

## Student Teachers' Beliefs about Teaching and Learning Science before and after a Science Methods Course

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اعتقادات الطلبة المعلمين بالنسبة لتعلم وتدرّيس العلوم قبل وبعد أخذهم  
لمادة أساليب تدرّيس العلوم

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### المخلص

هدفت هذه الدراسة إلى قياس معتقدات الطلبة المعلمين فيما يتعلق بتعلم وتدرّيس العلوم قبل وبعد دراستهم لمادة "أساليب تدرّيس العلوم". تألفت عينة الدراسة من ٤٥ طالباً معلماً من كلية العلوم التربوية في الجامعة الهاشمية / الأردن ممن التحقوا بمادة أساليب تدرّيس العلوم، خلال الفصل الأول للسنة الدراسية ٢٠٠١/٢٠٠٢ م. تم استخدام اختبار داست DASTT-C، وهو اختبار يقيّم رسومات الطلبة لانفسهم أثناء تدرّيسهم لمادة العلوم، قبل وبعد دراستهم للمادة. من خلال تحليل البيانات تبين أن الطلبة المعلمين قد أظهروا في رسوماتهم خصائص غير تقليدية، تتمثل في التمرّكز حول الطالب أثناء تعلم وتدرّيس العلوم، بعد أخذهم لمادة العلوم. وتؤكد نتائج الدراسة ضرورة التدرّيب الجيد للطلبة المعلمين؛ لتحسين معتقداتهم، وممارساتهم فيما يتعلق بتدرّيس وتعلم مادة العلوم.

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### *Abstract*

The purpose of this study was to measure the beliefs about science teaching and learning that student teachers construct prior and after a coursework in science teaching methods. The subjects of this study included 45 elementary student teachers attending the College of Educational Sciences at the Hashemite University, Jordan. All students were enrolled in their first science methods course during the fall semester of the academic year 2001/2002. The Draw-A-Science-Teacher-Test Checklist (DASTT-C) instrument, that measures students' illustrations of themselves as "a science teacher at work", was administered to the student teachers during the first meeting of their science methods course, and at the end of the course. Analysis of the illustrations revealed that most student teachers depicted less traditional student-centered elements of teaching and classroom images at the end of the course. The results support proper training of science teachers in order to improve their beliefs and practices of teaching and learning science for a systematic long lasting reform.

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Over the past decade, science education reform recommendations have been quite evident. These recommendations included the tasks of revising the curriculum, modifying the methods of teaching science, and adapting new methods of assessment. Those tasks fall upon schools and those who work in and with them, including teachers who are recognized as the central factor in the successful implementation of reform in science education. Accordingly, teachers should be acknowledged as facilitators of knowledge, and students are expected to participate in hands-on learning experiences and get involved in inquiry-oriented investigations, as stated by National Science Education Standards (National Research Council, 1996):

Emphasizing active science learning means shifting away from teachers presenting information and covering science topics. The perceived need to include all the topics, vocabulary, and information in the textbooks is in direct conflict with the central goal of having students learn scientific knowledge with understanding (p. 20).

Since 1989, the Educational system in Jordan has been undergoing a comprehensive reform. The major objective of the Educational Reform Plan is to improve the quality of educational output, and to enhance student achievement levels through concentrating upon the issues of quality, efficiency, and effectiveness of the educational system. Upgrading teacher qualifications, and modernizing pre-service teacher training educational programs are among the main elements of the reform plan.

One of the main goals of teaching science in Jordan, according to the Science Curriculum and its Guidelines at the Basic Educational Cycle (SCGBEC, 1988), as stated by the scientific team at the Ministry of Education goes as follows:

*In selecting the methods of teaching science, it is essential to emphasize the active role of the student through making him/ her the effective element in performing class activities, conducting laboratory experiments, carrying out discussions, exploring knowledge through individualized reading. Meanwhile, the teacher plays the role of a facilitator in providing the appropriate learning environment and the needed stimulating experiences (p. 26).*

The long history of traditional science learning experiences powerfully impact the way in which science student teachers understand the nature of science and the way in which science should be taught. A number of researchers have suggested that students bring to their teacher education training programs loosely defined educational beliefs based on their personal experiences as students that influence the judgments they make about their own and other's teaching. Calderhead and Robson (1991) indicated that preservice teachers held vivid images of teaching from their experiences as students, which in turn affect their interpretations of course experiences and influence the practices they would apply as teachers. Tobin, Briscoe & Holman (1990) reported that today's preservice teachers who have experienced yesterday's K-12 science learning in the form of text-based, didactic lessons, present science as an inert body of knowledge. In a study of preservice teachers' professional perspectives, Goodman (1988) implied that teachers were influenced by early childhood experiences which have a significant impact on their professional perspectives. Clark & Peterson (1986) indicated that teachers' conceptions of the processes of teaching and learning, and their beliefs about students' classroom activities and subject matter have an important influence on their instructional practices in the classroom settings.

This research begins with a concern for these beliefs that student teachers bring to science methods classes. As indicated, student teachers develop their beliefs about teaching and learning from years spent in the classroom as students. According to Pajares (1992), beliefs can be defined from a great number of conceptual frameworks that include: attitudes, values, judgments, axioms, opinions, ideology, perceptions, conceptions, conceptual systems, preconceptions, dispositions, implicit theories, explicit theories, personal theories, internal mental processes, action strategies, rules of practice, practical principals, perspectives, repertoires of understanding, and social strategies. In a study of science educators' definitions of beliefs, Oliver and Koballa (1992) obtained multiple definitions, where beliefs were often times equated with knowledge; antecedent of attitudes, motivation, and behavior; personal convictions that may or may not be based on observation or logical reasoning; or reflect a person's acceptance

or rejection of a proposition. Nespor (1987) argued that beliefs are drawn from previous events and experiences and are strong predictors of behavior, influential in organizing tasks, and serve as templates for one's own teaching practices. Nespor proposed that beliefs reside in episodic memory drawn from experiences that draw their power from previous events and influence the understanding of subsequent events, and are strong predictors of behavior.

Students' experiences that shape their beliefs about how science is taught are influenced by recent science lessons they have experienced. Brookhart & Freeman, (1992) focused on entering teacher candidates' beliefs about teaching and discussed the role between the nature of teacher beliefs and the impacts these beliefs have on their performance in the classroom. In an exploratory research, Simmons et al., (1999) investigated the perceptions and beliefs performances of beginning science and mathematics teachers as related to their classroom performances. It was revealed that teachers who professed student-centered beliefs, behaved in teacher-centered ways.

Apparently, student teachers' experiences that structure their beliefs as related to their professional practice are influenced by recent science lessons they have experienced. Since student teachers' beliefs regarding their performance in the classroom play a critical role in restructuring science education, educational researchers should take this matter into consideration as evident in the following statement by Tobin, Tippins, and Gallard (1994):

*Future research should seek to enhance our understanding of the relationships between teacher beliefs and science education reform. Any of the reform attempts of the past have ignored the role of teacher beliefs in sustaining the status quo. The studies reviewed in this section suggest that teacher beliefs are a critical ingredient in the factors that determine what happens in the classroom. (p. 64)*

Moreover, Kagan (1992) argue that if we want to better understand how teachers are able to improve their teaching practices, we need to better explore the construct of their beliefs and its varied form and function. Osterman and Kottkamp (1993) note a difference between "espoused theories," which they define as "what we are able to say we think and believe," and "theories-in-use," which are beliefs and assumptions existing beyond our conscious awareness and which exert much greater power over our actions and perceptions: "While espoused theories readily incorporate new information, theories-in-action resist change ... While we superficially adopt new ideas, our behavior often continues unchanged" (p.12). Teachers' theories-in-use were evident in the study carried out by Kagan (1992) who concluded, after reviewing 25 studies on teacher

beliefs, that teachers' beliefs appear to be relatively stable and resistant to change and associated with a particular teaching style

Student perceptions of scientists was first measured by Chambers (1983) who developed the Draw-A-Scientist-Test (DAST) as an open-ended projective test to provide information regarding children's perceptions of scientists. Children's drawings were rated according to particular characteristics present or absent in the drawings, allowing researchers to determine the images of scientists children hold. Finson, Beaver, and Crammond (1995) developed the Draw-A Scientist-Test Checklist (DAST-C) to further consider images and facilitate ease of assessment. The checklist provided drawing raters with stereotypic components identified in previous research making the identification and recording of such components more efficient and more readily quantifiable for data analyses. Thomas and Pederson (2001) modified the DAST-C to create the Draw-A-Science-Teacher-Test Checklist (DASTT-C). The rationale for such an instrument was that students' drawings might reveal much about their perceptions of themselves as science teachers in the same way as they reveal about their perceptions as scientists. As suggested earlier, the rationale behind that is that pre-service teacher's beliefs, as suggested by their drawings, are highly correlated with specific, intense memories of their own science learning experiences in elementary, high school, and college science courses. This stems from the work of Nespor (1987) who suggests that beliefs reside in episodic memory and are derived from personal experience with cultural sources of knowledge transmission. Nespor later maintained that these richly detailed, episodic memories later serve as an inspiration or a template for one's own teaching practices. The implications of episodic memory with belief systems are especially important to the current research, as these critical experiences are believed to influence and frame how one learns and how one uses what is learned.

### **Purpose of the Study**

The main purpose of this study was to examine the impact of science teaching methods course on elementary student teachers' beliefs of science teaching and learning. This research focused on the following question: What is the impact of a science methods course on students' beliefs of science teaching and learning?

### **Method**

#### **Subjects**

The subjects for this study consisted of 45 (40 females & 5 males) elementary student teachers enrolled in their first science teaching methods course during the first semester of the academic year 2001/2002 at the College of Educational

Studies/ Department of Curriculum and Instruction at the Hashemite University, Jordan. The students comprising the course section were classified as juniors. The science methods course in which the preservice teachers were enrolled was designed with a constructivist teaching/ learning approach in mind. Course topics included: nature of science, learning theory and theorists, issues in science education, and instructional strategies that promote engaging students actively in the learning process.

### The Instrument

The DASTT-C (Draw a Science Teacher Teaching Checklist) instrument, developed by Thomas and Pederson (2001), measures students' beliefs about science teaching and shows great potential for defining the ways in which student teachers develop and hold-on to stereotypical beliefs. The DASTT-C checklist indicators were derived from a review of the traditional and reform emphases as suggested in the new science teaching standards (NRC, 1996). Thomas and Pederson revised the DASTT-C to include elements they judged to be characteristic of science classrooms and science teachers. The DASTT-C score sheet (for the test administrator) consists of three sections: Teacher, Students, and Environment. Each section is scored in a dichotomous fashion with an indication of "present" or "not present". The response sheet provides blanks at the top for subjects to enter demographic information (identification number, date of drawing, etc.). In the center of the sheet is a square in which subjects are asked to make their drawing. Above the square is the drawing prompt,: "Draw a picture of yourself as a science teacher at work". The "Teacher" section of the instrument is divided into two subsections that focus on the teacher's activity (demonstrating, lecturing, using visual aids, etc.) and the teacher's position (location with respect to students, such as at the head of the classroom, and posture). The "Students" section of the instrument is likewise divided into two subsections that focus on the activities of students (passively receiving information, responding to the teacher, etc.) and students' positions (seated within the classroom). The third section, "Environment," consists of elements typically found inside classrooms, such as desks arranged in rows, symbols of teaching (e.g. chalkboards) and of science (e.g. science equipment), etc. Furthermore, the DASTT-C includes a short student narrative describing their drawings and indicating what the teacher and students are doing which helps define the meanings of their illustrative images and serve to guide student reflection. This descriptive narrative assists in scoring the drawings.

### Test Reliability and Validity

The internal consistency of the DASTT-C instrument was determined in the Jordanian culture on a pilot sample of 25 student teachers. A coefficient alpha was calculated for the DASTT-C dichotomous data set and was found to be 0.76, indicating an acceptable degree of internal consistency in the instrument. The instrument was also tested for inter-rater reliability. Four scorers, using the DASTT-C checklist, scored a set of ten pictures independently following the scoring directions. No significant difference was found in any of the sub scores or the total scores of the DASTT-C. Face validity of the instrument was also attained by four raters who indicated that the instrument appears to be relevant in terms of content.

### Data Collection

The instrument, The Draw-A-Science-Teacher-Test-Checklist (DASTT-C), was administered as a pre-test to the student teachers at the beginning of the semester during the first meeting of the science methods course in October, 2001, and a post-test at the end of the semester in January, 2002. Data gathered from the pre- and post- administration were analyzed. As indicated earlier, the elements included in each section of the instrument represent stereotypical aspects of teaching and classroom images. If a stereotypical element appeared in a subject's drawing, the scorer simply marked that element on the checklist in the space provided next to that particular element. Scores were later added to derive both sub-scores for each section as well as an overall checklist score. The total checklist scores range from 0 to 13. Given this score, student teachers were placed on a continuum from student-centered (0) to more teacher-centered (13) as indicated by the DASTT-C measure. Thus, students' illustrations were organized into two fairly distinct groups: student-centered (0-6 points) and teacher-centered (7-13 points). Teacher-centered teachers tend toward more factual content with very little real-world application, while in the student-centered teaching style, the teacher acts as the facilitator and guide in the learning activity.

### Results & Discussion

Both pre-course and post-course illustrations demonstrated many significant insights into the nature of beginning teachers' beliefs and practices before and after the science methods course with regard to the teacher's elements: several pre-course drawings illustrated the teacher demonstrating an experiment or activity all by himself, whereas few post-course illustrations exhibited that. While some students illustrated the teacher lecturing next to a chalkboard or giving directions prior the methods course, less students portrayed a similar behav-

ior by the teacher in their post-course drawings. In fact, most of the students' post-course illustrations demonstrated the teacher doing activities with the children (planting seeds, collecting leaves, or demonstrating an experiment). As for the teachers' use of visual aids while presenting the material as chalkboard, overhead, and charts, many of students' pre-course drawings illustrated those activities, while few post-course drawings revealed that. With reference to the teacher's position, several drawings placed the teacher standing in front of the class as a significant enlarged figure with the back of the students' tiny heads, whilst few of the students' post-course illustrations portrayed the teacher centrally located as head of the class. Remarkably, the majority of the students' post-course illustrations depicted the teacher roaming in the class. The teacher's motion was often labeled with arrows to indicate his movement in the classroom. It was sometimes difficult to locate the teacher, whose figure size was the same as the students, and often appeared standing off side observing. As for the teacher's posture, several students illustrated the teacher standing, not sitting or bending. This figure dropped slightly in the post-course drawings. In both tests, few illustrations portrayed the teacher sitting or bending (See Table 1).

**Table 1**  
The number and percent of student teachers who responded positively to the teacher elements of the DASTT on both the pretest and posttest.

Teacher Elements	Pretest		Posttest	
	Number	%	Number	%
Teacher Demonstrating Experiment/ Activity	27	60.0%	15	33.3%
Teacher Lecturing/ Giving Directions	22	48.9%	13	28.9%
Teacher Using Visual Aids (chalkboard, overhead, charts)	31	68.9%	21	46.7%
Teacher centrally located (head of class)	32	71.1%	12	26.7%
Teacher standing (not sitting or bending)	36	80.0%	33	73.3%

As regarding students' elements in the pre-course drawings a good number of students' illustrations exhibited the students listening or responding to their teacher. This figure dropped significantly in their post-course drawings. Particularly, the majority of the post-course drawings revealed the students working on their experiments either individually or with small groups. Likewise, many students' pre-course drawings exhibited the students responding to the teachers' questions by speaking, raising their hands, or listening, while less students demonstrated that in their post-course drawings. With respect to the students' position in the classroom, more pre-course illustrations exhibited the students seated on their desks than the post-course illustrations. Quite a few drawings revealed the students standing or moving around, which indicates the presence of an interactive learning environment in the classroom (See Table 2).

**Table 2:**

**The number and percentage of student teachers who responded positively to the student elements of the DASTT on both the pretest and posttest.**

Students Elements	Pretest		Posttest	
	Number	%	Number	%
Students watching listening	29	64.4%	13	28.9%
Students responding	31	68.9%	17	37.8%
Students seated	36	80%	28	62.2%

As for the environmental elements related to classroom organization, almost half of the students' pre-course illustrations showed the traditional rows-placement of students' desks and chairs. Very few post-course drawings illustrated the desks arranged in an organized setting in rows. This reveals the fact that a number of instructional strategies that require cooperative group activities cannot be carried out in a classroom with desks placed in rows. With reference to the location of the teacher's table, many pre-course drawings exhibited the teacher's table located in front of the classroom while a small number of post-course drawings revealed so. In fact, the teacher's table in some post-course drawing was placed on the side or completely missing. This suggests that the most students felt that this piece of furniture was not anymore necessary since they can work on their own, or with groups using their own tables or other coun-

ters. It is worth mentioning that the classroom organization in most post-course drawings included, in addition to the usual desks and chairs, extra worktables or cabinets, reference books, plants and animals. Half of the pre-course drawings illustrated the lab equipment placed on the teacher's table, while a small number of the post-course drawings revealed so. As for the presence of symbols of teaching in the classroom, nearly all the illustrations included teaching symbols as chalkboards and bulletin boards. Likewise a good number of the post-course drawings demonstrated so. Regarding the presence of symbols of science knowledge such as wall charts and lab instruments, more student teachers included those items in their pre-course illustrations than they did in their post-course drawings (See Table 3).

**Table 3**  
The Number and Percent of student teachers who responded positively to the environmental elements of the DASTT on both the pretest and posttest.

Environmental Elements	Pretest		Posttest	
	Number	%	Number	%
Desks Arranged in Rows	25	55.6%	2	4.4%
Teacher Desk Located in Front of the Room	27	60.0%	6	13.3%
Equipment on Teacher Table	23	51.1%	10	22.2%
Symbols of Teaching (chalkboards, bulletin boards)	44	97.8%	37	82.2%
Symbols of Science Knowledge (lab equipment, charts)	30	66.7%	21	46.7%

A closer examination of the findings indicate that the post-course illustrations fit more closely with non-traditional exploratory teaching that encourages inquiry and questions facilitated by the teacher, while the pre-course drawings fit with the traditional teaching where emphasis is on subject matter knowledge led by the teacher who organizes and delivers learning.

Based on their illustrations, students were organized into two fairly distinct groups: teacher-centered or teacher-centered based on their overall checklist score, prior and after taking the science methods course. Students who scored from (0-6) points were rated student-centered, and those who scored from (7-13) points were rated teacher-centered. An examination of the findings exhibited worthwhile results. On the pretest, the number of students teachers who were rated as teacher-centered student was found to be 39 (86.7%) and those who were rated student-centered were (13.3%). This case reversed completely on the posttest, where only 8 (17.8%) students were rated teacher-centered, while 37 (82.2%) students were rated student centered. What is evident from examining the results is that students' illustrations shifted from being teacher-centered to student-centered (See Table 4).

**Table 4**

**The number and percentage of student teachers who were rated teacher-centered and student-centered on both the pre-test and posttest.**

Test	Teacher-centered		Student-centered	
	Number of students	%	Number of students	%
Pre-test	39	86.7%	6	13.3%
Posttest	8	17.8%	37	82.2%

To determine whether there were significant differences between student teachers' total scores before and after the science methods course, as measured by the DASTT-C instrument; statistical analysis was carried by performing a t-test for dependent variables. As implied earlier, lower mean scores indicate that students held non-traditional student-centered beliefs. Significant differences at the ( $\alpha = 0.05$ ) were obtained which suggest that student teachers' responses, after the science methods course, shifted from being traditional teacher-centered to non-traditional student-centered. Further statistical analysis, applying the t-test,

revealed a statistically significant difference at the ( $\alpha= 0.05$ ) level, as related to the teacher, students, and environmental elements (See Table 5). The results of the analysis support contention that the science methods course had to some extent impacted the student teachers about their beliefs of science teaching and learning.

Table 5

T-test results for the differences in means between students' pre- and posttests scores, as measured by the DASTT-C, as related to their total scores, and each of the teacher, students and environmental elements.

Variable	Pre-Mean	Post-Mean	Pooled SD	t-ratio	p
Total	8.73	5.06	2.60	-9.45	0.000
Teacher	3.29	2.09	1.424	-5.65	0.000
Student	2.13	1.28	1.065	-5.32	0.000
Environment	3.31	1.68	1.248	-8.72	0.000

### Implication

Based on the results of this study, it has been noted that student teachers drawings yielded many significant insights into the nature of their beliefs about science teaching learning practices before and after the science methods course. The DASTT-C instrument served as a tool in assisting the student teachers in recollecting their initial beliefs and specific memorable episodes about how they were taught science, and illustrate that in their drawings. Apparently, during the course, student teachers had the opportunity to get introduced to several teaching methodological approaches that challenged their previous perceptions, and self-reflected on their old-fashioned professional image of themselves teaching science. The findings of this research revealed that student teachers' post-course illustrations conveyed an improved image of themselves as science teachers. This indicates that the researcher, who also taught the methods course, was able to change students' espoused theories that resulted from new learning.

However, caution should be taken that students might not reflect their beliefs, as demonstrated in their drawings, in their classroom actions and they will adopt student-centered type of teaching. There is a possibility that student teachers possess beliefs of themselves teaching science that might differ from what they might actually employ once in the classroom, as evident in the research analysis conducted by Simmons et al., (1999) which reveals that students' practices contrasted starkly with their beliefs: while teachers professed student-centered beliefs, they behaved in teacher-centered ways. Conversely, the exploratory study conducted by Levitt (2001) illustrates that teachers' expressed beliefs and classroom actions were consistent with the philosophy of current science education reform: teachers believed that teaching and learning of science should be student-centered and that reflected on their actions in the classroom.

However, beliefs can be strengthened or modified by classroom practice. Clark & Peterson (1986) indicates that events in the classroom and school setting provide either constraints or opportunities for the development of teachers' beliefs. Student teachers should be taught the way they are expected to teach. Therefore, teacher education programs should promote engaging students more actively in the educational process, and provide opportunities for teacher reflection. In their research, Hand and Treagust (1997) were able to change teachers' science classroom practices as a consequence of an in-service training program aimed at promoting constructivist teaching/ learning approaches. Likewise, Glasson and Lalik (1993) documented changes in teachers' beliefs and practices after engaging their students in social constructivist learning. Student teachers should be trained to take the initiative in organizing hands-on activities, laboratory investigations, and group work in order to build a classroom environment that maximizes student learning. Above all, teachers need to consider deeply effective teaching methodologies in order to improve their beliefs and practices in teaching and learning science. Anderson & Mitchener (1994) noted that change requires that teachers learn, rethink, and adopt a different knowledge, thought, and practices related to teaching. Proper training of science teachers in this fast-moving scientific age is a matter of increasing concern. There is always a demand for well-prepared teachers who can play an important mediating role in facilitating excellent instruction for a systematic long lasting reform.

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