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Social Interactions and Familial Relationships Preservice Science Teachers Describe During Interviews about Their Drawings of the Endocrine and Gastrointestinal Systems

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This study examined preservice science teachers' understandings of the structure and function of the human gastrointestinal and endocrine systems through drawings and interviews. Moreover, the preservice science teachers described where they thought they learned about the systems. The 142 preservice teachers were asked to draw the human gastrointestinal and endocrine systems and label the organs. Following the in class drawings, the preservice science teachers were interviewed by a classmate about the drawing, the function of the system, and where they believed they learned about the system. The study provided evidence that (1) preservice science teachers had more knowledge of the gastrointestinal system than the endocrine system; (2) the interviews yielded more information about the systems than did the drawings; (3) food was described as moving from the mouth to the anus, but absorption was not often mentioned; and (4) the prior social interactions that influenced the knowledge of the preservice science teachers were different for the gastrointestinal and endocrine systems.

Key Words: biology, drawings, organ systems, preservice science teachers, social constructivist theory

Introduction

Mike (To protect the identity of participants pseudonyms are used.): "Using your drawing explain the function of the endocrine system."
Katie: "Hmm... I didn't really draw anything. I'm not really sure exactly what it is."
Mike: "Can you tell me anything about the endocrine system?"
Katie: "I'm not sure. I think it has something to do with the thyroid."
Mike: "Where did you learn about the endocrine system?"

> Katie: "My Dad has thyroid cancer. I think it has something to do with that…I don't know what the endocrine system does. It might have something to do with…I don't know. I have no idea…I think maybe hormones or something like that. I don't know."

This is a dialog that occurred during a classmate interview between two preservice science teachers. Mike was interviewing Katie about her drawing of the endocrine system to determine her knowledge of its function. At first Katie assumed she did not know anything about the endocrine system because she could not draw the system. However, after her classmate asked her a question from the interview prompts, Katie remembered something about the endocrine system based on an interaction she had with her Dad. This interview, and others like it, led to my interest in how preservice science teachers interviewing each other might prompt them to further discuss their knowledge of the gastrointestinal and endocrine systems and to identify prior social contexts in which they learned about the systems.

Drawings have been used as a method of representing information because they motivate participants to learn more than conventional teaching (Hackling & Prain, 2005), contribute to the formulation of thinking and meaning (Brooks, 2005; Brooks 2009), and provide an individualized look at learner knowledge. Interest in the use of drawings in science learning has expanded because drawings reflect "new understandings of science as a multimodal discursive practice" (Ainsworth, Prain, & Tytler, 2011, p. 1097) and there has been "mounting evidence for its value in supporting quality learning" (p. 1097). However, previous studies have found that drawings of the human body do not provide a complete representation of the participant's knowledge (Khwaja & Saxton, 2001; Prokop, Fancovicová, & Tunnicliffe, 2009) and do not offer a glimpse of where they have learned about the systems. These conflicting notions indicate that further research is needed to better understand the role that drawings and interviews play in identifying our knowledge of the internal anatomy of the human body and the source of that knowledge. Additionally, drawings alone do not provide a context for where the preservice science teachers believe they learn about the systems. Therefore, in this study, drawings accompanied by interviews afforded a deeper look at the knowledge of the participants and the social interactions that shaped their knowledge. The drawings and interviews were analyzed to answer the following questions:

1. Which gastrointestinal and endocrine organs do preservice science teachers identify when they draw the systems?
2. What are preservice science teachers' understandings of the function of the gastrointestinal and endocrine systems?
3. Where do preservice science teachers believe they learn about the gastrointestinal and endocrine systems? Do the preservice science teachers describe social contexts?

Theoretical Framework

This study employed the social constructivist theory (Vygotsky, 1978) in order to interpret preservice science teachers' knowledge of the gastrointestinal and endocrine systems and how social interactions influenced their knowledge. The rationale for using the social constructivist theory came from the idea that science learning occurs through socially mediated experiences such as observations, conversations, and personal experiences that transpire throughout life (Bruner 1966; Lemke, 2001; Vosniadou 2001; Vygotsky 1978; Wood, Bruner, and Ross, 1976). Social experiences provide people with an opportunity to access prior knowledge about a subject and build on that knowledge to construct a new understanding (Bruning, Schraw, & Norby, 2011). The cognitive tools perspective of the social constructivist theory is one way in which a researcher may attain an understanding of a participant's prior knowledge. A cognitive tool allows participants to create a product, a drawing in this study, and impose meaning on the

product based on prior knowledge (Gredler, 1997). Therefore, the preservice science teachers' knowledge of the organ systems and the social sources of development that shaped their knowledge may be assessed through drawings and interviews. The interview was important to this study because the language used in the interview was assessed to reveal any knowledge the preservice science teachers did not provide in the drawings (Anderson, 2007; Gee, 1996; Lave & Wenger, 1991) and to define if there were social interactions that the preservice teachers identified as sources of knowledge (Rogoff, 1990).

Literature Review

Drawings have been touted as a way to determine the knowledge participants have of various topics in science education (Ainsworth et al., 2011; Brooks, 2005; Dempsey & Betz, 2001; Neumann & Hopf, 2012; Reiss et al., 2002; Yörek, 2007) and understandings of the natural world (Moseley, Desjean-Perrotta & Utley, 2010; Eloranta & Yli-Panula, 2005; Yli-Panula & Eloranta, 2011). Since the mid-1900s, drawings have been used to reveal what individuals know about the internal anatomy of the human body. In 1955, Tait and Ascher developed the Inside-of-the-Body Test to ascertain the knowledge 6th graders, psychiatric patients, military candidates, and hospitalized military personnel had of the internal anatomy of the human body. Since the 1950s, several studies asked participants to draw the inside of the body. In addition to drawing the inside of the human body, participants were asked to write about their drawings (Ormancı & Ören, 2011; Carvalho, Silva, Lima, Coquet, & Clement, 2004), draw and name organs on a picture (DeLuca, 1997), draw and/or write about the functions of the body systems (Mathai & Ramadas, 2009), draw and exchange drawings and complete a partner's drawing (Bahar, Ozel, Prokop, & Usak, 2008), draw and take an open-ended questionnaire (Prokop & Fancovicová, 2006), and draw and complete an interview (Carvalho et al., 2004; Rowlands, 2004). However, no studies were completed that asked participants to conduct classmate interviews about their drawings of the internal anatomy of the human body and describe where the participants believed they learned about the systems.

During the literature review, 10 studies were identified in which participants were asked to draw the internal anatomy of the human body. Table 1 identifies the 10 studies and the participants, methodologies, organs drawn least and most often, and organ systems drawn least and most successfully in each study. The results of the 10 studies were examined and used to (1) establish the two organ systems that would be analyzed and (2) conclude if classmate interviews were previously used as a data collection tool. Eight of the studies identified the gastrointestinal system as one of the most accurately drawn systems (Bartoszeck, Machado, & Amann-Gainotti, 2008, 2011; Reiss & Tunnicliffe, 2001; Patrick & Tunnicliffe, 2010; Reiss et al., 2002; Tait & Ascher, 1955) or reported that organs from the gastrointestinal system were correctly drawn most often (Óskarsdóttir, Stougaard, Fleischer, Jeronen, Lützen, & Kråkenes, 2011; Ozsevgec (2007). Seven of the studies stated that the endocrine system (Patrick & Tunnicliffe, 2010; Prokop & Fanèovièová, 2006; Reiss & Tunnicliffe, 2001; Reiss et al., 2002; Tait & Ascher, 1955) and its organs (Bartoszeck et al., 2008; Ozsevgec, 2007) were drawn the least often. From the ten studies the gastrointestinal and endocrine systems were found to be the most and least often successfully drawn systems, respectively.

The majority of the studies asked participants to draw the internal anatomy, but did not include additional data gathering tools. However, in addition to drawings, participants in three studies verbally named organs (Deluca, 1997; Ozsevgec, 2007), wrote about the drawings (Ozsevgec, 2007), and completed a questionnaire (Prokop & Fancovicová, 2006). Óskarsdóttir et al. (2011) utilized interviews as a data collection tool, but the interviewees were chosen based on whether or not their drawings were interesting, which indicated they did not interview all of the participants.

Table 1. Studies in which participants were asked to draw human internal anatomy including information about participants, methodology, and organs and systems drawn least and most successfully

Author(s)	Participants	Methodology	Organs drawn least often	Organ systems drawn least successfully	Organs drawn most often	Organ systems drawn most successfully
Tait & Ascher (1955)	107 psychiatric patients, 105 civilian/military candidates, 55 military men hospitalized on medical and surgical wards, 22 New York City sixth-graders	Drawings	Esophagus Pancreas Appendix	Reproductive Muscular Endocrine	Heart Lung Stomach	Cardiovascular Gastrointestinal Respiratory
DeLuca (1997)	50 participants in Italy (ages 5-7)	Drawings Naming organs	Not provided	Not provided	Bones Heart Lungs	Not provided
Reiss & Tunnicliffe (2001)	158 participants in England (4-20 years old)	Drawings	Not provided	Circulatory Endocrine Muscular	Heart	Gastrointestinal Respiratory Urogenital
Reiss et al. (2002)	40 (7 & 15 year olds) partici-pants in Australia, Brazil, Denmark, Ghana, Iceland, Northern Ireland, Portugal, Russia, Taiwan, Uganda, Venezuela	Drawings	Not provided	Muscular Endocrine Cardiovas-cular	Heart	Gastrointestinal Respiratory Skeletal
Prokop & Fancovicová (2006)	133 first year university participants in Turkey	Drawings Questionnaire	Not provided	Gastrointesti-nal Respiratory Endocrine	Heart Lungs Stomach	Nervous **Reproductive **Urinary Circulatory
Ozsevgec (2007)	55 participants (12 years old), 57 participants (14 years old) in Turkey	Drawings Writing Naming	Appendix Pancreas Bladder	Not provided	Heart Lungs Stomach	Not provided
Bartoszeck, Machado, & Amann-Gainotti (2008)	143 participants in Brazil (10-18 years old)	Drawings	Muscles Spleen Gallblad-der	Not provided	Heart Trachea Intesti-nes	Gastrointestinal Respiratory

Table 1. *Contiuned*

Author(s)	Participants	Methodology	Organs drawn least often	Organ systems drawn least successfully	Organs drawn most often	Organ systems drawn most successfully
Patrick & Tunnicliffe (2010)	71 classroom teachers	Drawings	Spleen Vagina Uterus	*Nervous *Skeletal Muscular Endocrine	Lungs Intestine Heart	Gastrointestinal Respiratory Urogenital
Bartoszeck, Machado, & Amann-Gainotti (2011)	396 participants in Brazil (5-11 years old), 237 participants in Brazil (12-14 years old)	Drawings	Genitals	Urogenital	Heart Brain	Gastrointestinal Respiratory
Óskarsdóttir, Stougaard, Fleischer, Jeronen, Lützen, & Kråkenes (2011)	20 participants in Denmark, Faroe Island, Greenland, Iceland and Norway (age 6) and 19 Finnish participants (ages 7-8)	Drawings Interviews	Not provided	Not provided	Brain Heart Stomach	Not provided

*Nervous and Skeletal had the same score. **Reproductive & Urinary were coded separately.

The benefit of employing interviews in conjunction with drawings was of interest, because the literature review suggested that when multiple data gathering tools were utilized a richer understanding of participant knowledge was established (Mathai & Ramadas, 2009; Rowlands, 2004; Texeira, 2000). On average, the information articulated during the interviews better expressed the structure and function concepts of the organs and systems than did the drawings alone.

In addition to the importance of including interviews with the drawings, studies revealed that asking participants to "Draw what you believe is inside your body." was not sufficient in determining if participants had a well-defined representation of participant knowledge. For example, Khwaja and Saxton (2001) and Prokop, et al. (2009) found that if participants were asked a more specific question concerning their drawings their ability to draw was higher. When Khwaja and Saxton (2001) analyzed skeletal system drawings obtained after general instruction (Draw what you think is inside your body.) and specific instruction (Draw the bones in your body.), they found that the level at which participants scored was higher in drawings in which participants received specific instructions. Prokop et al.'s (2009) study verified these findings by asking participants to "Draw what you think is inside your body." and "Draw the endocrine (or urinary) system that you think is inside your body." The results revealed that when participants were given specific instructions to draw a system, the participants scored significantly higher than they did when drawing a system as a part of the internal anatomy. While these studies demonstrated that the knowledge of participants may be obtained through drawings and interviews, research is needed to further explore the intricate web of knowledge of the systems in the human body and how that knowledge may be shaped by cultural experiences. Based on the social constructivist theory the role of the researcher is to establish the source of the information in order to better appreciate the knowledge of the participant. Therefore, in addition to being

asked to draw the gastrointestinal and endocrine systems preservice science teachers were asked to explain their knowledge of the system functions to a classmate and identify where they supposed they gained the knowledge.

Study Design and Methodology

Study Group (Participants)

This study took place during six science methods courses from fall 2007 to spring 2011 at two small suburban universities located in the southeastern United States of America. The science methods classes were made up of 142 preservice science teachers that would be teaching secondary science (students ages 14-18) and middle level science (students ages 11-14). The preservice science teachers were seniors (ages 20-28) in their fourth year of college and their second year in the undergraduate teacher education program and had completed an introductory biology course. The science methods course met for a three hour block once a week during the fall or spring semester. A total of 148 preservice science teachers participated, but six drawings and interviews were removed from the study due to interviews not being completed correctly, which left 142 preservice science teacher participants. Due to concerns about asking participants to identify their gender and race, participants were told they could provide this data but it was not necessary. Sixty-one percent of the participants chose not to identify their gender or race; therefore, gender and race were not reported in this study.

Data Collection

Drawings. During each of the science methods courses, two weeks were spent discussing and practicing various types of formative assessment. Drawings and classmate interviews were discussed as an assessment technique during the second formative assessment class. In order to provide the preservice science teachers with an opportunity to practice using drawings in their classroom, they were asked to draw the gastrointestinal system and the endocrine system. The preservice teachers were given an 8.5" x 11" sheet of white paper with an outline of the human body (Wikipedia, 2007) and were asked to "Draw the digestive system that is inside your body and label as many organs as possible." (Prokop et al., 2009). When the preservice science teachers were finished drawing the gastrointestinal system they completed an interview with a classmate. After the interview, preservice science teachers were given another sheet of white paper with an outline of the human body and asked to "Draw the endocrine system that is inside your body and label as many organs as possible." (Prokop et al., 2009). The preservice science teachers were given as much time as they desired to draw the systems. However, all of the preservice science teachers were finished with each drawing after 15 minutes.

Interviews. After the preservice science teachers completed a drawing, they were assigned a classmate, who interviewed them about the drawing. Classmate interviews were chosen because (1) interviews could be completed immediately after the drawing, (2) describing a drawing to a classmate might not be as intimidating as a teacher (King, 1989), (3) drawings allowed the candidates to practice questioning skills (King, 1994), and (4) the candidates modeled participant/participant interactions that could be used in the classroom (Webb, Nemer, & Ing, 2006).

A priori to the classmate interviews a protocol was established to insure that the classmate partners were asking the same questions. The interview protocols were straightforward and contained three questions. The Gastrointestinal System Protocol asked students to identify the digestive system instead of the gastrointestinal system, because digestive system is a more common term. Gastrointestinal System Protocol (After each part of the protocol, give them time to think and respond. Do not interrupt them as they speak.): (1) Use your drawing to explain what happens when you eat a cookie. When the participant stops talking, ask them the following

questions: (2) Can you tell me anything else about the digestive system? (3) Where did you learn about the digestive system? Tell me about your experiences with the digestive system. Endocrine System Protocol (After each part of the protocol, give them time to think and respond. Do not interrupt them as they speak.): (1) Use your drawing to explain the function of the endocrine system. When the participant stops talking, ask them the following questions: (2) Can you tell me anything else about the endocrine system? (3) Where did you learn about the endocrine system? Tell me about your experiences with the endocrine system.

Procedure. The preservice science teachers were given an 8.5" x 11" piece of paper and asked to draw the gastrointestinal system. When they finished with the drawings, the preservice science teachers were assigned a classmate partner and told that one person would be an interviewer and the other person would be the interviewee and asked about their drawing. The interviewer was given the Gastrointestinal System Protocol and told to use the protocol to question the interviewee about their drawing. The classmate partners completed one interview about the gastrointestinal system. Because the second interview would be influenced by the first interview, one person in the group was not interviewed. After the interview was completed, the interviewee was asked to return to their seat and the same process was employed for the drawings and interviews about the endocrine system. However, the interviewer from the Gastrointestinal System Protocol became the interviewee in the Endocrine System Protocol. The interviews were digitally recorded and lasted from 5 minutes to 15 minutes with a Mean of 12 minutes. The interviews were transcribed by the author into a Word document and stored for data analysis. The resulting data were 142 drawings each of the gastrointestinal and endocrine systems and 77 gastrointestinal system interviews and 65 endocrine system interviews.

Data Analysis

First, the drawings were analyzed to determine the organs that were drawn. Second, the six point scoring system developed by Prokop et al., (2009), shown in Table 2, was used to analyze the level at which participants drew the gastrointestinal and endocrine systems. Prokop et al.'s (2009) original endocrine system scale was adjusted at Level 6 to include additional organs and became a template to design a gastrointestinal system six point scale (Table 2). In order to determine the internal consistency of the reliability of the scoring system, a Cronbach's alpha was completed using SPSS and the system was found to be $\alpha = .77$, which indicated good reliability. To illustrate the analysis, Figure 1 presents an example of a participants' gastrointestinal system and endocrine system drawings. The gastrointestinal system was scored at Level 5, which denoted at least four organs in the correct position and labeled correctly. The endocrine system was scored at Level 3, because the participant drew and labeled one organ in the correct position. The author and a science education graduate student, who had a Masters of Science in Biology, independently analyzed the drawings using the gastrointestinal and endocrine six point scales. A Kappa statistic was computed to determine inter-rater reliability and the result was Kappa = 0.651 with an inter-rater agreement of 0.913. The drawings on which the Levels were in disagreement were compared and finalized through discussions.

The interviews were transcribed and the preservice science teachers' answers were analyzed using a Gastrointestinal and Endocrine System Knowledge Evaluation Instrument (DESKEI) (Table 4). The DESKEI was developed *a priori* and used to evaluate the preservice science teachers' explanations of the function(s) of the gastrointestinal and endocrine systems.

Table 2. Six point scale for scoring gastrointestinal and endocrine systems. The six point scale is based on Prokop et al. (2009)

Level	Description
Level 1	No representation of gastrointestinal (endocrine) organs
Level 2	One or more gastrointestinal (endocrine) organs placed at random
Level 3	One gastrointestinal (endocrine) organ in appropriate position and labeled
Level 4	Two or three gastrointestinal (endocrine) organs in appropriate position and labeled
Level 5	Four or five gastrointestinal (endocrine) organs in appropriate positions and labeled
Level 6	Gastrointestinal System: Six or more gastrointestinal organs (i.e. mouth, pharynx, esophagus, stomach, small intestine, duodenum, jejunum, ileum, pancreas, gallbladder, liver, large intestine (colon), rectum, anus) in appropriate positions and labeled with extensive relationships indicated between them [Endocrine System: All endocrine organs (i.e. hypothalamus, pineal body, thyroid gland, parathyroid, thymus, pancreas, adrenals, genital glands, pituitary) in appropriate positions and labeled with extensive relationships indicated between them]

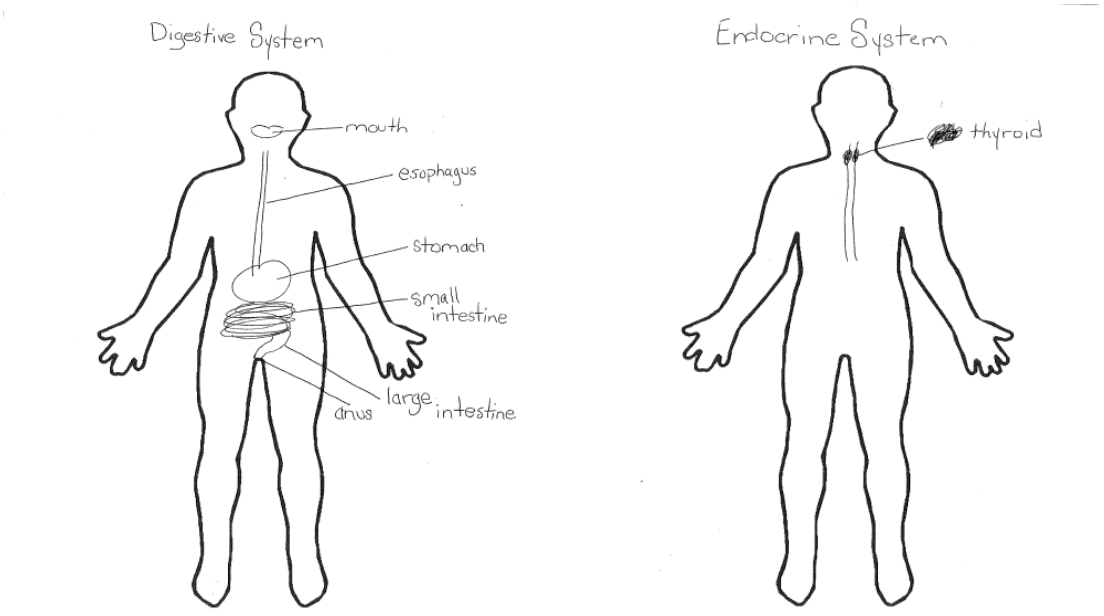

Figure 1. The drawings of the gastrointestinal system (Level 5) and endocrine system (Level 3) made by a preservice science teacher. The developed six point scoring system is based on the similar system of Prokop et al. (2009)

The DESKEI was modified from a coding system developed by Cakici (2005). Cakici's system placed participants' answers to the question of how digestion occurs into four categories: Scientific, Partially Scientific, Non-Scientific, and Descriptive. For this study, the gastrointestinal categories were adjusted to Function: Process, Function: Descriptive, Function: Other

Information, and Function: No Answer/Did Not Know. The Function: Other Information category for the endocrine system did not include specific information because the DESKEI was developed *a priori*. The author and the graduate student agreed to record any correct information in this category that did not fit into the other categories. The author and the graduate student separately and independently read the interviews and coded them using the DESKEI. A Kappa statistic was computed to determine inter-rater reliability and the result was Kappa = 0.628 with and inter-rater agreement of 0.814. The interviews in which disagreement occurred were compared and finalized through discussions.

Table 3. The Gastrointestinal and Endocrine System Knowledge Evaluation Instrument (DESKEI) and the number and percentage of preservice science teachers who used the terminology in the classmate interviews. The DESKEI is based on Cakici (2005). N=142

Gastrointestinal System N=77	N (%)	Endocrine System N= 65	N(%)
Function: Process		Function: Process	
(a) digestion begins in mouth	35 (46%)	(a) is a collection of glands	5 (8%)
(b) food moves through pharynx and/or esophagus (or tube)	45 (58%)	(b) secretes hormones	34 (53%)
(c) food is broken down in stomach (digestion)	73 (95%)	(c) regulates metabolism	8 (10%)
(d) absorption occurs in small intestine	28 (37%)	(d) regulates growth	19 (29%)
(e) liver and pancreas aid in digestion	5 (7%)	(e) regulates development	4 (6%)
(f) large intestine packages waste	16 (21%)	(f) regulates tissue functions	2 (1%)
(g) nutrients (digested food) are absorbed into the blood	12 (16%)	(g) regulates puberty/sexual maturity	31 (48%)
(h) egestion of remains through rectum	6 (8%)	(h) hormones are transported throughout the body by the blood stream	6 (9%)
(i) egestion of remains through anus	74 (96%)	(i) hormones regulate homeostasis (internal equilibrium)	1 (2%)
		(j) regulates menstrual cycles	32 (49%)
Function: Descriptive		Function—Descriptive	
food moves from the mouth to pharynx, esophagus, stomach intestines, and anus with no explanation of how digestions occurs	2 (3%)	hormones or chemicals move around the body (but no mode of transport)	19 (29%)
Function: Other Information		Function: Other Information	0 (0%)
(a) Participant used the word food throughout (does not mention nutrients or waste)	14 (18%)		
(b) Participant used the word melt to describe digestion	10 (13%)		
Function: No Answer/Did Not Know	0 (0%)	Function: No Answer/Did Not Know	16 (25%)

Results

Preservice Science Teachers' Knowledge of the Organs

Gastrointestinal. Table 4 presents the organs that were drawn. In the gastrointestinal system drawings, the small intestine (93%) was drawn most successfully followed by the stomach (91%) and esophagus (86%). Similar to the drawing of the gastrointestinal system in Figure 1, many preservice science teachers represented the gastrointestinal system as a tube that began at the neck (esophagus) and emptied into the stomach. After the stomach was a swirl of lines or tubes that were labeled the intestine or small intestine and shown exiting through the anus (69%). Of the preservice science teachers who drew the mouth (32%), 61% of them did not draw the pharynx or a connection between the mouth and the esophagus. The drawing of the gastrointestinal system in Figure 1 was scored at Level 5 and represents a common illustration among the drawings of the candidates. Table 5 illustrates the Levels at which the preservice science teachers scored on the drawings. The Mean Level was 4.35 (SD=0.53). The majority of preservice science teachers (68%) scored at Level 5 which means they correctly drew and labeled four or five organs in the appropriate location. However, 30% of them drew three or less organs successfully. Even though the Mean score was 4.35 and the majority of participants scored at Level 5 or above, few preservice science teachers drew the pancreas (12%), gallbladder (8%), liver (8%), and rectum (7%) and only three participants labeled the three segments of the small intestine (duodenum, jejunum, ileum).

Table 4. The number of candidates correctly drawing each organ in the gastrointestinal and endocrine systems. N=142

Gastrointestinal System	N (%)	Endocrine System	N (%)
Small intestine	132 (93%)	Ovaries	17 (11%)
Stomach	129 (91%)	Thyroid	12 (8%)
Esophagus	122 (86%)	Pituitary	11 (8%)
Anus	98 (69%)	Testes	9 (6%)
Large intestine (colon)	65 (46%)	Pancreas	6 (4%)
Mouth	45 (32%)	Parathyroid	3 (2%)
Pharynx	23 (16%)	Adrenal	2 (1%)
Pancreas	17 (12%)	Hypothalamus	2 (1%)
Gallbladder	11 (8%)	Pineal body	2 (1%)
Liver	11 (8%)	Thymus	2 (1%)
Rectum	10 (7%)		
Duodenum	3 (2%)		
Jejunum	3 (2%)		
Ileum	3 (2%)		

Endocrine. Because the preservice science teachers were not as familiar with the endocrine system, their drawings of the endocrine system were not as rich as their drawings of the gastrointestinal system. Table 4 illustrates that the most frequently drawn and labeled organs were the ovary (11%) followed by the thyroid (8%), pituitary (8%), and testes (8%). Two (1%) preservice science teachers drew and labeled the hypothalamus, pineal body, and thymus. When the endocrine system drawings were analyzed using the six point scale, the Mean score was 1.77 (SD=.90), which means most of the preservice science teachers scored at Level I (71%) (Table 5). Scoring at Level I meant they did not draw or label a single organ in the endocrine system. No participants scored at Level 6 or drew and labeled six or more organs.

Table 5. Number of participants who scored at each Level for the gastrointestinal and endocrine systems. N=142

Level	Gastrointestinal System N (%)	Endocrine System N (%)
Level 1	7 (5%)	101 (71%)
Level 2	11 (8%)	0 (0%)
Level 3	10 (7%)	22 (16%)
Level 4	14 (10%)	10 (7%)
Level 5	97 (68%)	9 (6%)
Level 6	3 (2%)	0 (0%)
Total	**142 (100%)**	**142 (100%)**

Preservice Science Teachers' Knowledge of the Function of the Systems

Gastrointestinal. Participants' views about the function of the organs of the gastrointestinal system and the number of participants giving each response are presented in Table 3. Overall, the preservice science teachers were aware of the function of the gastrointestinal system and were able to use scientific terms to articulate that food breaks down in the stomach (95%) and egestion occurs through the anus (96%). However, half as many preservice science teachers described digestion as beginning in the mouth (46%) and moving through a tube, pharynx and/or esophagus, to the stomach (58%). The preservice science teachers were more familiar with describing the processes that occur in the upper part of the gastrointestinal system. The small intestine (37%) was identified as a place for absorption to occur, while 21% recognized that the large intestine or colon packages waste and 8% mentioned egestion through the rectum.

In explanation of what happened to the cookie, one preservice science teacher (Meghan) provided a superficial answer that did not explain what followed after digestion occurred in the stomach:

> The cookie is chewed up in the mouth and moves through the esophagus into the stomach. Digestion begins in the stomach where the food is broken down by enzymes. Then the food moves into the intestine. In the intestine all the stuff the body needs is taken out. Then all the stuff that is left over leaves the body through the anus.

She used the term intestine instead of explaining that absorption occurs in the small intestine, water is absorbed in the large intestine, bacteria ferment waste in the large intestine, and feces is packaged in the large intestine. Similar to the majority of preservice science teachers (92%) she did not mention the rectum in her explanation.

In the following explanation, Mack described in more detail what happened when the cookie entered the mouth, but described the cookie as "smushy food" as it moved through the gastrointestinal tract.

> OK…so when I put the cookie in my mouth I start to chew the cookie with my teeth and this makes the cookie fall apart. Then these juices are released…mmm…I think from my mouth. The cookie breaks down some more and these juices make the cookie smushy…you know like liquidy…so the food can go down my throat. Then this squishy, smushy food goes down to my stomach and then it becomes more liquidy and then digestion finishes breaking down this mushy food. The mushy leftover stuff then

> goes into my intestine and moves through there and moves around and then all the stuff that is left over from that goes out.

Mack described the breaking down of the food as beginning in the mouth, but called the enzymes "juices". He used the same terms, "smushy" and "liquidy", to stand for both food and waste. Like Meghan, Mack did not clearly state that waste left the body. However, unlike Meghan he did not mention the word "esophagus, but he was aware that the food moved from the mouth to the stomach through the "throat".

Three percent of the preservice science teachers did not describe any accurate concepts for the physiological functions of the gastrointestinal functions. Bobby stated that "I don't know…like…the cookie goes in the mouth and is chewed up and then moves to the stomach. The food leaves the stomach and goes into the intestine and leaves through the anus." Bobby's reply was not coded in the Function: Process instead it was coded as Function: Descriptive. His answer did not describe a process for the gastrointestinal system as defined on the DESKEI. He did recognize that the food goes into the mouth, but he did not state that digestion begins in the mouth, food is broken down, nutrients are absorbed or that waste leaves through the anus. In his description "food" leaves the anus.

Endocrine. The endocrine system interviews were richer than the drawings and provided additional information. Even though 71% of the drawings did not provoke the preservice teachers to draw or label an organ in the endocrine system, when asked to describe the function of the endocrine system 75% knew some correct information. The preservice science teachers were aware that the endocrine system secretes hormones (53%), regulates puberty/sexual maturity (48%), regulates the menstrual cycle (49%), and regulates growth (29%). Preservice science teachers, who stated that hormones move around the body (29%), did not elaborate on how the hormones were transported. A typical comment was "I think it has something to do with hormones that move around the body." or "It sends information from the ovary to the body so you know when to have a period." This indicated that there was some awareness of the endocrine system, but participants may not have understood the intricacy of how to draw the system.

Sources of Knowledge and Experiences

When the preservice science teachers were asked to talk about where they had learned about the gastrointestinal and endocrine systems their replies were not the same. The percentages do not add up to 100% because a participant may have named more than one source of information. School, mentioned by 79% of the participants, was the place identified most often by preservice science teachers as a source of information about the gastrointestinal system. Tammy stated that she learned about the gastrointestinal system at "School." and described a memory from her biology class. "I remember my biology teacher in high school was talking about how to make farts. You know what I mean. How our body makes gas. It was really funny." Lillian designated the pictures in her high school biology book as important. "Well, our biology book had really cool pictures of the inside of the body." Tommy expressed that the

> teacher taught about all the systems, but I remember the digestive system the best…I think…I think it was because I knew about it already when she taught it. I don't know it just seems like the easiest one to remember. Like…you know we all eat and stuff and we all fart and we all go to the bathroom. When we did the cat dissection in class it was like…the easiest system to identify. It just seems like I just know about it…I don't know why…It's just around all the time. People talk about stomach aches and you see commercials about it all the time. Hmmm…ahhhh…Oh yeah…Everybody has a stomach problem. You know like that commercial shows with the digestive system with the pill going down.

Participants also named media sources (69%) such as television (not specific), commercials, documentaries, and medical programs. Commercials were cited by 41% of the preservice science teachers as a source of information about the gastrointestinal system. Windi described her origin of knowledge about the gastrointestinal system in the following way: "There is a commercial about [brand name removed] that shows how a pill goes from the mouth to the stomach." This particular commercial was described by 25% of the participants. In addition to commercials, participants named specific television shows such as "House", "Bones", and "Grey's Anatomy", which are medical dramas, and reality medical shows such as "Dr. Oz" and "The Doctors". Isabel stated "I saw this show one time on Dr. Oz about how you need the bacteria in your stomach. He gave a remedy for indigestion. My Dad has indigestion so he was all excited about that."

Other sources of information or experiences related to the health issues of family/friends/others (37%) and personal health (12%). Books (17%) were also provided as an answer and 15% stated they did not know or they did not have any experiences. The stories that the preservice science teachers told about health issues included people that were not a part of their family. For example, Betsy stated

> Well my Mom's friend has Crohn's disease. I think it's got something to do with her intestine. She was always sick…going to the bathroom all the time. We always had to make sure there was a bathroom close by when we traveled. Then she found out what she had and they gave her some kind of medicine and it got better. She still gets sick sometimes but not so bad now.

Betty had a similar story about someone with whom she worked.

> I worked with this woman who had cancer in her throat. Maybe in her esophagus…mmmm…I can't remember. She got to where she couldn't swallow food well and then she started getting sick when she ate. She went to the doctor and they said she had cancer.

The excerpts presented above represent the types of answers participants provided about their sources of knowledge and experiences with the gastrointestinal system. The findings were much different for the endocrine system.

The preservice science teachers stated that they learned about the endocrine system most often from family (45%) and personal (15%) health issues. Moreover, they did not mention the internet, television or books. John stated that he knew about the parathyroid because "My Dad had something wrong with his parathyroid. It wasn't cancer…I don't think…but I can't remember. So I know a lot about that. They took it out. I think it has something to do with calcium." Students also identified their Mom, sibling's, or other family member's medical conditions such as "ovarian cancer", "testicular cancer", and "pancreatic cancer". In addition to the health concerns of family, preservice science teachers recognized personal health issues. When asked about her knowledge of the endocrine system, Sara said "I know about ovaries producing hormones that regulate female stuff because I have problems."

School was mentioned by 7% of the participants, while 59% of the preservice science teachers did not provide any source of information. When Jennifer responded to the prompt asking her to discuss where she learned about the gastrointestinal system and her experiences, her answer was not well defined.

> Aaaaa…hmm…well…I'm not sure. I wish I had had the digestive system. I know a lot about that. Why did I get this one? This sucks. I got the hard one and you got the easy one. Everybody knows about the digestive system. I didn't draw anything on

> the picture, because I don't know anything. I don't really know anything about it. I'm sure I've heard of it, but I don't really know anything about it. I couldn't draw anything because I didn't know anything. This is not fair. Ask me about the digestive system.

The answer Jennifer provided was in stark contrast to the description provided by Tommy above when he was asked about his knowledge about and experiences with the gastrointestinal system.

Discussion

The social constructivist theory posits a relationship between knowledge, personal experiences and social interactions. In this study, I was interested in discerning the knowledge that preservice science teachers have of the gastrointestinal and endocrine systems, but I was mostly interested in the places and social experiences that preservice science teachers deemed as important to their knowledge of the systems. An analysis of the collected data permitted me to answer the three main research questions and define the following conclusions about the preservice science teachers in the study: (1) They drew the gastrointestinal system more successfully than the endocrine system. (2) They were better able to explain the function(s) of the gastrointestinal system, but still had some gaps in their knowledge. (3) The social interactions that the preservice science teachers identified for the endocrine system were based on societal norms, but the social interactions they identified for the gastrointestinal system were more personal and related to family and self. The first two conclusions were expected based on the previous studies provided in Table 1, but the idea that the social interactions that the preservice science teachers had could be distinguished between the gastrointestinal and endocrine systems was of great interest. Therefore, the discussion focuses on exposing the rationales for the differences.

According to Merriam (1998) knowledge is created by individuals interacting with the social world and experiences are 'lived' and 'felt' through contextual and concrete experiences. The results of this study support the supposition of Merriam (1998) that, "reality is constructed by individuals interacting with their social worlds" (p. 25). The social interactions that the preservice science teachers describe for the gastrointestinal system are based on widespread cultural and societal interactions; whereas, the sources of knowledge for the endocrine system are constructed from familial interactions. This implies that knowledge of the two systems is explored in unique social communities (Yore, Hand, & Florence, 2004). The social community in which the gastrointestinal system is discovered is a matter of public record. People feel comfortable discussing the gastrointestinal system as it is considered an accepted cultural phenomenon and part of society. Discussions about the gastrointestinal system seem to be communal or collective experiences that produce similar images. The group social experiences, such as school, commercials, and medical television, are mass experiences that preservice science teachers have within their culture and produce a shared understanding of the gastrointestinal system. The social community that discusses the endocrine system is tribal and the social interactions are private and personal. The group social experiences that the preservice science teachers identify are not mass experiences, but instead appear to be tied to emotional encounters that occur within personal relationships.

Implications

An implication of this research is that the interactions and experiences students have in and out of school are important in their development of knowledge about the human body systems. However, the types of interactions and experiences that influence their knowledge are different for each system. The findings have implications for teachers, school systems, curriculum developers and teacher preparation programs. Each group should be aware of their impact in promoting students' knowledge of the systems and, based on the data from this study, should

consider ways of teaching that promote social exchanges. For example, presenting students with a scenario to analyze, as a group, is an option when teaching the systems of the human body. By asking students to apply their knowledge of the systems to a real-life situation, they synthesize a variety of perspectives that will allow them to socially navigate possible solutions. Social interactions will offer students an opportunity to apply their knowledge and identify their lack of knowledge. Offering a medical scenario as the focus of a group discussion or project can promote critical thinking among the members and allow the members of the group to work as a team to achieve a goal. Structured interactions with classmates, content, and instructors that are based on discussions and scenarios provide participants with opportunities for social interactions. However, these interactions may be less structured by offering participants an opportunity to discuss medical scenarios that they choose and peak their interest. These unstructured topics may open the students up to discussions and social interactions in which they feel comfortable sharing information (Solomon, 1987). Participants need to connect socially with each other to stimulate their thoughts about previous social situations which may lead to cognitive stimulation.

I postulate that a framework of social interactions that include a broad context (media, friends, everyday acquaintances, school, etc) and familial relationships contribute to the construction of knowledge of the human body systems in various ways and should be considered in the classroom. Therefore, I recommend that science content courses for preservice teachers be framed to use social interactions that teachers may model with students.

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