

Learning Progressions in Instructional Design: Expectations and Practice of Scientists Becoming Teachers in the Preservice and First-Year Settings

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Abstract

The purpose of this study was to ascertain the ways former professional scientists who are learning to become teachers understand the planning and implementation of instructional design 1) while they are in a university program learning to become teachers and 2) during their first year of full-time teaching in a secondary classroom. The study used a grounded theory approach and was informed by multiple classroom observations, lesson planning artifacts, and interviews. It was found that during their methods class the teacher candidates employed both student-centered and backwards design principles. However, once the teacher candidates started teaching full-time, they no longer designed instruction and instead adopted lesson plans from veteran teachers, adapting only small parts to become more student-centered.

Key Words: professional development, secondary science teachers, career-changers, pedagogical content knowledge, grounded theory design

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Teacher educators strive to provide experiences that prepare future teachers to have a wide variety of ideas, strategies, tools, and concepts in their pedagogical repertoire in order to effectively engage students (Feiman-Nemser, 2001). In particular, secondary science teachers require a deep understanding of the content and pedagogy, which may not be fully employed during a preservice program (Hollon, Roth, & Anderson, 1991). A core feature of the nexus of content and pedagogy taught in most university-based teaching methods courses is detailed written unit plans (Clark & Peterson, 1986; Kauchak & Eggen, 1989), as planning is a psychological process of envisioning future goals and activities to reach those goals (Clark & Dunn, 1991). However, it has been recognized over many years that veteran teachers do not use lesson plans that resemble the ones required in the university (Clark & Peterson, 1986). This mismatch of outputs for preservice and inservice teachers presents a challenge for teacher preparation programs in terms of teaching the process of instructional design. The purpose of this study was to address the need to understand what core planning knowledge and skills must be taught to new preservice teachers in a first methods class so that they are prepared with regard to effective instructional design in their first year. The present study ascertains the ways career-changers, former professional scientists who are learning to become teachers, understand the planning and implementation of instructional design at two points in their development as teachers: (a) while they are in a university program learning to become teachers and (b) during their first year of full-time teaching in a secondary classroom.

Mikeska, Anderson, & Schwarz (2009) frame three issues of practice that are of importance to teacher educator and preservice teachers regarding instructional design: engaging students in scientific practices, organizing instruction, and understanding students. Since the preservice teachers in this study were well-versed in their content as they have practiced science for many years, the study focused on two of those three important components: the organization of instruction and understanding of students. Instructional design was considered to be both lesson planning; the systematic development of daily objectives, activities, and assessments; unit planning; and the construction of a group of coherent lessons that teach one major scientific concept.

While participating in a teacher preparation program, teacher candidates are expected to move past designing a lesson based on intuition. Carefully designed, student-centered curriculum can address student misunderstanding of content (Driver, Squires, Rushworth & Wood-Robinson, 1997), and students engaged in this type of learning have more ability to think flexibly to solve problems (Ausubel, 1968; Bransford, Brown, & Cocking, 1999). Teacher candidates in this project were encouraged to view lesson design and student understanding simultaneously, so that they are inseparable parts of a system. This study examined how the principles taught in the methods course are perceived and implemented during the first year of teaching, thereby capturing the progression as participants went from preservice to inservice placement. Additionally, a project goal was to explore the needs of preservice teachers in terms of their teacher education experiences to design instruction.

There is an increasing recognition that teachers are professionals and are not only capable of designing instruction, but are the central informants to the process (Tobias & Baffert, 2009). Some empirical studies have shown that presenting design principles to teachers can aid in teachers' ability to see themselves as instructional designers rather than merely implementers

(Bannan-Ritland, 2003; Bybee, 1997; Edelson, 2001; Schwarz & Gwekwerere, 2007). Several studies have examined the planning behaviors of elementary teachers (e.g., Collopy, 2003; Davis, 2006; McCutcheon, 1982; Schwarz & Gwekwerere, 2007), but few have examined the instructional design practices of secondary teachers who have professional experience as scientists. The participants in this study were of particular interest because they were former professional scientists who were studying to become teachers. Since they had extensive content knowledge, they could potentially concentrate on more sophisticated techniques of instructional design.

Teacher Candidate Knowledge of Student Understanding

Stern and Roseman (2004) argued for the development of student-centered curricula that incorporate learners' ideas and promote active thinking about phenomena to learn science. It has been well-known that preservice teachers tend to focus on their own performance, rather than on student performance, in the classroom (Fuller, 1969). Teacher candidates tend to lack experiences of interacting with students in learning situations and can often view knowledge as static (Meyer, 2004), which promotes the mistaken assumption that students can learn by being told information. Additionally, career-changers may enter a teacher education program with a priority to excite students about science, which can often lead to a neglect of content instruction for the sake of engaging students, a trend that is prevalent in elementary education (Anderson, Smith, & Peasley, 2000). Another factor that can contribute to a teacher-centered instructional design is the lack of teacher candidate knowledge regarding redesigning instruction when students have difficulties (Magnusson, Krajcik & Borko, 1999; Smith & Neale, 1989). Given that professional scientists who want to become teachers most likely did not have many difficulties learning science, career-changers may not have the necessary viewpoint to analyze student difficulties learning science content. The methods class instruction in this study took into account that the career-changers may have an ego-centric orientation toward the classroom, especially because this group of teacher candidates had been professional scientists and participated in pre-college schooling before reform-based inquiry instruction.

Pedagogical Content Knowledge

Pedagogical content knowledge (PCK), also known as the knowledge needed to adapt content instruction to an appropriate developmental level for students, is a necessary element of effective teaching, and, in turn, knowledge about how students learn is a core element of PCK (Magnusson et al., 1999; Shulman, 1986). Preservice teachers tend to have difficulty enacting PCK in lesson planning because they have little experience in interacting with learners (Van Driel, De Jong, & Verloop, 2002). The backgrounds of the preservice teachers were of special concern in this project because they were professional scientists. It was expected that they would have had experiences while they themselves were students in secondary school in which science was easy for them to learn, which has the potential to later cause them as preservice teachers to pay less attention to PCK. To address this possible deficiency, the methods course in this study was designed to pay particular attention to "PCK readiness" (Smithey, 2008), which is the skills and knowledge that form the foundation to a more sophisticated understanding and ability to implement PCK in classroom instruction. Examples of PCK readiness in the methods course include: the consideration of supportive learning strategies, a proactive stance toward addressing

misconceptions, developing compelling questions that drive the instruction, and designing a more student-centered approach in assessing knowledge.

Elements of the Science Teaching Methods Course

Lesson planning in the teaching practice tends to be cyclic and dependent on prior experiences with students (McCutcheon, 1982), which poses a challenge for the authenticity of the university methods course experience in writing unit plans in which teacher candidates do not have immediate access to secondary students. Research on teacher planning processes in both elementary and secondary settings shows that often teachers' intentions derive initially from activities, rather than overarching themes (Bromme & Juhl, 1988; Brown, 1988; Hollingsworth, 1989), so the goal of the methods course was to encourage teacher candidates to view lesson planning in a thematic way. The course also took into account that teacher candidates needed to address the uncertainties they would face in the classrooms and write detailed lesson plans for units to make the task less ambiguous (Borko & Niles, 1987).

The purpose of the methods class was to assist the career-changers to find their own processes and strategies for effective instructional design rather than to follow prescribed steps. The culminating project of the methods class was the design of a month-long unit plan that corresponded to a unit of study the teacher candidates would be teaching during their internship (student teaching for 15 weeks). Although somewhat defined by state standards, the teacher candidates had many choices in the design of their plans including a choice of grade level, block scheduling or daily classes, and topic. Because all of the instruction in the methods course led to the composition of the unit plan, teacher candidates were expected to display their design skills using *Understanding by Design* (Wiggins & McTighe, 1998) as an organizing framework and inquiry as a tool for lesson organization and assessment of student understanding. For many years, the learning cycle has been viewed as an effective instructional model (Atkin & Karplus, 1962; Karplus, 1979; Karplus & Thier, 1967; Lawson, 1995; Settlage, 2000) and the learning cycle model has been shown to enhance learners' outcomes (Barman, 1992; Cavalla & Laubach, 2001; Dwyer & Lopez, 2001; Jinkins, 2001; Lovoie, 1999; Odom & Kelly, 2001; Musheno & Lawson, 1999). There was a high level of detail expected in the unit plans, and the teacher candidates were given a template to use along with the instructions that all written materials including student handouts needed to accompany the lesson plans so that a substitute teacher would be able to teach the class.

The research questions that drove this study were:

- RQ1. How do career-changers approach instructional design and describe their strategies for planning instruction before they enter the classroom and then after their first year of teaching?
- RQ2. What elements of instructional design taught in the methods class continue to be maintained during the first year of teaching?
- RQ3. If new teachers alter their strategies for instructional design, why do they decide to change?

Methods

Participants

The teacher candidates ($N = 18$) were selected because they had extensive experience as professional scientists ($M = 11.3$ years) and were now working to become secondary science teachers. Table 1 displays the characteristics of the teacher candidates during the preservice portion of this study.

Table 1
Characteristics of Teacher Candidates

Identification	Years as a scientist	Content area for licensure	Unit plan topic
Teacher Candidate 1	7	Physics	Motion
Teacher Candidate 2	6	Earth Science	Fossils
Teacher Candidate 3	15	Chemistry	Stoichiometry
Teacher Candidate 4	16	Biology	Genetics
Teacher Candidate 5	4	Earth Science	Rocks and Minerals
Teacher Candidate 6	6	Biology	Cells
Teacher Candidate 7	20	Physics	Motion
Teacher Candidate 8	4	Earth Science	Rocks and Minerals
Teacher Candidate 9	9	Chemistry	Bonding
Teacher Candidate 10	2	Biology	Taxonomy
Teacher Candidate 11	22	Earth Science	Oceans
Teacher Candidate 12	8	Biology	Cells
Teacher Candidate 13	12	Physics	Conservation of Energy
Teacher Candidate 14	16	Biology	Genetics
Teacher Candidate 15	5	Earth Science	Earth's Changing Processes
Teacher Candidate 16	11	Biology	Biomes
Teacher Candidate 17	17	Chemistry	Reactions

Teacher Candidate 18	25	Chemistry	Solutions
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Four of the teachers from this group were followed into the classroom during their first year of teaching science. The mean years of service as a professional scientist for the first-year teachers were 11.5 years. Table 2 displays the characteristics of the first-year teachers.

Table 2
Characteristics of First-Year Teachers

Identification	Years as a scientist	Classes taught	Unit plan topic during the methods class
Teacher 1	16	High School Biology	Genetics
Teacher 2	15 High	School Chemistry	Stoichiometry
Teacher 3	9 High	School Chemistry	Bonding
Teacher 4	6	Middle School Life Science	Cells

This study has a grounded theory approach to developing meaningful themes about the needs of preservice and new inservice teachers in terms of planning lessons. Self-report and performance observations were collected, and all data sources in combination helped to triangulate the themes and ideas that emerged (Creswell & Plano Clark, 2007).

Data Sources

Data sources for the preservice teacher group consisted of four sources: (a) a month-long unit plan for teaching science lessons developed in the science teaching methods class, (b) a videotape of the implementation of one 30-minute lesson to high school students (also called microteaching), (c) an analysis and reflection by the teacher candidate of the student learning during the microteaching, and (d) an interview that occurred a month after the methods class was completed. Data sources for the inservice teacher group consisted of three slightly different sources due to logistical reasons: (a) field notes from seven observations over a 15-week period, (b) lesson plan artifacts from a 15-week period in their second semester of their first year of teaching full-time, and (c) an interview that occurred at the end of their first year of full-time teaching. No one source of data served as the main data set because they were equally rich and were considered informative in their own right.

The data were analyzed using a constant comparative process (Corbin & Strauss, 2008). First, the interview transcripts for each participant were read as a whole for the overall understanding of the communication. Second, each statement that had meaning about instructional design and the relationship of instructional design to implementation of lessons was placed in a matrix. Axial codes were developed independently by two researchers and two doctoral research assistants and compared for alignment (Glaser, 1992). The alignment was

initially 90% of codes among all four people, but after a discussion the alignment was 100% of codes. These codes were also identified on the written lesson plans, the videotapes of implementation, the field notes from the observations in the classrooms, and the post-observation interviews.

Findings

This investigation examined how 1) career-changers approached instructional design before they entered the classroom and again after they had been teaching for one year, 2) the elements of instructional design that persisted from the methods class into full-time teaching, and 3) the reasons for changing instructional design. Several codes emerged in the data sources including planning processes, instructional sequence, how students learn, instructional design needs, and influences of colleagues. In this section, each theme will be discussed by emergent code and each group's perceptions will be discussed within that code.

Processes of planning. The length of time considered for planning instruction differed between the preservice and the inservice teachers. The preservice teacher group looked at brief time frames, such as a day or a week. They reported that they utilized backwards design for their unit plan, but on a lesson-to-lesson basis rather than as an entire unit, distorting the intended backwards design principles taught in the course. For example, one preservice teacher explained the following: "[I will plan] what am I going to finish by the end of the period, and then structure whatever it is that I need to get to that point, so it would be a backward planning" (Teacher Candidate 4). Teacher Candidate 9 discussed her process of developing the unit plan as filling up each day. Although the plans are goal-oriented within each day, the teacher candidate made no attempt to connect day to day lessons:

I typically start with what goals I want my students to walk away with and try to think of an activity which would help demonstrate this. I then create a short lesson to introduce the topic and the activity and form a set of questions for the ending. So in short, I jump around.

Teacher Candidate 17 used the terms associated with *Understanding by Design* accurately, but was not able to fully explain how essential questions might be used as a theme to connect daily material: "The essential questions will help students to group information as they learn it and to make it applicable to things they already know." Teacher Candidate 17 believed that if a teacher presented an essential question to the students, then the students would naturally see the consistency in the material.

Although preservice teachers reported they looked at planning in smaller chunks, as they developed their planning skills into their first year of teaching, they planned in larger segments of time. All four first-year teachers in this study identified their process of planning in larger time spans, and as a result they were able to teach in a thematic way. The inservice teachers discussed their approach to instructional design over a large time frame. For example, they discussed planning a month at a time, which allowed for them to explicitly connect ideas to the student over many days. Teacher 1 described an example of how she connected the materials across units:

I started out by posing big questions and ideas...such as, I tell them that all living things have a cycle from birth to death and that cells being the basic unit of life. I tell them the whys [*sic*] and the purpose of cellular reproduction before I tell them the details of how it is done. I go from big picture to the details in usually everything I teach.

Teacher 3 began her unit design with an integrated theme and then worked down to the daily plans:

I first look at the state standards I need to cover, and I try to combine the topics together into a unit. Then, I look at the content and try to determine the simplest way to teach the topic to the students. After I planned out the lecture, I try to incorporate some kind of activity that gets my students to get out of their seats and interact with each other.

Teacher 4 planned in a very similar way to Teacher 3:

I first think about the main topics that I want to cover, a combination of topics and what I think is important that isn't necessarily covered on [the state standards]. Then I think about a logical way to link these topics. After that I start deciding how long I want to spend on each topic. Then I start planning appropriate activities and assessments for all these topics that I will cover.

When the teachers planned instruction over larger frames of time than single days, they could see how the topics they teach are integrated and be effective in combining and reinforcing topics in their instructional design.

Another difference found in the processes teacher candidates and teachers used to plan was the orientation of the goal for instruction. The teacher candidates focused on the state standards they are required to meet, and first-year teachers focused their instruction on assessment of student learning. Out of 18 teacher candidates, 16 explicitly stated that they begin lesson planning with the state objectives and create activities from this information. The first-year teachers all mentioned the state standards in their lesson plans, but focused the production of activities on assessment of student learning. Teacher 4 characterized the role of student learning in planning in her process: "Usually, I'll grade papers first so that I have an idea if my students understand the material or not." The first-year teachers used the state standards as a table of contents, rather than a full list of outcomes.

Instructional sequence. The preservice teachers reported planning their instructional sequence in terms of topics, rather than student prior knowledge. Teacher Candidate 14 stated,

I like to teach chronologically, so I would start with an introduction to Newton. Then, one by one go over each of the three laws. With each law, I would do a demonstration or activity showing how the law works in our universe. Finish the lesson off with some conceptual questions and practice problems for homework.

Not having experience directly teaching students, the preservice teachers at first attended primarily to the topics. As they progressed into their first year they began to see the importance of student prior knowledge in planning instruction. The inservice teachers discussed student learning in conjunction with the content. Teacher 3 stated,

When I am planning for instruction, I look first at the skill level and the spread of skill level within the class to decide how in depth and how much I would plan to cover. Then for most topics I usually like to open up instruction with some sort of thought provoking question about the content before I cover it so I get a good idea of where they stand and what they already know.

The trends of the teacher candidates setting their goals for instruction as state standards but the teachers setting their goals for student learning were both pervasive through all data sources.

How students learn. Preservice teachers focused on the foundational knowledge that they felt students needed to be told before they could do activities. Often they would plan lessons that had student-centered portions of activities, but they were always prefaced with some lecture notes generated by the teacher. Teacher Candidate 12 talked about his typical organization for each class period:

I would plan out a way if they had read something about it the night before, I would plan out a way to cover what I think the highlights are and maybe work a simple problem...before letting them do a lab.

Teacher Candidate 5 described a concern that she felt that she was oriented toward lecture, but did not trust that the students would know the material without her guidance: “For me I always like to work with lecture outlines and notes.”

The majority of lessons from both the inservice and preservice teachers had the same goal: instructing students on background knowledge. However, the inservice teachers’ lessons had more opportunities for students to make sense of the content rather than being directly instructed on the content. Teacher 4 started lessons with student involvement rather than telling students about the content and then doing hands-on activities. Teacher 1 echoed the idea that instructional design needs to keep students actively learning:

Then for most topics I usually like to open up instruction with some sort of thought provoking question about the content before I cover it so I get a good idea of where they stand and what they already know. Then I usually take their comments and responses and incorporate them into the activity.

Teachers 2 and 3 expressed the need to lecture first on some particular topics, but other topics were able to be taught using student-centered methods first. Teacher 2 said,

It really varies depending on the material. Sometimes I lecture if I find a unit to be more difficult. Sometimes if it’s an easier unit, I will usually do more independent work where the kids work in groups and present.

Teacher 3 said,

Sometimes I teach content first before activities - sometimes I try to give them an exploratory activity first or pretest... it depends on the content. For example, in the unit I am teaching now - on DNA - I am first going over how DNA was discovered - then they are going to engage in a couple of activities to explore more how DNA is structured (webquest, creating DNA models, etc.).

Instructional design. The preservice teachers were asked to visualize how they might plan in five years, based on their experience with the course. All teacher candidates explained the same idea in different ways; once one becomes a teacher, a “form of auto-pilot kicks in as the lessons become second nature” (Teacher Candidate 8). They would not need to write more than a few words as cues for their lesson plans. One of the more disconcerting comments explained by Teacher Candidate 11 expressed that the detailed lesson plans required for the methods class were “really valuable, but then I had to think and say ‘Would I do this for 9 months? Probably not.’” However, many of the preservice teachers commented they would have to take into account student learning to adjust their lessons, even though they did not have much experience with it during the methods course. Teacher Candidate 4 articulated a good reason to have detailed written lesson plans as a beginning teacher: “It’s just that this was my first opportunity to practice these methods and I don’t yet feel that I have a firm grasp of how I will employ them in the classroom.”

The inservice teachers did not plan the way they did in the methods class. Instead of writing out details of the lesson, they depended on the PowerPoint lecture notes as a script to their lesson. Teacher 3 explained, “I did not do written lesson plans, but what I did do was written lecture notes, well developed lab plans, and a very well kept Blackboard and agenda book.”

Teacher 4 concurred,

[I don’t plan as I did in the methods class] not to the same degree... I follow the same flow - begin with the end in mind, etc. I am very thorough with my lesson planning for [the methods class], so it was/is difficult to maintain that degree of lesson planning (I wish I could) - but I do NOT throw out all caution to the wind and wing it every day...I just don't have time to write down every little thing I am planning on doing and saying to the students like I did in the [methods] unit plan.

Influences of colleagues. All of the inservice teachers admitted that they no longer plan their own lessons, but use already packaged lessons given to them by veteran teachers. Teacher 1 stated, “For many of the units that I teach, I was actually given lessons plans from other teachers that teach the same content when I started.” Teacher 2 shared the same experience: “I had some ideas about how I was going to approach chemistry and those went out the window when I met with my fellow chemistry teachers.” Teacher 4 also used lessons from veteran teachers, called tried and true lessons, but altered them frequently: “I do use tried and true lesson plans (I almost always change them a bit to fit my style), but I do make many of my own too, like 50/50.” The pressure of having up to 140 students to attend to, making lesson plans from scratch, and keeping up with teaching responsibilities outside of the classroom competes with the easier option of adopting lessons that may not be as creative, but have worked for other teachers. Veteran colleagues have a large influence over the lesson planning practices of new teachers.

Discussion

Given the two core elements taught in the methods class, student-centered learning and backwards design, the evidence suggests that only student-centered learning was maintained into the first year of teaching. The lack of attention to backwards design was attributed to the

influence of colleagues, corroborating the idea that first-year teachers are more likely to adapt existing materials rather than develop new ones (Grossman & Thompson, 2004). The adaptations made on each day-to-day lesson were more conducive to student-centered activities than backwards design. Also, the overall design of instruction was now determined by the teachers' veteran colleagues because they encouraged new teachers to do what has always been done. Backwards design was more difficult to incorporate because it requires constructing instruction as a whole unit rather than inserting new ideas using a modular approach.

The findings of this study inform teacher educators about what is needed to be taught in methods class so that inducted teachers can be successful. If new preservice teachers can be taught to develop focused formative and summative assessments that efficiently measure student understanding of concepts, this skill can lay the foundation of thematic, meaningful lessons for positive learning environments. The key knowledge that needs to be taught to preservice teachers is the ability to articulate measurable learning objectives and design quality assessments to determine if students have learned well. Using this approach, the teachers have a starting point (the measurable objectives) and a final destination (the assessment), which will give focus and meaning to the activities they develop along the route. Using this approach, all lessons can be given coherence because the outcomes of student learning are well known by the teacher from the very beginning of the planning process. Thematic units depend on the coherence of learning objectives and assessments of student learning.

Earlier experiences with K-12 students and mentor teachers may be another way to aid in preparing teacher candidates for the pressures of first-year teaching, which may consequently serve to help first-year teachers maintain their creativity in instructional design. Nilsson and Van Driel (2010) found that in a two-way relationship between student-teacher and mentor both parties learn more about instructional design and content knowledge. Fruitful relationships between teacher candidates, especially ones who were professional scientists, and mentor teachers can foster more student-centered and creative curriculum. Perhaps multiple experiences with teacher-mentors and at different schools will encourage more creativity as the classroom mentor teachers will experience multiple instructional strategies and discussions with career-changers. This will minimize the notion that a mentor teacher is the expert and should be the model of mutual learning, which may transfer to teachers' first year of employment in which they rely more on experienced colleagues as the experts. Structuring meaningful, interactive experiences in K-12 classrooms early and frequently in teacher preparation programs can lessen the stress of the hierarchical relationship between teacher candidate and university professor, and increase productive communication between teacher candidate and mentor before the teacher candidate begins his or her student teaching in the classroom.

The results of this study articulate preliminary information about what is relevant to teach in a science teaching methods class in order to prepare teacher candidates for authentic, effective, and viable practices as teachers. In examining empirical evidence on instructional design, we can prepare preservice teachers more efficiently and effectively. The results of this exploratory study indicate that although teacher candidates are creative in designing instruction during teacher preparation programs, when new teachers reach the field they tend to not depend on their own skills in developing lesson plans and resort to using instructional design that is handed down to them by veteran teachers. Perhaps this reliance on other materials is a survival tactic to allow

them to get through the challenges of the first year or two, and further work should be pursued to determine if this trend persists for more than the first few years. First-year teachers stop looking for ways to improve on student learning because the “experts” have indicated that the lessons they are given were “tried and true.” During their time as preservice teachers, they recognized their limited PCK and were more interested in looking for more ways to improve student learning to be successful. This barrier could be reduced if teacher preparation programs taught teacher candidates how to develop strong, efficient assessments of student learning (both formative and summative). When teachers can understand their starting point for learning (measurable objectives) and what the student should leave the classroom knowing (the assessments), then the learning activities will have coherence and meaning. Teacher educators can guide new teachers to focus more on thematic planning and reduce their reliance on planning daily lessons that are then placed together for a unit.

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