RESIDENT SCIENTISTS' CURRICULUM AND INSTRUCTIONAL DECISIONS FOR HIGH SCHOOL CLASSROOMS

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Abstract

This study explored Resident Scientists' curriculum, instructional and assessment decisions for high school classrooms. We also attempted to find out the factors that influenced their decisions. A sample comprised eight Resident Scientists who were providing science content knowledge and pedagogical support to teachers in schools through the National Science Foundation (NSF) GK-12 outreach project in the Midwest of the USA. Data were collected through an open-ended questionnaire. Results show that Resident Scientists made short-termed decisions on curriculum, instruction and assessment for high school classrooms. Their decisions were mainly influenced by partner teachers, textbooks, and antecedent factors. Moreover, their decisions encompassed elements of accountability in the school system. They also exhibited lack of knowledge about the USA Science Education Standards. However, their decisions were within the framework that integrated content and pedagogical support to teachers. The findings have implications for science teaching and learning and the NSF GK-12 program.
Key words: *curriculum, decision, instruction, resident scientist, GK-12.*

Statement of the Problem

Research on science teachers' instructional decisions and factors that influence their decisions has increasingly been recognized as an essential element in science education because it forms an ideal base for teacher education and professional development programs (Aikenhead, 1984; Westerman, 1991; Sanchez & Valcarcel, 1999; Mumba et al., 2007; Mumba & Chitiyo, 2008). The underlining assumption on teacher decision making research is that teachers make instructional judgments and decisions in schools and such decisions guide their instructional practice (Shavelson & Stern, 1981; Calderhead, 1984; Bell & Lederman, 2003). As such, researchers have examined science teachers' instructional decisions and factors that influence such decisions for different grade levels (Shavelson & Stern, 1981; Clark & Peterson, 1986; Westerman, 1991; Klimczak & Balli, 1995; Mumba & Chitiyo, 2008). In general, these studies found that when teachers made instructional decisions they considered information about student attributes, content, goals and objectives, and outcomes. Factors such as the physical and organizational characteristics of the school and classrooms, teachers' practical knowledge, their beliefs about teaching and attitude towards subject content and pedagogy also influenced teacher decision making (Duschl, & Wright, 1989; Sanchez & Valcarcel, 1999). Other studies have reported that teachers' instructional decisions are based on personal values, beliefs, internal and external circumstances, as well as what happens while the instruction is taking place Westerman,1991; Klimczak et al., 1995).

Recently, Mumba & Chitiyo (2008) studied high school science teachers' curriculum, instructional and assessment decisions for inclusive classrooms. Mumba & Chitiyo reported that although science teachers' curriculum, instructional and assessment decisions were within the framework that integrated content and practical classroom knowledge for regular classes, their decisions were unlikely to promote effective science teaching in inclusive classrooms. Teachers' decisions were mainly associated with accountability and personal interests and preferences of science teaching methods for regular classrooms. As such, most science teachers exhibited their lack of knowledge about effective science teaching in inclusive classrooms. This problem was attributed to teachers' lack of training in special education.

Although researchers have examined science teachers' instructional decisions the focus has only been on pre-service and in-service science teachers. No study has explored scientists' instructional decisions for high school classrooms. Yet, today, many scientists are working with teachers and students in schools through science education outreach programs. As such, a comparable knowledge base on scientists' curriculum, instructional and assessment decisions for high school classrooms and factors that influence their decisions does not exist. Such knowledge base is essential for building outreach programs that would offer effective science teaching and learning in high school classrooms. Therefore, attention to scientists' curriculum, instructional and assessment decisions for high school classrooms is warranted, as this may contribute to better science teaching and learning in schools. Thus, the purpose of this study was to explore Resident Scientists' curriculum, instructional and assessment decisions for high school classrooms. Two research questions guided this study (a) How do Resident Scientists decide on what to teach, how to teach, and how to assess student learning in schools? (b) What factors influence their decisions?

The findings of this study have significant implications for science teaching and learning, teacher education, teacher professional development and outreach programs. For example, knowing curriculum, instructional and assessment decisions Resident Scientists' are making in schools is important to those who are involved in science education outreach programs and teacher education. Furthermore, this study does not only contribute to the existing literature on the involvement of scientists in high school science education but also leads to understanding how they decide on the content to teach, and how to teach that content in high school classrooms and the factors that influence their decisions. For that reason, the findings of this study are of particular interest to teacher professional development providers who wish to understand how scientists decide on the curriculum, instructional strategies and assessment criteria for high school classrooms. However, this study focused on one particular area of scientists' decision making-specifically, pre-active instructional decisions. Pre-active decisions refer to the choices teachers make as they plan for teaching and reflect on their teaching.

Methodology of Research

Context of the Study

This study was conducted in the Heartland Ecological/Environmental Academic Research Training (HEART) GK12 project at Southern Illinois University Carbondale in USA. This is one of the 200 outreach projects funded by the National Science Foundation (NSF) under the GK-12 program in the USA. The main goal of the project is to improve science teaching and learning in local schools by sending Resident Scientists (Masters and doctoral students in science disciplines) to schools to help teachers with subject matter knowledge and teaching. Resident Scientists were training to be scientists and not to be certified as teachers. In addition to their involvement in the outreach project, Resident Scientists conducted scientific research for their degree programs and professional development. The project started in 2007, and it is in the third year of its five-year plan. The project is following the NSF model of putting scientists in K-12 classrooms to provide content and pedagogical support to science teachers. This model is based on the premise that

Resident Scientists can be good content knowledge resources to K-12 teachers and their students. The project recruits and supports Resident Scientists through fellowships. Resident Scientists also act as role models in K-12 classrooms to foster positive attitudes towards science among students. Since its inception, the project has trained and supported more than twelve Resident Scientists from the Departments of Plant Biology, Geology, Zoology, and Molecular Biology within the University. A Resident Scientist is only allowed to be in the project for a maximum period of two years. At the beginning of the school year new Resident Scientists are matched with partner teachers. Later in the year, as Resident Scientists establish stronger working relationships with teachers in participating schools, matching with additional teachers occurs. In some of the schools, they work with a single teacher. In other schools, a pair of Resident Scientists works with a single teacher or with a pair of teachers. They spend 15 hours per week preparing and teaching science lessons in schools.

Sample

A sample comprised eight Resident Scientists, six females and two males. The profiles of the Resident Scientists are shown in Table 1 below.

Table 1. Profiles of Resident Scientists.

Resident Scientist	Degree program	Discipline for Degree program	Teaching Experience (Months)		High School Worked in	Subjects taught in Schools	# of students taught in schools
			TA	RS			
Pete	PhD	Plant Biology	30	18	Robinson	Ecology, Biology, Anatomy & Physiology, Zoology	60
Sara	PhD	Plant Biology	0	6	Jefferson	Intro science, Biology, Advanced Biology & Anatomy	84
Jennifer	PhD	Plant Biology	12	6	Sugar Creek	Biology	40
Helen	PhD	Plant Biology	0	18	Robinson	Chemistry & AP Environmental Science	67
Erin	MS	Plant Biology	5	7	High Point	Chemistry & Food Science	60
Kate	PhD	Molecular Biology	5	18	Robinson	Biology	62
Amanda	MS	Geology	0	6	Jefferson	Biology & Physics	130
Ken	MS	Geology	0	18	Sugar Creek	Physical science, chemistry & Biology	75

Note: TA= Teaching Assistant; RS= Resident Scientist

All the Resident Scientists had no formal teacher training and teaching experience at the K-12 level before joining the project. One Resident Scientist had a teaching experience at a community college as an instructor for 2 years. Four of them had teaching experience in undergraduate university courses through teaching assistantships. Five Resident Scientists were in PhD programs; four in Plant Biology and one in Molecular Biology. Three Resident Scientists were in masters' degree programs; two in Geology and one in Plant Biology. Their teaching experience as teaching assistants prior to joining the project ranged from zero to two and half years. At the time of data collection, their teaching experience as Resident Scientists in the project ranged from six to eighteen months.

Data Collection Instrument

Data were collected through a 23 item-open-ended questionnaire that was emailed to the participants. The purpose in emailing the questionnaire was to allow Resident Scientists the freedom to complete it at their leisure in hopes they would provide answers that were more complete. The questionnaire consisted of four sections: the first section had 5 questions on demographic information such as participants' degree programs, teaching experiences as teaching assistants and as Resident Scientists; the second section had 5 questions that focused on curriculum decisions, the factors that influenced their decisions, and the challenges they have faced in implementing this decisions; the third section had 8 questions that focused on instructional decisions made by Resident Scientists and the factors that influenced such decisions, and the fourth section had 5 items that focused on assessment decisions made by Resident Scientists, including the factors that influenced their decisions.

Data analysis

Data were analyzed using a constant comparative method (Strauss & Corbin, 1998). The procedure involved reading (and re-reading) responses in the questionnaire. Essentially, each line, sentence, and paragraph in the questionnaire responses was read in search of the answer to these two questions: What is this about? What is being referenced here? Then, the Resident Scientists' responses were open-coded to identify recurring themes. These provided the representative profiles of the group of Resident Scientists being studied. The authors conducted the initial stages of data analysis using this procedure independently. Following each stage they met to discuss the results and resolved any differences in the themes and categorization. However, they collaborated on the last stage of analysis and the final set of themes presented in the next section was a result of this process.

Results of Research

Curriculum Decisions

Generally, Resident Scientists made short-termed decisions because they lacked complete understanding of science curriculum for individual grades and classes in schools and they had no ownership or control of the classes in schools.

Most decisions…are not long-termed because the teacher knows what to cover in a year… I just help where she needs help. This makes it difficult to make decisions on what to teach in each class or grade for that year. I also don't have complete control of the classes. The teacher is in complete control…because she is the owner of the classes (Ken).

From the excerpt, Ken implies that the partner teacher has the prescribed curriculum for each grade level and class. Ken is only there to provide content and pedagogical support to the teacher. He has no authority to change the curriculum. He can only teach what is prescribed in the existing curriculum supplied to the teacher. As such, the Resident Scientists decided on what to teach by first consulting partner teachers.

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… a week or two before I am to give a lesson, I discuss with the teacher on what topics she will be covering in class. I ask the teacher what she wants me to work on. So…this involves conversations and feedback from the teacher on the topics, experiments and demonstrations to do (Jennifer).

Both Ken and Jennifer imply that they depended on the teacher to help them decide the topics to teach in science lessons. This was the expected practice because the Resident Scientists were mainly there to provide content knowledge and instructional support to teachers. It was during these discussions that the scope and depth of the content were agreed upon. The discussions also provided the Resident Scientists with opportunities to suggest activities to be included in the lesson that were not part of the existing lessons.

I work with the teacher to fit a lesson or activity into the existing curriculum that the teacher is focused on at that time. I add new ideas or activity, but still tie it to the existing curriculum (Sara).

Resident Scientists' decisions on what to teach in high school classrooms were also influenced by other factors such as: textbooks, topics, teacher's needs, standardized exams like ACT and the required course content. For example, Kate said "…decisions are largely determined by the layout of the textbook. I would plan an activity that dealt with a particular topic within the chapter in the biology text that was being taught that week". Similarly, Erin said "I listen to what the teacher needs to be covered during my lesson time. I also take into account students' interests and what is required for them to pass ACT exam…, time is another factor I look at when deciding what to teach". Some antecedent factors such as grade level, regular or advanced placement classes, students' abilities and general interest in science also influenced their curriculum decisions. This is illustrated in the following excerpt: "I consider their grade level, interest and whether they are in regular or advanced placement (AP) classes. This is important information for the depth of the content to be covered in a lesson" (Ken). Ken implies that when teachers make decisions on what to teach, they should consider antecedent factors if they are to be successful in their lessons.

Instructional Decisions

Resident Scientists reported using multiple teaching and learning strategies. In particular, their instructional decisions encompassed several teaching methods such as discussions, question and answer, demonstrations, inquiry activities, lectures, computer-based simulations, debates, field trips, laboratory activities and case studies. Most Resident Scientists said they use these teaching methods because they have worked well in their classrooms. "I use them because they seem to work. Students are engaged in activities. During discussions, students share thoughts, teach classmates, and regurgitate information from previous activities and courses" (Amanda).

Their instructional decisions were influenced by several factors such as: antecedent factors (students' abilities, time, and grade level), feedback from partner teachers, opinions of other Resident Scientists, freedom to try new ways to teach, their previous experience as teaching assistants, textbooks, how to make labs exciting, available materials and facilities, and interest level among students. Their experience in college courses also influenced their instructional decisions for high school classrooms. For example, Pete said:

I had one college professor that insisted we always learned more from our mistakes and thus none of his labs ever ended with correct results. Thus, I tend to favor instruction that forces kids to think and be creative and learn to accept that some things do not go as planned, and the best thing to do is to try it again.

Furthermore, some Resident Scientists' instructional decisions were based on partner teachers' instructional experience on a particular topic in previous classes.

I usually bounce ideas off the teacher I work with. I ask her what she had done in the past and what she would like to improve on a certain topic or lesson. Based on her responses, I try to come up with something that will work for that particular topic (Sara).

Both Pete and Sara imply that instructional experience in previous courses and lessons is an essential factor in deciding how to teach certain science topics or courses in order to help students learn the intended content and skills. However, Pete's approach is in keeping with the common theme in education that teachers *tend to teach the way they were taught.*

By and large, Resident Scientists said their decisions on how to teach science lessons have been helpful. They based their assertion on the feedback from students, teachers, and their own observations during lessons. For example, Ken said "my decision to use more hands-on experiments in class seems to have worked well. Students are engaged and ask a lot of questions on the day I teach and do these experiments. Similarly, Jennifer said "I had one freshman tell me she could tell which labs I wrote because they were interesting ones. Students also prefer to be in the lab, so my focus is to get them into the lab more often. Their retention of the material seems to have improved".

On the other hand, Resident Scientists have experienced challenges in implementing the teaching methods stated above. Some of the challenges are: schools block some websites that have good videos and online learning resources, some students have no process skills to do labs, lack of interest in science among students, and negative attitude towards science among students.

Assessment Decisions

It was evident in questionnaire responses that most Resident Scientists did not have a complete understanding of assessment. Most of them were not explicit on how they made assessment decisions. However, their decisions on assessment were mainly based on the information from partner teachers. For example, Kate said: "my main source of assessment ideas has been from my partner teacher. He tells me how to assess students' learning".

In general, the assessment strategies employed by this group of Resident Scientists took the form of pre and post-tests, asking students questions during class, quizzes, journaling, and lab reports. Most of them also said they used these assessment strategies because they are the same ones partner teachers used and students were comfortable with these assessment strategies as they were less intimidating. Five Resident Scientists found these assessments helpful in determining students' learning. Their judgment was based on the feedback from students and partner teachers. For example Pete said "I think that by answering the questions, students are able to also see what they have learned and what concepts they are still struggling with". On the other hand, three Resident Scientists were not sure if these assessment strategies were the best for assessing students' learning. "I honestly don't know. They seem to like the clickers the best as it is more engaging and gives instant feedback. Testing is typical, but the active note taking seems to help students retain information better. Journaling had mixed results and needs to be investigated in more detail (Helen).

From the excerpts, Pete is comfortable with the assessment strategies because they worked well in the classes. On the other hand, Helen implies that there are more assessment strategies a teacher can use to assess students' learning.

Discussion

The purpose of this study was to explore Resident Scientists' curriculum, instructional and assessment decisions for high school classrooms and the factors that influenced their decisions. There was a prevailing belief among Resident Scientists that since they were just there to provide content and pedagogical support to teachers, they could only decide on what to teach and how to teach it after consulting partner teachers. As such, Resident Scientists made short-termed decisions on curriculum, instruction and assessment. Such short-term decisions on curriculum, instruction and assessment were precipitated by three factors: they had no authority to impose curriculum on teachers, they lacked complete understanding of the school science curriculum, and they had no control of the courses or classes in schools.

Resident Scientists' curriculum and instructional decisions were also influenced by the way the content was outlined in the textbooks. For this, a textbook was also the principal source of the content and activities. Resident Scientists justified the use of textbooks because partner teachers supplied them and in their opinions the teacher supplied textbooks were thorough and contained the basic necessary content to be covered in a particular grade level or course. The use of textbooks as curriculum guides supports the previous findings which states that when science teachers make decisions on what to teach they heavily rely on textbooks for accountability purposes (Sanchez & Valcarcel, 1999; Porlán, & Martín del Pozo, 2004; Mumba & Chitiyo, 2008).

Surprisingly, this group of Resident Scientists did not cite the USA Science Education Standards (SES) as one of the factors that influenced their pre-active instructional phase decisions. In the USA, the main guides for K-12 science curriculum are the National Science Education Standards (NSES) (National Research Council [NRC], 1996). In addition, each State has its own Science Education Standards that are aligned with the NSES. The SES are aimed at achieving scientific literacy among students and they accentuate an inquiry-based science teaching approach. Therefore, science teachers are expected to align their science lessons with SES. The fact that Resident Scientists heavily relied on partner teachers for curriculum and instructional decisions indicates there is a good chance that they did not explicitly align the lessons with SES. We attribute this problem to Resident Scientists' lack of training in pedagogy where SES are introduced, interpreted and discussed. For this reason, given the importance of SES in the US education system, we encourage the NSF GK-12 project coordinators to provide training on SES to Resident Scientists for them to be aware of SES and gain skills for aligning lessons with the SES.

Based on the findings in this study and those reported by Mumba et al (2007) the NSF GK-12 project coordinators also need to take into account their Resident Scientists' pre-existing conceptions of curriculum, instructional and assessment decisions if they are to effectively move them towards a more appropriate and preferred process for making decisions on curriculum, instructional and assessment for high school classrooms. Similarly, other science education outreach projects elsewhere should provide explicit instruction to scientists on curriculum, instructional and assessment decisions for high school classrooms that are linked with effective science teaching and learning. Strengths and weaknesses of different instructional decisions should also be explicitly addressed to the participants. Such intervention, coupled with a continuous and supportive environment, would help the NSF GK-12 program in the US achieve its goal, which is to improve science teaching and learning in schools.

It is worth noting that this exploratory study mainly focused on Resident Scientists' curriculum, instructional and assessment decisions for high school classrooms at pre-active instructional phase and the factors that influenced their decisions. Future research should focus on Resident Scientists' decisions during active and post-active instructional phases to better understand their decision making process for high school classrooms.

Conclusions

Resident Scientists' decisions on curriculum, instruction and assessment for high school classrooms were mainly influenced by partner teachers, textbooks, standardized tests, available resources and facilities and antecedent factors such as grade levels, students' abilities, time and students' interest in science. They also made some decisions based on their previous experiences in college level science courses. The first three factors are associated with partner teachers' accountability requirements at school and school district levels. Surprisingly, Resident Scientists' decisions were not influenced by the USA Science Education Standards which are the main guides for teaching, learning and assessment in the US schools. Thus, it can be concluded that Resident Scientists' pre-active decisions were teacher dependent and served two main functions: accountability in the school system and extra help to teachers. It is also concluded that their decision process was within the framework that integrated content knowledge and pedagogical support to teachers. As such, their pre-active decisions encompassed the elements of the NSF GK-12 program, one of which is Resident Scientists to provide content and provide support to teachers. However, the Resident Scientists exhibited their lack of knowledge about the USA Science Education Standards which they are expected to address in schools.

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