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Preservice Teachers' Memories of Their Secondary Science Education Experiences

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Abstract Understanding preservice teachers' memories of their education may aid towards articulating high-impact teaching practices. This study describes 246 preservice teachers' perceptions of their secondary science education experiences through a questionnaire and 28-item survey. ANOVA was statistically significant about participants' memories of science with 15 of the 28 survey items. Descriptive statistics through SPSS further showed that a teacher's enthusiastic nature (87%) and positive attitude towards science (87%) were regarded as highly memorable. In addition, explaining abstract concepts well (79%), and guiding the students' conceptual development with practical science activities (73%) may be considered as memorable secondary science teaching strategies. Implementing science lessons with one or more of these memorable science teaching practices may "make a difference" towards influencing high school students' positive long-term memories about science and their science education. Further research in other key learning areas may provide a clearer picture of high-impact teaching and a way to enhance pedagogical practices.

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Literature Review

Students at all levels deserve equal opportunities to learn about science and its various applications. Academic culture as well as school environments can have an impact on students' science learning and achievements. Due to teachers' varied practices, students receive different science education experiences. Quality of teaching and an engaging learning environment are essential for students' learning of science. Yet, an education system reveals certain classroom practices bounded by limitations of the environment (Monk et al. 2002). Students' opportunities for learning science and the quality of instructional delivery within a stimulating learning environment (Nolen 2003) were reported as predictors of students' achievement in science.

Science educators continually explore ways for preservice teachers and teachers to improve their science teaching practices (Monk and Dillon 1995). Practical texts have been designed to guide science teaching (e.g., Newton 2008; Wellington and Ireson 2008). Some provide specific pathways for teaching science such as outlining strategies that develop scientific literacy (Bybee et al. 2007). Yet, it is research into practices that can substantiate effective teaching practices. The difficulties in defining effective science teaching are embedded in the numerous characteristics and roles of the classroom teacher. In secondary science, effective teaching requires close attention to detail (Parkinson 2004). Exemplary science teachers utilize effective management strategies, encourage student participation within a favourable learning environment, and

monitor student understandings of the content taught (Bybee et al. 2007; Tobin and Fraser 1988). Woolnough (1994) states effective science teachers are "knowledgeable, competent and enthusiastic in their subject and in class management, and understanding and sympathetic to students and their needs" (p. 43). For many years, educators (Burry and Bolland 1992; Bybee et al. 2007) have noted that, apart from careful planning and good management, outstanding science teachers are facilitators of the learning process.

Effective science teaching strategies have been articulated through empirical research. A teacher can engage and motivate students by targeting their misconceptions about the topic or key concepts (e.g., Broek and Kendeou 2008). Numerous studies and educators (e.g., see Tauber and Mester 2006, pp. 5–8) have shown that students are far more engaged in lessons where the teacher displays enthusiasm. Not surprisingly, teachers who have positive attitude towards teaching a subject can influence a student far more than those who have negative attitudes (Ediger 2002). This positive attitude may be noted when the teacher displays enthusiasm for the subject. Facilitating cooperative group work with interactive activities appears as an effective strategy (Hudson and Ginns 2007). Students learnt well through practical, hands-on activities across a wide range of topics including life and living topics about animals and plants (Skamp 2007). Selecting high-impact teaching strategies can assist teachers to make science more memorable (Hudson 2007; Hudson and Kidman 2008).

Seidel and Prenzel (2004) examined the teaching and learning processes in 50 randomly selected science classrooms in Germany and reported variation of: teaching methods, clarity and coherence of goals, learners' orientation, facilitation of conceptual change and handling of mistakes and functions of experiments in scientific inquiry. These appeared to play significant roles for influencing students' learning in science. Aypay (2002) reported that students' previous grade point average (GPA), taking preparatory courses, and having an ideal teacher who provides guidance were all positively associated with 8th grade Turkish students' science achievement. In another study conducted with 8th grade Turkish students, Aypay et al. (2007) examined high and low performing schools based on students' science achievements in TIMSS-99. They indicated that teacher-centered classroom practices such as copying notes from the board, demonstrations by teachers, explaining the rules and definitions, and discussing a practical or story problem related to everyday life were more observed in high performing classes related to science. Some of these strategies do not align with the current constructivist theory where hands-on experiences facilitate the social construction of knowledge (Vygotsky 1986). Conversely, there will be students who are motivated to learn through teacher-centered approaches. Teacher-centered classroom practices, enjoyment of science and SES were observed to be predictors of science achievement of 8th grade Turkish students based on TIMSS-99 data (Özdemir 2003). On the other hand, Sivan et al. (1991) revealed that students who received an education through active learning and student-centered instruction performed better in their learning, and developed communication, problem solving and critical thinking skills. Kalem and Fer (2003) also reported students' increased interest and learning as a function of active learning practices which requires students' high level of engagement in teaching–learning process. Hence, the aforementioned evidence indicates that there is tension between teacher-centered and student-centered approaches for ensuring student success, particularly in comparison with other schools, states and countries. Indeed, science experiences and methods of teaching can vary between schools and classrooms within states and systems.

Determining the effectiveness of science teaching may be evidenced though students' results. This could be demonstrated through tests and authentic assessments. However, science educators emphasise that learning science is for life, and so the effectiveness of teaching may be linked to the level of impact the science learning has had on the student. This could be noted in adults' career choices and how adults' reflect upon their science learning at school. Taylor et al. (1999) surveyed 80 women who taught science and categorised their most memorable science classes as follows: (1) activity-based instructional techniques, (2) teacher-student relationships, and (3) knowledge and appreciation of science content. This study aims to describe preservice teachers' positive and negative secondary science education experiences. It also aims to pinpoint teaching practices that have been memorable to preservice teachers, as a way of determining the impact of their science education experiences. Indeed, what are preservice teachers' memories of their secondary science teachers' practices?

Contexts

There were two European contexts for collecting data, that is, one from Turkey and one from Slovakia. Turkish data were gathered from three different universities (males = 44, females = 102). All participants were preservice teachers studying to become teachers of students aged between 12 and 15 years. This teaching degree involves 4 years of university education. Participants were either in their second, third or fourth year of the degree. These Turkish university students undertake many science units during their degree (e.g., biology, physics, chemistry, and Earth science), some

culture units (e.g., Turkish history, literature, English) and educational units (e.g., introduction to educational science, curriculum and instruction, educational measurement, educational technology, counseling and guidance). The degree also entails practical work such as teaching science, science laboratory application, special methods to science education, and observations of science teachers in the schools. The degree provides for significant time to experience teaching in schools (about 6 h each week).

The Slovakian context involved preservice teachers (males = 6, females = 94) studying in a Slovakian Faculty of Education. These participants were training as future biology teachers. Specifically, these participants study biology then complete another degree course (e.g., mathematics, or arts, or physics, or language). The double degree takes 5 years to complete and will qualify them to teach students aged between 10–18 years. The first 3 years entails a Bachelor of Science degree and the following 2 years involves learning how to teach biology; generally with units in the didactic of biology, practical training in schools and special science units (e.g., ornithology, entomology, ethnology, human biology). In their last year, these preservice teachers are focused on completing their assessments and involvement in professional school experiences.

All participants were adults and received a secondary education with one or more subjects in science. The purpose of this research was to analyse preservice teachers' memories (which also may be noted as reflections) of their secondary science lessons and teaching practices that appeared to have long-term effects. This research builds upon Australian studies conducted for primary science (Hudson 2007) and secondary science education (Hudson and Kidman 2008, $n = 167$).

Data Collection and Analysis

This study involved 246 preservice teachers (146 from Turkey & 100 from Slovakia) who reflected on their own secondary science learning experiences through a questionnaire and survey, which used a five point Likert type scale, that is, strongly disagree to strongly agree (SD, D, U [uncertain], A, SA). Written responses to questions around memories of secondary science teaching were collated into themes as they emerged. Survey data from the initial secondary science study (Hudson and Kidman 2008, $n = 167$) indicated that remembering science education may be the result of having an enthusiastic science teacher. Hence, one item on the survey (Item 3) was constructed as follows: I think I would remember science if my teacher was enthusiastic about teaching science. There were 28 survey items constructed as a result of data from both Australian studies (see Appendix 1). This survey was translated into Turkish and Slovak language for participants to complete and written responses were back translated into English by two of the researchers.

Descriptive statistics with percentages were used to analyse their secondary science experiences. The survey instrument had a Cronbach alpha score for internal consistency of .88, which was above the recommended baseline reading of .70 (Hittleman and Simon 2006). An analysis of variance (ANOVA) was conducted through SPSS, a statistical software package, to determine gender and age differences with the survey responses. ANOVA was also conducted to analyse the participants' positive or negative secondary science experiences with their response to each survey item. In this study, the 146 Turkish preservice teachers completed the 30-min survey during 30–40 min while the 100 Slovakian preservice teachers completed the survey during 30–35 min. These preservice teachers were asked to recall their secondary science education experiences, specifically recalling science teachers' practices, and use this memory to respond to the survey.

Results and Discussion

The preservice teacher group ($n = 246$) consisted of 20% males and 80% females. These participants were studying to become secondary science teachers. There were 28% who were younger than 22 years of age and 72% were between 22 and 29 years of age. These participants were studying science at high school with 13% in biology, 46% in physics, and 41% in chemistry. There were 69% who claimed their secondary science teaching was a positive experience with 24% as a negative experience and only 7% were undecided.

These preservice teachers described in the questionnaire what made them remember their secondary science learning experiences. Despite 30% of participants believing that their memory of science was largely due to examinations and quizzes, all other reasons were indicated by less than 10% of participants (Table 1). Surprisingly, the teacher's role and affective domain, teacher's content knowledge, hands-on experiences, and small class sizes were not considered as reasons in the written responses, even though these appear as reasons in other literature (e.g., Hudson 2007). This distinction may be the result of a country's educational differences for learning science. These participants also noted strategies that may help them to remember their secondary science education. Again, surprisingly, teacher's knowledge and interesting explanations along with examinations were noted as more favourable than practical hands-on activities (Table 1).

Other responses about teachers included explaining difficult concepts and demonstrations of science concepts

Table 1 Secondary science learning experiences ($n = 246$)

Reasons for memory of science	%*	Strategies that would assist to remember	%*
Examination, quizzes	30	Interesting explanations	25
Real-life examples	9	Knowledgeable	18
Tools	8	Exams only	13
Portfolio	7	Practical and testing	9
Excursion	5	Materials	8
Questioning	4	Educational tools	5
Repetition/rote learning	2	Excursions	2
Explaining clearly	2	Learning style	2
Presenting films/videos	1	Personal qualities	1

* NB: Some respondents recorded more than one response

through video. A teacher's sense of humour, modelling practice, and judging were also considered memorable by single participants. These preservice teachers ($n = 246$) recorded their memories of their science teachers' negative practices, that is, not considering students' interests (67%) and presenting science lessons without explanations (69%). Only 31% disagreed that copying lesson notes would be memorable and 33% disagreed that being told they were wrong would be memorable. The literature highlights teacher directed activities such as copying notes from the board would be unfavorable (Kisac 2000; Tekbiyik and Akdeniz 2008), yet this study showed that most participants considered copying notes as a favorable memory. There is controversy about constructivism, particularly with the notion that teacher-centered approaches can be effective where students do not have alternative conceptions or misconceptions. It is possible that the educational culture of learning science may dictate to some degree what would be memorable. In addition, previous academic work and personal motivations may also contribute to memorable experiences. Hence, secondary students from different countries may view and value their science experiences differently (see Hudson 2007, for a western comparison to this study).

ANOVA results revealed no statistical differences between any of the survey items and gender or age. However, ANOVA results were statistically significant for male responses about whether their secondary science experience was positive with 15 of the 28 survey items. Three items (1, 15, 16) were $p < .05$ while 12 items (3, 4, 5, 6, 9, 10, 18, 19, 20, 21, 23, 28) were highly significant ($p = .000$). These preservice teachers indicated on the survey effective secondary science teachers' practices as a reason for remembering their science learning. As there were considerable numbers unsure about the teaching practice, the "uncertain" results were also included in the tables. The majority of participants indicated that targeting students' misconceptions (70%) and providing opportunities for independent study (83%) were reasons for remembering their science teachers' practices. Targeting students' interests and having lessons relevant to the student's life are advocated as desirable teaching practices, however, less than 50% agreed that they would remember their science as a result of these practices (Table 2).

Sixty-eight percent of participants claimed that certain topics within science can be memorable. Yet, most of these participants disagreed that science involving animals or dissection would be memorable. For example, most preservice teachers opted for the study of plants (68%) but not animals (22%) with half the participants agreeing that studying life cycles would be memorable (Table 2). According to the ANOVA, responses about dissection, animals, and life cycles cannot be attributed to gender or country (i.e., Slovakia or Turkey) so a qualitative study is required to understand reasons for these responses. These may be due to cultural interactions with animals or the types of hands-on science activities that involve investigating animals, if done at all.

It is claimed that teachers can make a difference and that their teaching practices can facilitate the learning process.

Table 2 Targeting students' interests and topics ($n = 246$)

Teaching practices	SA + A* %	Uncertain %
Targeting students' interests		
Misconceptions	70	15
Students' interests	44	39
Relevant to student's life	37	28
Independent studies in science	83	6
Selection of topics		
Dissection	22	3
Animals	22	21
Topics	68	24
Plants	68	20
Circuitry	46	30
Life cycles	50	22

* *SA* strongly agree, *A* agree

Table 3 Teachers' affective domain and articulation of concepts ($n = 246$)

Teaching practice	SA + A %	Uncertain %
Teacher's affective domain		
Enthusiastic	87	6
Positive attitude towards science	87	9
Organised with equipment	77	11
Concepts from teachers		
Science concepts	54	15
Abstract science concepts	79	7
Purposes	50	29

Indeed, a teacher's affective domain was considered to be influential by the majority of these participants ($n = 246$), particularly a teacher's enthusiasm and positive attitude towards science (87%; Table 3). Only half the participant group thought that articulating the purpose of the lesson would be memorable. Nevertheless, 74% indicated making abstract science concepts easy to understand was memorable.

These participants appreciated assistance from the teacher but also wanted to get on with the science learning without being a dominating teacher. Hence, 81% agreed that the teacher needs to explain concepts without too many explanations and a further 83% wanted to experiment and discover the science for themselves, particularly in group work (70%; Table 4). However, they emphasized memorable teaching practices when the teacher provides practical and usable science (73%), science excursions (72%), and showing how to record scientific results (75%). Surprisingly, 99% indicated that they would remember the science teaching if the teacher corrected them when they were not correct with their scientific knowledge.

A teacher's enthusiastic nature and positive attitude towards science were regarded as highly memorable. In addition, explaining abstract concepts well, and guiding the students' conceptual development with practical, hands-on science activities that can also include excursions, may be considered as highly memorable secondary science teaching strategies. Implementing science lessons with one or more of these memorable science teaching practices may "make a difference" towards influencing students' positive long-term memories about science and their science education. Conversely, avoiding negative practices may also assist in averting strong negative long-term memories about science.

Table 4 Science teaching practices ($n = 246$)

Science teaching practice	SA + A %	Uncertain %
Without too many explanations	81	7
Practical and usable knowledge	73	18
Hands-on science	48	40
Group work	70	9
Experiment and discover concepts	83	14
Corrected me	99	.5
Science excursions	72	21
How to record science results	75	20

Conclusion

This study investigated 246 preservice teachers' responses about their memories of their secondary science learning experiences. Results in this study indicated secondary science teaching was remembered more favourably for middle-eastern adults when science teachers were enthusiastic, positive and well organised. They also claimed that targeting misconceptions, providing independent studies with practical applications, group work, and excursions would also be memorable. A teacher's strategy of explaining concepts well, showing students how to record science results and correcting students was noted as highly favourable. Data about memorable science education may lead towards identifying high-impact science lessons and how secondary science teachers can be more effective.

Teaching approaches can vary for different educational levels and contexts, yet memorable science teaching practices for Turkish and Slovakian preservice teachers were predominantly focused on the teacher's affective domain and hands-on activities. Memorable secondary science education factors in western studies (Hudson 2007; Hudson and Kidman 2008) were also mainly due to student-centered learning with a teacher's affective domain facilitating hands-on experiences. However, written responses in this study showed differences that may be due to the culture of learning within an education system. For example, Australian schools tend to focus heavily on hands-on activities while comments from middle-eastern schools mainly focused on teacher-centered approaches such as examinations and teacher's explanation or knowledge.

Despite usurping the dominant constructivist paradigm with middle-eastern students' remembering teacher-centered science education in their questionnaire, student-centered learning was favoured in their survey responses. Data highlighted memories of positive and negative teaching practices, which can be used to assist teachers in planning for high-impact science lessons as a potential way for making a lifelong difference. It is proposed that knowledge of positive high-impact teaching practices may assist preservice teachers and teachers. On the other hand, knowledge

of negative teaching strategies can be disseminated so that teachers can avoid such. Further research investigating adults' memories of their learning experiences across other key learning areas may lead to a general theory of high-impact teaching and learning. Teachers generally aim to make a difference; therefore targeting how to create long-term impacts in adults may assist them to achieve this aim.

Appendix: Remembering Your Secondary Science Education

Remembering Your Secondary Science Education

SECTION 1: To preserve your anonymity, write your mother's maiden name on this survey. Please ***circle*** or ***write*** the answers that apply to you.

Mother's maiden name:_____

a) What is your gender? Male Female
b) What is your age? <22 yrs 22 - 29 yrs 30 - 39 yrs >40 yrs
c) Please list science units you had completed in Years 11 and 12 at high school (e.g., biology, physics, chemistry, multi-strand) or write none.
d) What degree or diploma are you currently enrolled in?
e) Please list any other qualifications you may have?

1. As a secondary student, was secondary school science a positive experience? *(Circle)* Yes No
2. Why or why not?
3. Briefly, state one secondary science experience.
4. Why do you think you remember this experience?
5. Describe a secondary science experience you world prefer NOT to remember.

SECTION 2: Drawing on your memories about science teaching and learning while you were a student at secondary school, please indicate the degree to which you agree or disagree with each statement below by circling only one response to the right of each statement.

Key: SD = Strongly Disagree D = Disagree U = Uncertain A = Agree SA = Strongly Agree

I think I would remember science if my teacher:					
1. targeted my misconceptions about science.	SD	D	U	A	SA
2. organised science activities that involved dissection.	SD	D	U	A	SA
3. was enthusiastic about teaching science.	SD	D	U	A	SA
4. taught the lesson without too many explanations.	SD	D	U	A	SA
5. facilitated group work with my peers.	SD	D	U	A	SA
6. constructed science lessons that had practical and usable knowledge.	SD	D	U	A	SA
7. planned a lesson without worrying about my interests.	SD	D	U	A	SA
8. provided hands-on science experiences.	SD	D	U	A	SA
9. talked about the science concepts in fine detail.	SD	D	U	A	SA
10. explained abstract science concepts in simple terms.	SD	D	U	A	SA
11. presented opportunities for me to copy lesson notes from the board.	SD	D	U	A	SA
12. conducted lessons that included interactivity with animals.	SD	D	U	A	SA
13. articulated clearly the purposes for the science lesson.	SD	D	U	A	SA
14. let me do the science activity without explaining the reason.	SD	D	U	A	SA
15. considered my interests when devising a science activity.	SD	D	U	A	SA
16. had a positive attitude towards science.	SD	D	U	A	SA
17. let me experiment and discover concepts for myself.	SD	D	U	A	SA
18. corrected me when I was not correct.	SD	D	U	A	SA
19. provided a wide selection of science topics.	SD	D	U	A	SA
20. conducted lessons that included interactivity with plants.	SD	D	U	A	SA
21. organised lessons that required the use of science equipment.	SD	D	U	A	SA
22. made science relevant to my life.	SD	D	U	A	SA
23. took me on science excursions (e.g., museum, planetarium).	SD	D	U	A	SA
24. told me I was wrong when I was wrong.	SD	D	U	A	SA
25. presented opportunities for independent studies in science.	SD	D	U	A	SA
26. demonstrated circuitry.	SD	D	U	A	SA
27. taught me about life cycles.	SD	D	U	A	SA
28. showed me how to record science results in a scientific way.	SD	D	U	A	SA

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