groups functioned

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well in only a few departments, such as physics at CU, where such discussions were part of a preexisting culture of teaching and learning in the department.[2] Even when establishing such a working group is not successful, it can be productive for the SES to gather some relevant faculty for one or two meetings to discuss outcomes of course transformation. Typically, several faculty members were interested because they would be teaching the course concurrently or in a later semester, had taught the course in the past, or were teaching a follow-on course.

In order to lead such a meeting of faculty, the SES needed to have good facilitation skills, including the ability to actively listen. The book *Getting to Yes* by Roger Fisher and William Ury is a useful guide for working with faculty members, and it is one of the books that SESs were given when they first started the job. Additionally, several things that did and did not work well for SESs in facilitating faculty meetings are outlined in Table 4.1.

What Are Students Learning?

SESs engaged in a variety of activities to generate data to drive course transformations. These activities were typically undertaken in collaboration with the faculty member(s) teaching the course, or the faculty working group, if one existed.

Identify students' prior knowledge. What knowledge and skills should students have (or what knowledge and skills are they assumed to have) at the beginning of the course? SES methods for identifying and assessing such prior knowledge included conducting interviews with faculty members; searching the discipline's education research literature to identify relevant student ideas or misconceptions; and developing diagnostic pretests, homework, or other activities to measure student knowledge upon entry into the course.

Identify student learning difficulties. Where do students tend to struggle with the content? These are the key areas where course development should focus. SES methods included four ways to identify learning difficulties. First, interviews conducted with faculty who had taught the course or subsequent courses, to determine which topics or skills students had the most difficulty with. Second, searching the discipline's education research

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Table 4.1. Do's and don'ts for meetings with faculty members

To productively lead a faculty meeting . . .	
Do . . .	Don't . . .
Meet with faculty individually to identify their personal priorities and concerns	Treat the group as the only source of input, or as a singular unit
Encourage broad participation, inviting the entire faculty and targeting individual faculty members	Rely on mass emails alone
Distribute a clear agenda and other materials in advance	Be too rigid in following the agenda
Choose a topic that will motivate faculty to attend	Call a general meeting without a topic of broad or urgent interest
Designate a knowledgeable facilitator who can guide and synthesize discussion	Hold a meeting with no leader/facilitator, or have a leader who is focused on expressing his or her own opinion
Approach discussions in the spirit of soliciting faculty guidance and input	Proselytize about education
Discuss course objectives and pedagogical issues	Create the impression you are telling faculty how to teach
Send out summaries of meeting accomplishments	Assume faculty will remember or recognize the progress made
Hold several meetings	Rely on a single meeting
Synthesize meeting results and produce working documents for circulation and discussion in the next meeting	Expect most faculty to consistently do homework
Survey faculty to establish areas of consensus and priority (for example, rate the relative importance of learning goals). Ensure they have an opportunity to express views, even if they choose not to	Expect to reach clear consensus through discussion
Follow up with faculty about how their input has been used	Move ahead with the project without letting faculty know the outcomes of their investment of time

Source: Adapted from Rachel E. Pepper, Stephanie V. Chasteen, Steven J. Pollock, Katherine K. Perkins, "Facilitating Faculty Conversations: Development of Consensus Learning Goals," *2011 Physics Education Research Conference* (Melville, NY: American Institute of Physics, 2012), 291.

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literature for studies on student learning in the topical area. Third, examining existing course data (for example, homework, tests, surveys) for insight. Finally, it was always revealing to observe, survey, and interview students.

The last item, collecting data from students, was an important part of what many SESs did. This included observing students during class, help hours, and/or discussions, particularly noting student questions. Another data source was student attitude surveys, including asking what they found most useful about the course, or how they viewed the course and its content.[3] Finally, the most in-depth examination involved individual or group interviews. Student interviews were typically done in a cognitive "think aloud" format as the students worked through problems or questions. (See Appendix 2 for a guide to interviewing both students and faculty that was used in the SES training.) Conceptual assessments were carried out by administering validated instruments and short formative assessments (such as two-minute papers or short, targeted questions created by the SES) during class or at the end of the course.

Many of these activities and questions naturally led to research on student learning. Before the SES embarked on such a research study, it was helpful to make sure that the data would be of interest and use to the faculty members. Thus, the SES began by asking faculty members whether there were any data on student learning or attitudes that they were particularly interested in seeing.

Develop measures of student learning. An important part of the SES job was assessment, obtaining measures of student learning to determine the effectiveness of the transformation of course materials and teaching. This assessment data could take many forms. One form was student scores on traditional assessments (for example, exams and homework), although care had to be taken in using typical faculty-prepared questions as they were often not very meaningful. Successfully solving them often involved knowing some obscure trick, or they could be solved by simple memorization of facts or procedures without much grasp of the material. Other forms of assessment include student responses on feedback and attitude surveys (both midterm and end-of-term); student scores on conceptual assessments, validated or not; observation of the course, either through field notes or by means of validated observational protocols, such as student engagement or instructor practice;[4] and other course data, such as drop/fail/withdraw rates, attendance, or persistence in major.

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Ideally, such data would be acquired both before and after the transformation of each course. However, as discussed in Chapters 3 and 6, it was difficult to obtain baseline data on student learning (that is, measures of student learning prior to course transformations), which would allow comparison to post-transformation results.

We initially encouraged the SEI departments to develop and validate instructor-independent measures of learning, as described by Adams and Wieman.[5] Over time, however, we reduced our emphasis on such conceptual assessments, because the level of effort and expertise required to develop them was too high relative to the value placed on such assessment data by the faculty. The one case in which such assessments were developed and routinely used as envisioned by the SEI was in the CU physics department, in which SES time was devoted to a single course over multiple years, and such work was supported both through the existing physics education research group and external grants.[6] A few other tests of conceptual mastery and attitudes about learning were developed as part of SEI activities, but the degree to which they were used is unclear. In most other departments, if the instructor had developed some reasonable measures of learning (usually in consultation with the SES) that could be used repeatedly, this worked fairly well, even without independent validation of the assessment.

What Instructional Approaches Improve Student Learning?

The next step of the SES job was to decide on the methods and materials that would be used to better teach the content. During this phase, the SES collaborated closely with faculty, faculty teams, and TAs. Typically, the SES played a larger role in material development at the beginning of the course transformation process, gradually transitioning into a more advisory role as the project progressed, providing feedback on materials developed by the faculty.

Develop curricular materials and teaching approaches. The SES began by finding out what the faculty were most interested in—what were the educational challenges they wanted to overcome, and what teaching skills did they want to develop? The SES acted as a knowledgeable coach during this phase of the project; it was important to avoid coming across to faculty as "preachy," or as having an agenda. Letting faculty interests drive the collaboration was one way to achieve a productive partnership.

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Next, the SES might describe a variety of teaching approaches that could be used (such as clicker questions with peer instruction, in-class worksheets, or case study teaching), and give the faculty member an opportunity to observe these methods in action in another course.

Using the learning goals as a guide, the SES could then develop a variety of materials for use in specific classes (for example, clicker questions, worksheets, tutorials, invention activities, case studies) or out of class (for example, homework, recitation activities, tutorials, labs). This was always done in collaboration with the faculty member, who made the final decision as to what would be used.

Lastly, the SES could provide the instructor with feedback on short and long-term student outcomes based on their scores on assessments and on classroom observations (see below). I discovered that with any research-based teaching method, there are countless possible ways to implement it badly. This was particularly likely to happen when the instructor did not understand the underlying principles of learning on which the method was based. A large part of the SES's job was to master these principles and guide the faculty member in how to avoid the pitfalls.

As part of their training, SESs learned about many common mistakes and how to avoid them when implementing new teaching methods, and passed this guidance on to the instructors. (This list of common mistakes and good practices grew substantially over the course of the SEI, based on SES observations. See Appendix 1.) This SES support in avoiding many early unpleasant stumbles as the faculty members adopted new teaching methods played a large part in the success of the SEI.

When applicable, the SES could help co-teach some of these activities in class—giving the SES more direct experience with student interaction in the activity, and providing the faculty member with additional instructional support and an opportunity to observe unfamiliar teaching methods in operation. While such co-teaching in the process of implementing new materials and methods was encouraged, it was necessary for SEI Central to have oversight and to define restrictions (discussed below) to ensure that SESs were not simply used as replacement instructors.

Observe the transformed course. The SES typically observed the classes in the transformed course and provided ongoing feedback to the instructor based on those observations. Again, it was important for the SES to develop a supportive, coaching relationship with the faculty member, so

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that they could function as a partnership. To achieve this, the SES could focus on giving feedback that (1) related directly to areas where the faculty member had already expressed interest, (2) had the greatest potential for improving student learning, or (3) had the greatest potential for changing the faculty member's perspective on teaching (for example, suggesting ways to get students more intellectually engaged with a concept). This was arguably one of the more sensitive aspects of the SES job, and they received substantial training and support in developing positive approaches to faculty coaching, especially as our own understanding of these best practices evolved over time. It was important for the feedback/discussion with the instructor to occur very soon after the observed class. Brief feedback immediately after class, when the class was fresh in the instructor's mind, was more useful than a detailed meeting a few days later.

SESs typically found it difficult at first to know what to look for in class observations out of the vast assortment of things they could be watching, and so this was an important part of their training. Although the most useful feedback tended to involve specific details about how particular issues or student questions and concerns were handled in a given class, and what they could learn from watching and listening to nearby students, it was useful to develop some standardized observation protocols.[7] These allowed the SESs to quantitatively and reliably characterize student engagement and how the faculty and students were spending their time during a class period. Such quantitative numbers could sometimes be more effective in convincing faculty to change their practice than subjective feedback from the SESs, particularly if the quantitative results were surprising to faculty. For example, the Classroom Observation Protocol for Undergraduate STEM (COPUS) observations showed some faculty that although they intended to use active learning methods, they spent more class time lecturing, with students passively listening, than they had realized.

Archiving and Disseminating the Results

In order for course materials to be used by others, they must be archived and shared with the community—both within and outside of the department. Thus, part of the SES role was to create a course materials package that would be available for use by instructors in the department and in the

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broader education community. Typically, this archiving task was undertaken after the second iteration of the transformed course.

Faculty indicated that they wanted to have materials arranged so that they could easily pick and choose what they wanted to use, rather than have to search through an entire package. Significant time and effort were devoted to creating an online course materials management system so that materials across departments and institutions would be centralized and organized into a common structure.[8] It was challenging to create a model that worked for all possible cases and was easily used; regrettably, this online structure served more as a resource for SEI staff than for faculty. Among instructors, course binders (either as electronic zip files or as paper binders) were still the mainstay. SESs were extremely helpful in creating this organized archive, because existing departmental structures and expectations provided no incentive for a faculty member to expend the necessary effort to document, organize, and communicate the course changes for an external audience, including other faculty in their department. Once the SEI funding ended, however, there was no clear mechanism or responsibility for maintaining these archives in a department.

Another aspect of dissemination involved presentation and publication of research papers on course assessments, research findings, student learning, course transformation, or other aspects of the SEI work. SESs and departments were told that an SES was expected to publish at approximately half the rate of a regular research postdoctoral fellow in the department. This expectation was set for two reasons: (1) professional development and status of the SES, and (2) establishing a standard for the quality of work done by the SEI as suitable for publication in a peer-reviewed science education journal.

It was a continual challenge to get SESs and departments to meet this publication expectation, primarily because it was not well aligned with either of their priorities. The publication of educational research was not seen to be of great importance. I would regularly encourage SESs to do so, but with at best limited success, except for the few who saw such publication as important for their future careers (those who planned to become faculty members doing education research). That said, the current total of more than 120 publications (www.cwsei.ubc.ca/SEI_research) across both institutions is significant and has contributed substantially to the literature on educational change and student learning within and across disciplines.

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In addition, there is a substantial amount of unpublished work generated by the SEI that could also be a contribution to discipline-based education research—but will likely never be published.

Local dissemination of SEI results was clearly beneficial to the SEI efforts within departments and was practiced regularly by the SESs (often in collaboration with faculty members) in the most successful departments. This dissemination took several forms: monthly newsletters describing SEI activities and notable results, verbal reports at faculty meetings, more extensive write-ups provided in advance of discussions at departmental retreats, and departmental colloquia and seminars on notable SEI work. The last of these were usually presented jointly by an SES and a faculty member. As well as distributing the newsletters in the usual manner, it was found to be productive to prominently post them where they would stimulate discussion, such as in the faculty coffee room and right outside the door to the departmental office.

SEI Central also ran an annual end-of-year mini-conference at which all the SESs and some faculty would present posters on their work. All of the SESs were very involved in this event, usually presenting multiple posters. This event would bring in a limited number of faculty who were not involved in SEI work to learn more about the SEI activities and results in their own department. These events were particularly successful at bringing together faculty and SESs already involved in SEI work from across the departments for discussion. An added benefit of this conference was that the posters were then uploaded to the SEI website, providing a public archive of the SES work (see, for example, www.cwsei.ubc.ca/EOYevent2014.html).

In a few cases, dissemination also included creating written and video-based materials aimed at helping faculty use a variety of instructional techniques. For example, videos, workshops, and a booklet were developed by SESs for helping faculty use clickers and learning goals effectively, and all have been cited and used beyond CU and UBC.[9]

SES Responsibilities

The SES position is unlike any that traditionally exists within a department, and most existing positions—such as instructor, course support personnel, or researcher—provided a misleading model for the vision of the SES as an embedded expert in education. Over time, SEI Central found that

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clearly defining the SES role made for a more productive experience for all involved.

One lesson learned (which resulted in program improvements at UBC compared to CU) was to make the SES role and responsibilities clearer to departments and to the SESs themselves at the point of initial hiring.

SES training and meeting attendance. We needed to clearly indicate that attendance at the weekly SES training and reading group meetings was mandatory. It was not realistic to assume that SESs would be able to quickly develop the necessary skills for such a complex job simply by reading relevant articles and books. At UBC, both the meeting expectations and the training program was much more formalized than at CU, with regular schedules and expected deliverables for training exercises. These expectations were mentioned during the job interview, explained to new SESs when they arrived, and communicated clearly to the departmental director. These clear expectations were important for ensuring that the necessary training was given priority, especially in light of all the other time demands that the SESs encountered. As discussed below, this structure also contributed to a more cohesive, supportive SES cohort.

Balancing work demands. One of the most demanding aspects of the SES position, and one that all new SESs struggled with initially, involved balancing the demands of training and learning, working with multiple faculty members, and producing material for courses in a timely manner. In the early days, SESs experienced a great deal of frustration around juggling these multiple demands, in part because the expectations had not been made sufficiently clear to them and to departments. They did not always know what they needed to do in order to do a "good job." While the job always required good time management skills, the frustration associated with the multiple demands largely dissipated over time—likely due to the various adaptations that were made to the program, such as improved departmental planning structures and SES supervision and training. In particular, both the departments and the new SES were advised that their first semester should be spent on a small project rather than a full course transformation, as the latter was overwhelming at that stage. An additional factor in improving SES job satisfaction was the presence of the SES community (about fifteen to twenty SESs during the most active years at UBC) that communicated expectations and other guidance to new SESs.

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SES activity reports. SESs were required to provide brief (one-page) reports of their progress (initially every two weeks, later once per month). These reports went to both SEI Central and the SEI department director. These were reviewed by SEI Central with particular attention to:

- Whether the SESs were planning properly and dealing effectively with the large number of different demands on their time, or becoming overwhelmed
- Whether the department was paying attention to what was being expected of the SESs, or whether multiple faculty members were putting demands on them with no central coordination or oversight
- Whether any of the SESs were working on something for which there was research literature, prior SEI work, or people who could be helpful to them but which they didn't know about
- Whether they were spending time productively and not wasting time due to poor work habits or lack of cooperation or support from faculty or the department

The fact that all of the issues listed were encountered fairly regularly made it clear that such reports and responses to them were needed. Having such reports in hand during the meetings between SEI Central and the departments also made those meetings more focused and productive.

SES Supervision

An ongoing challenge was establishing to all concerned how the SESs fit within a chain of command—to whom they would report, and who would be responsible for managing their priorities. It was vital that SESs be seen as members of the department and resources to its faculty. In cases where faculty members viewed SESs as thrust into the department by myself or the university administration to "fix" departmental instruction, the results were predictably poor.

However, it was also important that SEI Central be able to provide oversight to ensure that SES time was being used effectively, that departments were providing adequate supervision, and that the SESs received the necessary training and professional development to be successful. In some cases, SESs became so engrossed in their daily activities and the demands of course transformation that they neglected the training and meeting requirements—which had a negative impact on their performance. In other

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cases, departments sent them off to work with unwilling faculty members with no help or guidance.

Thus there was a continual tension between SEI Central and the departments in terms of who controlled the SESs' time. Laying out clear, explicit expectations, as described above, along with providing a formal training program and clear supervisory structure within the departments, was very helpful in this regard, but the issue required constant attention. It was important to be helpful and supportive of the SESs while being quite explicit, to both SESs and department directors, as to what issues and decisions were the responsibility of department directors and not SEI Central.

The SES and departmental activities were monitored through the SES meetings, email reports, other communications, and the regular meetings between SEI Central and each department (including the departmental director and SESs). In order to keep responsibilities and lines of authority clear, we had meetings with the department's SEI director and the SESs, and occasionally department chairs, to explicitly go over which issues SEI Central would *not* provide input or decisions on, and why these should be handled by the department. On rare occasions, this would also mean discussing with an SES and a department director what was expected of the SES with regard to SEI Central activities—for example, that the SES was required to attend important training sessions and provide required reports.

SES Morale

In the early days, many SESs arrived excited to have been hired to make improvements in teaching in the department but soon became very frustrated. As described elsewhere, it was not uncommon for a department to assign an SES to transform a course but overlook the fact that the faculty member teaching that course was not interested in working with the SES and/or changing their teaching methods. I expended a lot of time and effort trying to preserve SES morale under such conditions. Even with this effort, approximately 25 percent of the early SESs quit before the end of their appointment, usually after about one year. About 25 percent of the rest of the early SESs were on the verge of quitting. As the expectations for department management of SEI activities became more clearly established (for example, the department set expectations and made agreements with a faculty member *before* sending the SES to work with that person), the SES training program better addressed specific issues (such as faculty resistance,

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common SES experiences, and appropriate expectations), and a more vibrant SES community grew over time, this attrition became much less of a problem. In the later years of the SEI, nearly all SESs remained for two or more years, often leaving only after being recruited for very attractive long-term positions, with our blessings.

SES Teaching Responsibilities

Initially, a rule was established that SEI-supported SESs could not have primary responsibility for teaching a course—that is, they could not be the instructor of record. This was done to prevent them from simply being used as free replacement instructors. Having a highly qualified instructor who is not paid from department funds is very tempting, especially to a chair who is grappling with budget problems and not particularly supportive of the SEI work.

This restriction was modified when it became apparent that teaching experience was an important part of SESs' professional development, both to help them to do their current job well (increasing their credibility in the department and giving them valuable experience to draw upon) and as résumé experience for future positions. Allowing SESs to teach had the added benefit of providing a model for faculty of how they might use various teaching techniques—SESs regularly invited faculty to observe their own classes.

Thus SESs were allowed to, and regularly did, teach as the instructor of record for courses, with the proviso that SEI funds would not be used to pay their SES salary for that time, and that an SEI-supported SES would not teach more than one course a year. It was necessary for SEI Central to monitor such situations fairly closely to avoid exploitation of the SES and misuse of SEI funds.

How to Work Effectively with Faculty

As described before, it was important that SESs act as partners and gentle coaches to faculty. Below are several elements of effective faculty partnership that worked well.

Developing and communicating scholarly expertise around teaching and learning. SESs who took their roles as educational scholars and departmental resources seriously were particularly effective. Faculty came to recognize that those SESs had valuable and unique expertise, and this resulted

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in more effective working relationships. Many SESs have commented on the importance of having both disciplinary and pedagogical expertise in achieving the respect of the faculty and establishing good working relationships. Additionally, in the few cases where an SES's disciplinary expertise was weak, that individual's effectiveness was noticeably reduced.

One example of dissemination of scholarly expertise was the monthly newsletter produced by the Department of Earth, Ocean, and Atmospheric Sciences, the *EOAS-SEI Times*.[10] Designed to be easily skimmed, these two-page documents with titles such as "An Instructor's Clicker Cheat Sheet," "Making the Most out of the First Day of Class," and "Department Feedback about EOAS-SEI" helped to inform faculty about relevant literature and best practices, as well as SEI efforts in the department.

Finding interested faculty. Originally it was assumed that at the proposal stage departments would identify a list of courses to be transformed, and that this would serve as guidance for SES work. In some cases, with strong and consistent departmental leadership, this model was followed productively (see Chapter 5 for a noteworthy example from EOAS).[11] The SESs then systematically worked through a list of predetermined courses to transform.

In many cases, however, SESs discovered that faculty teaching those courses previously identified for transformation were not necessarily interested in the course transformation efforts. In such circumstances, it proved more productive to have the SESs work with individual faculty members who were interested in making changes in their teaching rather than working on a particular course. This represented a shift from *course-focused* work to *faculty-focused* work. Initially we were rather nervous about this, as it implied an abandonment of the model of departmental ownership of courses. We became more comfortable with this approach as we saw that the more faculty members who were engaged in thinking about and changing their teaching, the more the culture of the department with regard to teaching was changing. This, in turn, resulted in more faculty spontaneously deciding to learn about and adopt new teaching methods.

SES Training and Community

Originally the naïve assumption was that new SESs would be able to develop adequate skills by reading books and articles, applying those ideas in

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practice, reflecting on the experience, and engaging in further reading and discussion in informal meetings. This was not generally the case. SES training was formalized over time by providing a more consistent and coherent training experience. While numerous models were tested, in this section I present the version of SES training that was found to work best. It included a new SES development series, reading group, and ongoing regular SES meetings.

One difference between UBC and CU that impacted the training was the *number* of SESs in each program. At CU, there were fewer total SESs, and few new SESs were hired after the initial program initiation. At UBC, on the other hand, the program was larger, and there was a new cohort of SESs each year. This made it more feasible to support regular initial and ongoing training for SESs, which created a greater sense of community and collaboration among SESs at UBC. It also made it possible to involve experienced SESs in the training of incoming SESs, which had multiple benefits. Thus, the impact of SES training, the resulting SES capacity, and the sense of SES community was significantly greater at UBC than at CU.

New SES Development Series

During the first semester after being hired, SESs engaged in a structured, one-semester seminar and discussion series, the STLF Development Series (STLF being the UBC name for SES). The series consisted of approximately one 90-minute meeting per week for twelve weeks. Each week, SESs would read an article or section of a book in advance of the meeting. The primary texts used were *How People Learn,* by John Bransford et al., *How Learning Works,* by Susan Ambrose et al., and, as mentioned above, *Getting to Yes,* by Roger Fisher and William Ury.[12] During the meeting, they would discuss the reading and work in small groups to put the lessons into practice, such as applying the strategies to create activities for courses with which they were involved and discussing the proposed activities.[13] An abbreviated list of topics covered included:

Effect of prior knowledge
Knowledge organization: expert vs. novice
Motivation
Learning and transfer
Deliberate practice

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Development of self-directed learners
Learning goals
Formative assessment
Memory and retention
Peer instruction and effective clicker use
Group work
Characteristics of expert tutors

These weekly assignments and discussions were directly linked to things that would be done in a course transformation, and included analyzing the principles and research behind the activity design, as well as SEI Central staff providing feedback on their work. There was also considerable discussion and guidance in the training about how to work most effectively with faculty. The first semester of an SES's work was typically devoted to planning a course transformation and to the Development Series.

The schedule of the training program for new SESs was made available to existing SESs, which resulted in many coming to specific sessions. By the end of the SEI program, many of the weekly training sessions were facilitated by senior SESs, which greatly enhanced both SES community and capacity. In addition to lessons in teaching and learning, senior SESs were able to help their newer colleagues navigate the often subtle aspects of the job and set realistic expectations. I learned that the few SESs who had significant training in education research (including PhD-level training) still needed to go through the training program to be effective, although this was not always obvious to those SESs themselves.

There were often non-SES people who were interested in the SES training program (such as new faculty or instructors), and participation was encouraged. As a one-time experiment, we tried having an abbreviated SES program specifically for new UBC science faculty, but it was not very successful. Although new faculty members did sign up (in response to encouragement from the dean), attendance and completion of assignments were quite erratic.

SES Meetings

In addition to the new SES Development Series, SEI Central held a meeting with all the SESs every two weeks. These meetings provided ongoing professional development for SESs, facilitated the sharing of ideas and resources, and built community. They also provided a venue where SESs

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could easily discuss and seek help from SEI Central on sensitive issues within their department (usually involving difficult interactions with faculty). Meeting topics varied: discussion of new research studies in the literature, designing effective research studies, data analysis, designing effective instructional activities, conducting cognitive interviews with students, sharing experiences of what worked well in a department (or not), and presentation of work by some of the SESs, particularly when they had tried some novel method and had data on the results.

Science Education Reading Group

SEI Central also ran a reading group that met every two weeks, in which a science education or cognitive psychology paper was discussed. The reading group included a number of faculty members and graduate students as well as the SESs. The focus of the papers varied, with topics including valuable teaching methods that had good supporting data, fundamental research about learning and brain science, and examples of good and bad research papers to help SESs and faculty in thinking about carrying out and publishing research on their own educational activities. A particularly valuable aspect of the reading group was the online Basecamp tool that led to the large virtual reading group, discussed below.

In-Person Community Building

The SESs at UBC developed into a cohort, working together and helping each other, both within and across departments. There were many factors that contributed to this happening much more at UBC than at CU. This included larger numbers of SESs, regular meetings, regular readings and frequent use of discussion group, regular social events, a good meeting space more connected with SEI Central, more management oversight, having existing SESs participate in training of new ones, and to some extent the personalities involved, as some individuals took it upon themselves to develop a community.

Online Community Building Tool

SEI Central also provided various activities aimed at building community among the SESs. One helpful tool for this was the use of a commercial

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project management tool called Basecamp. Basecamp allows for threaded discussion, file attachments, and email notifications to users, among other functions. Basecamp thus provided a central location for SESs (across both institutions, to some degree) to ask questions, discuss specific topics and to share papers and other materials, and for SEI Central to quickly send guidance and resources to all SESs at once. As new SESs joined, they were added to Basecamp, and then could use the previous conversations and posted materials as a resource. We frequently were able to answer questions from new SESs just by referring them to the existing materials on Basecamp.

At UBC there was ongoing involvement on Basecamp of UBC SEI alumni (that is, former SESs) who had gone on to other jobs and institutions. Former SESs typically remained on Basecamp, and they would continue to contribute (at a reduced rate) to discussions, providing advice and materials, and letting current SESs know about job openings. As SEI alumni grow in number and have spread throughout Canada, the United States, and beyond, this online community provides a valuable resource for current and former SESs.

One portion of Basecamp that has been particularly valuable is the virtual reading group. This group was originally started as a way to provide materials for the in-person reading group to prepare for each meeting and facilitate ongoing discussions and sharing of related materials. An increasing number of people have signed up for this group, including CU and UBC faculty and SESs, and this virtual group now numbers over two hundred. Although only a small fraction participate in discussions of papers, we find that a much larger number regularly read the papers and comments. Basecamp also allows new users to easily access previous papers and the discussions around them.

Career Paths of SESs

Initially it was difficult to know what the long-term career path for SESs would be, and there was some concern as to whether the experience was a suitable step toward a successful long-term career. However, experience has shown that SESs have had desirable career options, and in many cases are able to choose among multiple attractive offers. There are clearly viable career paths for individuals with this training and experience.

In Canada, where tenure-track teaching faculty positions are fairly common, that has been the most common career path for UBC SESs. They

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have proven to be *very* competitive for such jobs, as they bring a unique level of expertise in learning and teaching in their disciplines.

In the United States, there has been somewhat more variation. A few SESs have gone to college or university tenure-track positions with a focus on teaching, and others to long-term untenured teaching positions—sometimes in the department for which they worked as an SES. A few SESs have gone into tenure-track faculty positions in science departments, carrying out research in discipline-based education. A number have also been hired to run university centers for teaching and learning, or the science portion of such centers.

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