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Mathematics and Science Teaching Fellows' Instructional Planning for K-12 Classrooms

This study explored a cohort of the National Science Foundation (NSF) GK-12 Teaching Fellows' instructional planning for K-12 classrooms.

Introduction

Instructional planning has increasingly been recognized as an essential element for good teaching at different levels of education (Calderhead, 1984; Hewson & Hewson, 1987; Lubinski, 1993; Shavelson, & Stern, 1981; Tobin, Tippins, & Gallard, 1995). Instructional planning constitutes many things which teachers consider and do when they are planning for teaching (Sanchez & Valcarcel, 1999). It provides a roadmap that assists the teachers to focus on achievable objectives and learners' needs (Clark & Yinger, 1987), and to create a flow of events with starting, middle, and ending points in a lesson. As such, its primary purpose is to provide students with meaningful learning experiences (Bruce, Bruce, Conrad, & Huang, 1997).

Several studies have examined and reported teachers' instructional planning practices. For example, Aikenhead (1984) conducted a case study in which he explored the decision-making that occurred when teachers planned for teaching. Aikenhead found that teachers made decisions within a framework that holistically integrated the subject matter and practical classroom knowledge. According to Aikenhead, practical classroom knowledge embraces the basic beliefs of a teacher and the socialization of the learners. Duschl and Wright (1989) investigated the manner and degree to which teachers considered the nature of the subject matter in their decision-making as they planned their lessons. They found that the teachers' decisions on content selection, implementation, and development of instructional tasks were dominated by consideration of three factors: student development, curriculum guide objectives, and pressure of accountability from school administrators. Aguirre, Haggerty, and Linder (1990) also found that teachers' instructional practices are influenced by factors such as previous schooling experience, teaching experience, context, and role models. Other studies report that when teachers are planning for teaching, they create, arrange, organize, and design events that should occur in the classroom (Freiberg & Driscoll, 2000), and consider the nature of instructional approaches and activities to be used in a lesson (Lederman, Gess-Newsome, & Latz,1994; Lubinski, 1993). Mellado (1998) also states that teachers use their conceptions about teaching as frameworks for adopting teaching strategies, and these in turn influence the quality of instruction and outcome of student learning. Bellon, Bellon and Blank (1992) found that instructional planning occurs in three phases: Pre-active, Active (Interactive), and Post-active. In the Pre-active phase, teachers make decisions about instructional goals, objectives, teaching strategies, grouping and seating arrangements, and use of teaching materials. The Active phase involves the interactions between the teacher and students during the actual teaching. The Post-active phase involves evaluating the instructional episode through self-reflection practices and examination of student data sources (e.g. tests, papers, and projects).

There is also paucity of research that compares trained teachers' instructional planning practices with those of scientists and mathematicians in training who are involved in mathematics and science teaching in K-12 schools.

Although several studies have investigated instructional planning pro-

cesses, studies of this nature have only focused on pre-service and in-service teachers. However, it is also of value to explore instructional planning practices of university graduate students in traditional mathematics and science degree programs, who are providing content knowledge and instructional support to K-12 teachers in schools through university-school partnership programs. The traditional mathematics and science degree programs are programs that prepare mathematicians and scientists, respectively. The graduate students in these programs have content backgrounds and career goals that differ greatly from K-12 mathematics and science pre-service and in-service teachers.

There is also paucity of research that compares trained teachers' instructional planning practices with those of scientists and mathematicians in training who are involved in mathematics and science teaching in K-12 schools. Yet, such a knowledge base could be essential in designing outreach programs that would be successful in helping graduate students or scientists and mathematicians acquire desirable instructional planning practices. The assumption is that these graduate students or scientists and mathematicians would translate the desirable instructional planning practices into effective instructional practices in K-12 classrooms, and this in turn would improve the quality of mathematics and science learning among K-12 students.

Our study explored university mathematics and science graduate students' instructional planning practices for K-12 classrooms. All the participants were serving in a National Science Foundation (NSF)-funded GK-12 project. The GK-12 program is a mathematics and science education outreach program that uses the content knowledge and skills of graduate students and faculty at US universities to improve teaching and learning in schools. The acronym GK-12 is used to mean that the Fellows provide content knowledge and instructional support in classrooms from kindergarten to twelfth grade.

The successful instructional planning demonstrated by the Fellows in this study does not refute the value of undergraduate pre-service teacher education, but does provide supporting data for other models of teacher education.

The graduate students who work in the NSF GK-12 program are called Teaching Fellows. They are offered Fellowships as compensation for their work in schools. The Fellows, however, are not training to become full-time teachers, nor do they become certified to teach as a result of their involvement in this program. The Fellows are training to be scientists and mathematicians. Therefore, in addition to their involvement in this program, they are engaged in authentic scientific and mathematical research for their graduate degree programs and professional development. At the request of partner K-12 teachers, the Fellows plan and teach hands-on lessons in participating schools. The Fellows also help partner teachers infuse new content into the curriculum, act as role models for students, and learn about how K-12 schools and teachers operate.

Our study is driven by three questions:

1. How do the Fellows plan for K-12 classroom teaching?
2. What do the Fellows think about their instructional planning?
3. How do their instructional planning practices relate to instructional planning best practices as revealed in the current literature?

Context of the study

This study was conducted as part of a GK-12 project at a medium-sized university (21,000 students) in the Midwest of the USA. The GK-12 project is an eight-year-long university-school partnership project involving the departments of Biological Sciences, Chemistry, and Mathematics, and more than ten school districts within a one hour drive from the university. The project started in 2001 and this study was conducted in the fourth year of the eight-year plan. The project has four interrelated goals: to use the science content knowledge and skills of university graduate students and faculty to increase scientific literacy among high school students; to enhance K-12 teachers' science content and pedagogical knowledge; to enhance teachers' knowledge and skills for conducting action research; and to enhance the existing partnerships and create new ones among the university and local schools. Within the second goal, the project regards good instructional planning as an essential element for effective teaching practices by the Fellows in schools. The schools and districts within which the project occurs are in small towns of 2000-5000 people, and in small cities of 50,000 people, with student populations of 300-500 and 1700-2500

respectively. At the beginning of a school year the Fellows are matched to schools and teachers by the project directors. Later in the year, as the Fellows establish stronger working relationships with teachers in participating schools, additional self-selected matching occurs. In some schools, the Fellows work with a single teacher. In other cases, a pair of Fellows works with a single teacher or with a pair of teachers. The Fellows have been told that their roles are to plan collaboratively among themselves and with the teachers, and to deliver inquiry-based mathematics and science lessons to classrooms.

Methodology

Participants

We studied a cohort of fifteen Fellows who were serving in the project between Fall 2004 and Spring 2005 semesters. Subject areas and degree programs for the Fellows are shown in Table 1. None of the Fellows had formal teacher training and teaching experience at the K-12 level before joining the project. However, the majority of them had one year of teaching experience in undergraduate university courses through teaching assistantships.

Data collection

Data were collected through semi-structured interviews, lesson plans, reflective journals and minutes of project meetings. Semi-structured interviews were administered to Fellows on separate days. The interview duration ranged from 30 to 45 minutes. Sample questions from the interviews were: How do you plan for your teaching in schools? What factors do you consider when planning lessons or units? What do you think about your planning? Depending on the responses provided by the Fellows, follow-up questions were asked to probe further about emerging issues. The interviews were conducted and transcribed by the first two authors. The other sources of data were the lesson plans the Fellows prepared and taught in schools during the data collection period. Ten lesson plans (four in Chemistry, three in Biology and three in Mathematics) were randomly selected from a group of thirty multi-day lessons. The Fellows also kept reflective journals in which they documented their project activities, including how they planned for teaching in schools. Fifteen journals, one from each participant, were examined. Three of the authors attended and took the minutes of the bi-weekly project meetings that focused on how the Fellows planned and taught lessons in schools.

Data analysis

Data were analyzed using the procedure proposed by Strauss and Corbin (1998). The procedure involves first reading the text line by line, coding the text to identify recurring themes and descriptors, and then establishing regularities which override individual differences, thus defining the representative profile of the group studied. An attempt was made to ensure objectivity during data analysis by continually revisiting the data to verify the elements of emerging themes. The first two authors conducted the analysis; themes that emerged from the analysis are presented in the results section below.

Results

Six recurring themes emerged from the analysis: Planning procedure; Antecedent conditions; Scope and depth of content; Content selection and sequencing; Resources; and Assessment of instructional planning.

Planning procedure

In most cases, the Fellows' lesson and unit planning involved the following procedures: consulting partner teachers, examining existing curriculum used by the teachers, identifying topics, formulating goals and objectives, identifying appropriate State Learning Standards, developing activities and assessment tools, and gathering necessary materials for activities. However, their planning procedure was not linear but rather recursive, as illustrated by the interview excerpt below:

> I start by identifying a topic, formulate objectives and align them with Learning Standards … but this is not the case all the time … . because I also moved from one section of the lesson to another just to make sure that all the relevant aspects have been considered (John).

According to John, lesson planning is a continuous process where one has to think about many factors as

Table 1: Profiles of the Participants

Subject area	Number of Fellows	Gender		Degree program	
		Female	Male	MS	PhD
Chemistry	5	2	3	5	0
Biology	6	4	2	3	3
Mathematics	4	3	1	1	3

he or she plans for teaching. Indeed, most lessons and units we examined showed that the Fellows revisited them several times.

Antecedent factors

The Fellows considered several antecedent factors such as age of students, their abilities, grade level, class size, type of students (regular or advanced placement classes), location of the schools, and facilities available in schools. The Fellows also made references to these factors during project meetings. For example, in one of the meetings, Sara stated some factors she considered when planning for her teaching.

> I consider their ages, prior knowledge and ability to handle the content and perform activities. I don't make assumptions for different classes. It has been helpful to consider a lot of these things when planning for teaching in schools (Sara).

Sara implies that when teachers plan for teaching, they should consider several instructional factors if they are to be successful in their lessons. The extent to which these antecedent conditions were considered varied from one lesson or unit to another and from Fellow to Fellow. When asked how they knew or determined the antecedent factors to consider in their planning, the Fellows said that they relied on classroom observations, informal conversations with students and partner teachers, and students' performance records. However, a small number of reflective journals and lesson plans showed that some Fellows prepared and administered tests that were aimed at eliciting students' prior knowledge.

Scope and depth of content

To a large extent, most antecedent conditions outlined above influenced the scope and depth of content in the lessons and units. The Fellows also said they used the goals and objectives of the lessons to determine the scope and depth of the content to be addressed in a particular lesson or unit. As indicated in the planning procedure, the Fellows consulted the partner teachers before they started developing full lessons. For example, in an interview excerpt below, Peter, biology Fellow, talks about the importance of the discussions with the partner teachers.

> I discuss with my partner teachers before I decide on the nature of the content to be addressed in a lesson or unit … because they have curriculum from the school districts to complete in a school year. I make sure that the content is not off the curriculum. However, I include content and activities that are challenging to students (Peter).

Peter consulted partner teachers and developed lessons and units using curriculum guides given to teachers by their school districts. This was the expected practice, because the Fellows were mainly there to provide content knowledge and instructional support to the teachers. It was during the discussions with the teachers that the scope and depth of content to be covered in a lesson or unit were agreed upon. The discussions also provided the Fellows with opportunities to suggest science and mathematics concepts to be included in the lesson or unit that were not part of the existing curriculum.

Content selection and sequencing

When asked about how they selected and sequenced the content in the lessons and units, most Fellows said they used a systematic approach for introducing the concepts in their lessons. For example, in a reflective statement below, Jaime, a mathematics teaching Fellow, talks about how she sequenced content in her lessons and units.

> I start with simple or obvious concepts and then build on them as the lesson or unit progresses. So far, this approach has worked very well (Jaime).

Jaime implies that it is better to start with basic concepts and build on them as the lesson progresses. A majority of the Fellows said that this approach helped students participate, become interested, and understand the concepts in the lesson. Indeed, the lesson plans and units we analyzed showed that most Fellows presented the concepts in this manner.

Resources

The Fellows used several resources during their instructional planning, such as existing lessons, technology and textbooks they found in schools. They also used any resources that were available in the library and departmental resource centers at the university, such as college textbooks, science and mathematics journals, curriculum units, biological species and teaching models. According to the Fellows, resources at the university provided content, activities and other relevant information that were not available in the K-12 schools. In an interview excerpt below, Tina, a chemistry Fellow, names the resources she used.

> I consult several sources when I plan for my teaching … such as science education websites,

> journals, and textbooks. I also use the lessons from other teachers … modify them or make them more challenging and interesting by including more activities (Tina).

Tina used both electronic and paper-based resources when planning her lessons and units. She also used resources and lessons from teachers, and made them more activity-based and interesting to students. The Fellows also said that they found technology a useful tool in their planning for teaching in schools. Several science lessons that were analyzed had laboratory activities that involved the use of computers for simulations and data gathering and processing. A majority of mathematics lessons also involved the use of calculators and probes for data collection, numerical manipulation and graphing.

Assessment of instructional planning

Most Fellows said that they assessed their instructional planning practices through students' and teachers' feedback and their own self-reflection practices. Generally, the Fellows said that they were satisfied with their instructional planning practices. They attributed their satisfaction to successful instructional experiences in schools, collaboration with partner teachers, information searching skills and opportunity to plan and teach more lessons. In the excerpts below Andrew, a biology Fellow and Charles, a mathematics Fellow, explain why they were satisfied with their instructional planning and how they assessed themselves.

> I am pretty satisfied with my planning strategy … because my lessons go on well in schools…and students give me positive feedback. My partner teachers like the way the lessons are planned and taught. The more I teach the better I teach. (Andrew).

> I ask myself questions during planning and after teaching. Are the activities challenging? How helpful is this activity to students? How did the lesson go? Did I achieve the objectives? After answering them I have an idea about my planning and teaching (Charles).

Andrew, Charles and the rest of the Fellows made value judgments about their instructional planning based on feedback from students and teachers and their self-reflections on the lessons and teaching.

Conclusions and Discussion

These findings demonstrate that most of the factors the Fellows considered during instructional planning were similar to those reported in previous studies that involved pre-service and in-service teachers (Aikenhead, 1984; Bellon et al., 1992; Duschl & Wright, 1989; Lederman, Gess-Newsome, & Latz, 1994; Lubinski, 1993; Sanchez & Valcarcel, 1999; Shavelson & Stern, 1981). In particular, Fellows were concerned with antecedent conditions, and consideration of scope and depth, and identification of content; and their planning procedures were similar to those of pre-service teachers. Their collaborative planning practices were also consistent with those that can lead to effective teaching and learning in schools when non-teachers act as experts and bring resources to the classroom (Bruce et al., 1997). Clearly, the Fellows were also generally satisfied with their instructional planning – perhaps even as a result of the layered considerations they brought to instructional planning.

Although the cohort of the Fellows in this study did not receive formal training in instructional planning, they learned how to plan for instruction through practice and interactions with partner teachers. As dedicated professional teacher educators, the authors have a vested interest in the use of direct instruction for pre-service teachers, but for these Fellows, direct instruction is not vital. Rather, on-the-job training under the guidance of an expert can be an effective method of teaching instructional planning.

The successful instructional planning demonstrated by the Fellows in this study does not refute the value of undergraduate pre-service teacher education, but does provide supporting data for other models of teacher education. The findings of this study also reinforce our professional observations in science and mathematics teacher education that some teachers tend to learn about instructional planning more effectively outside the traditional academic courses.

Future research should focus on whether there is a relationship between the Fellows' instructional planning practices and their knowledge base of science and mathematics teaching. In addition, most of the instructional planning themes in this study were found to be in Pre-active phase of the model developed by Bellon et al. (1992). This result should not be too surprising considering that the purpose of the study was to explore the Fellows' instructional planning practices - most of which occurred in the Pre-active phase. Therefore, a study should be conducted to examine the Fellows' considerations in Pre-active, Active, and Post-active instructional phases. This will lead to a better understand-

ing of what the Fellows do in each of the three phases of instructional planning.

Finally, one limitation of this study was that only the GK-12 Fellows' instructional planning practices were explored. There were no data collected from the partner teachers who worked with the Fellows in schools. We suggest that future studies should attempt to collect data from the Fellows and partner teachers to provide contrast or additional support to conclusions reported in this study.

Implications

Our data support the hypothesis that direct mentoring by practicing teachers can be an effective means of modeling and communicating appropriate instructional planning skills. This approach may be useful in alternative teacher training programs, where students (in similar fashion to GK-12 Fellows) may receive minimal formal instruction in lesson planning.

Since the Fellows in this type of project are themselves graduate students in science and mathematics, these findings suggest that GK-12 Fellows could be useful in the training of graduate teaching assistants. The Fellows learned a great deal about how to plan for teaching through practice and through interactions with teachers and K-12 students. Therefore, academic departments at universities that have GK-12 projects can use the Fellows' expertise in teaching assistantship programs through presentations on instructional planning and/or mentoring teaching assistants.

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