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Investigating Preservice Elementary Teachers' Self-Efficacy Relative to Self-Image as a Science Teacher

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Abstract

This paper is part of the examination of a pilot investigation into the possible relationship between preservice teachers' self-efficacy and perceptions of self as a science teacher. Self-efficacy was measured using the Science Teaching Efficacy Belief Instrument, Form B (STEBI-B) developed by Riggs and Enochs (1990). Perceptions of self as a science teacher were measured using the revised DASTT-C. In this instance, pretest and posttest data generated by both instruments for a single elementary science methods class were utilized and compared. In addition, preservice teachers wrote brief narrative descriptions of their drawings. These data were compared in an attempt to determine if any relationship appears to exist between DASTT-C and STEBI scores.

Introduction

One concern of science educators is the attitude of preservice science teachers toward science teaching. Consequently, the goal of developing positive attitudes in preservice teachers emerges frequently in science education courses and programs. Negative attitudes and low comfort levels toward science and/or science teaching, particularly at the elementary school level, tend to lead to the sporadic teaching of science, the teaching of science during inadequate blocks of time, or the omission of science instruction from the school day (Finson & Beaver, 1994; Koballa & Crawley, 1985; Riggs & Enochs, 1990; Wilson & Scharmann, 1994).

At least some aspects of attitude appear to be related to self-efficacy. In science teaching contexts, self-efficacy is an individual's belief that one has the ability to effectively perform science teaching behaviors (called personal science teaching efficacy) as well as one's belief that his or her students can learn science given factors external to the teacher (called science teaching outcome expectancy) such as gender, ethnicity, and so on (Ramey-Gassert, Shroyer, & Staver, 1996). When teachers have a low self-efficacy, their teaching tends to be characterized by authoritative, teacher-centered roles with a less clear understanding of the various developmental levels of their students. Rubeck and Enochs (1991) reported that teachers who were weak in content background tended to have significantly lower personal efficacy than did teachers with strong content backgrounds. In contrast, teachers with a high self-efficacy tend to teach in ways characterized by the use of inquiry approaches, more student-centered thought, beliefs that they can help any student overcome learning problems and succeed, and are more knowledgeable of their students' developmental levels. One logical conclusion is that the way preservice teachers view themselves and their roles in a science teaching context is at least partially derived from their self-efficacy (Riggs & Enochs, 1990).

The attitudes students possess with respect to science may also be related to the ways they perceive themselves in the role of being a scientist. Yager and Yager (1985), for example, found that if the work in which scientists engage is viewed as being unpleasant, then one's perception of a scientist (or the prospect of becoming a scientist) becomes more negative. Investigations into the perceptions of scientists have occurred for decades, with a notable early study being Mead and Metraux's work in 1957. Their work led later researchers to examine elements of students' perceptions which could be classified as stereotypical (Chambers, 1983; Schibeci & Sorensen, 1993; Ward, 1977). The elements of one's perceptions about scientists can be revealed through drawings one makes of a scientist. These stereotypical elements were refined by Chambers (1983) in his Draw-A-Scientist Test and later organized into a quantifiable checklist (the DAST-C) format by Finson, Beaver, and Cramond (1995).

Building on this concept of the ways self-perceptions can evidence themselves in drawings, Thomas and Pedersen (1998) reasoned that preservice teachers' drawings might also reveal their perceptions about themselves as science teachers. In their work, Thomas and Pedersen began with the DAST-C and revised it to include elements they judged to be characteristic of science classrooms and science teachers, calling the instrument the Draw-A-Science-Teacher Teaching Checklist (DASTT-C). Through a collaborative effort with over a dozen science educators, the DASTT-C was further revised and refined over the duration of nearly two years.

In 1999, Finson, Riggs, and Jesunathadas (1999) reported on a preliminary effort to compare preservice teachers' DASTT-C scores with those from the STEBI-B. For purposes of their study, these researchers identified four variables from the DASTT-C to compare with STEBI scores: (1) teacher demonstrating/handling/manipulating objects, (2) students conducting hands-on activity, (3) environment inside, and (4) environment including symbols of science. Procedurally, only pretest data from three different elementary science methods sections were compared. Results indicated preservice teachers with high self-efficacies were more inclined to include drawings showing outdoor environments used for teaching, students engaged in group work doing hands-on activities, and captions which added description and detail to the drawing. In contrast, low self-efficacy preservice teachers' drawings tended to exclude students, be centered indoors, had relatively few if any captions, and showed the teacher as the central figure. These results supported the underpinning STEBI theory's notion that those with higher self-efficacy believe in their own ability to teach, and are willing to add explanations focusing on the steps of their pictured lessons. These results further supported the theory's premise that individuals having high self-efficacy are more likely to utilize teaching strategies allowing students more variability in their classroom behavior. This led to the study hypothesis that preservice teachers who become less stereotypical in their perceptions of their science teaching will also develop higher levels of self-efficacy.

Procedures

Instruments

DASTT-C. The DASTT-C (Draw-A-Science-Teacher Teaching Checklist) consists of three sections: (1) Teacher, (2) Students, and (3) Environment. The "Teacher" section of the instrument is divided into two subsections which 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 which focus on the activities of students (passively receiving information, responding to the teacher, etc.) and students' positions (as 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 symbols of science (e.g., science equipment). Each element in each section of the instrument is considered by the instrument's developers to depict stereotypical elements of teaching and classroom images. If a stereotypical element appears in a subject's drawing, the scorer can simply mark that element on the checklist. Marks can later be added to derive both subscores for each section as well as an overall checklist score. Total checklist scores can range from 0 to 14. The "Teacher" subscore can range from 0 to 6, the "Students" subscore can range from 0 to 3, and the "Environment" subscore can range from 0 to 5. In each case, the higher the score, the more stereotypical the image being examined. (The instrument's reliability was determined by calculating the coefficient alpha using the Kuder-Richardson 20. The coefficient alpha was reported by the instrument's developers to be 0.82.)

Accompanying the checklist itself is the Subject Response Sheet. This sheet provides blanks at the top for subjects to enter demographic information (gender, preservice or inservice, grade level [elementary, middle/jr. high, high school], identification number, and date]. In the center of the sheet is a square in which subjects are asked to make their drawing. Beneath the square is the drawing prompt, "Draw a picture of yourself as a science teacher at work."

STEBI-B. The STEBI-B consists of 23 statements which are divided to provide two subscores. Subscore statements are randomly embedded within the 23 statements of the instrument. Thirteen of the statements yield scores for the Personal Science Teaching Efficacy (PSTE) subscale while ten yield scores for the Outcome Expectancy (OE) subscale. All 23 statements have a five-point Likert-type scale. Respondents select one answer for each statement according to whether they strongly agree (5), agree (4), are uncertain (3), disagree (2), or strongly disagree (1). Any positively worded statement is scored by awarding five points for "strongly agree" responses, four points for "agree" responses, and so forth. Negatively worded statements are scored by reversing the numeric values. The range of PSTE scores possible is 13-65 while that of OE scores is 10-50. The instrument's developers established reliability coefficients of 0.90 and 0.79 for the PSTE and OE subscales respectively. Adding the two subscores together to derive an overall STEBI score is an inappropriate use of the instrument. Factor analysis was used to determine instrument validity (Riggs & Enochs, 1990).

Subjects

The subjects for this study were 27 elementary education majors attending a rural mid-sized midwestern regional four-year university. All were enrolled in an elementary science methods course during the spring semester of the academic year. The course met twice each of the fifteen weeks of the semester for seventy-five minutes. The students enrolled in the course section were juniors, and twenty of them were female.

Data Collection

Both the STEBI-B and DASTT-C were administered to the preservice teachers during the first meeting of the course in January as pretests, and they were administered again on the final day of the semester as posttests. The same instructor administered both pretests and posttests, as well as instructed the course. For each test administration, the only directions provided by the instructor were, "Draw a picture of yourself as a science teacher at work" and "When finished with your drawing, turn it over and write a description of yourself as a science teacher at work." Preservice teachers were provided the DASTT-C drawing page (a page with some demographic information listed at the top and with a square space in the center of the page for the drawing) and pencils if needed.

The science methods course in which the students (preservice teachers) enrolled was designed so they would have primary responsibility for contributing to the content of the course. At the beginning of the course, students were provided a list of course topics for each day of the semester. Students were placed in cooperative groups and were instructed to research information regarding each daily topic. The intent was for students to seek information from their textbook, library resources, and the Internet on the "topic of the day" in order to be prepared to present that information during the day on which that topic was discussed in class. Part of each class session was devoted to students sharing the information they had gathered, discussing it, and evaluating the information insofar as it pertained to teaching science to elementary children. As needed, the instructor would add information to the discussion and would pose questions to students to guide them in their reflections and analyses of the information presented. Course topics included those typical of most science methods courses—for example, science process skills, learning theory and theorists, issues in science/science education, types of lesson planning and delivery modes, constructivism, and types of inquiry.

Another part of the class session would be spent in hands-on activities relating to the topic, which were designed to illustrate a variety of lesson types, including open-ended, closed-ended, verification, and inquiry-based activities. The activities were then examined with respect to how they related to the topic information previously discussed and as to how they could be applied to elementary children at different grade levels. When appropriate, safety and technological issues were addressed. Another aspect of the course was project-based, in which students began by selecting a topic on which they individually could do an inquiry investigation. This model has been suggested by a number of researchers in recent literature (Crawford, 1999). Each student was required to complete his or her inquiry investigation and then write a technical report following a prescribed format. The project was later used as a basis for students developing classroom lessons targeting specified grade levels, which were in turn used as a basis for the development of both traditional and performance assessments. During the semester, students were also afforded opportunities through other courses to observe elementary classrooms in the field and to begin preparing and delivering lessons to children.

Data Analysis

For data analysis, all drawings were scored using the DASTT-C checklist, as were all written narratives. Dependent t-tests were performed on pre-/post-DASTT-C drawing data, DASTT-C narrative data, and STEBI-B data (for both OE and PSTE subscales). Pearson correlations were then calculated for comparisons between DASTT-C and STEBI-B scores. For comparative purposes in the correlations, student scores on the OE and PSTE subscales were categorized as either "high" or "low" for both pretests and posttests. "High" OE scores were scores equal to or exceeding one standard deviation above the mean, while "low" OE scores were scores equal to or less than one standard deviation below the mean. PSTE scores were similarly categorized into "high" and "low" groupings. These procedures were followed because previous studies (Finson & Beaver, 1994; Rubeck & Enochs, 1991) indicate that subjects having low PSTE scores tend to teach, or view their teaching, to be more expository, while those having high PSTE scores tend to use more exploratory strategies. Additionally, low PSTE scoring subjects tend to see themselves as control figures who teach indoors and whose drawings tend to lack students. With regard to drawings, those subjects having high PSTE scores are more likely to include images in their drawings of teaching outdoors, using hands-on activities, and utilizing group work strategies, while those having low PSTE scores draw images which include indoor didactic teaching to students placed in rows. The hypothesis of the study reported here was that preservice teachers who become less stereotypical in their perceptions of their science teaching will also develop higher levels of self-efficacy. Another way of looking at this hypothesis is that subjects having low DASTT-C scores will view themselves and their teaching as less stereotypical and should tend toward higher PSTE scores on the STEBI-B.

Results

Dependent t-tests were conducted on pretest-posttest data for DASTT-C drawings. Analysis was performed on total checklist scores as well as for each subsection of the checklist. As shown in Table 1, means for total checklist scores decreased from pretesting to posttesting (= 6.148, = 5.333). There were similar decreases in means from pretesting to posttesting for the "Teacher" (= 3.444, = 2.667) and "Environment" (= 1.889, = 1.593) subsections. The "Students" subsection means showed an increase by posttesting (= 0.815, = 1.074). Only the mean change for the "Teacher" subsection was significant ($p < 0.001$).

Table 1
Means and Standard Deviations on DASTT-C Drawings (n=27)

Checklist Section	Pretest	Pretest SD	Posttest	Posttest SD
Teacher	3.444*	1.155	2.667*	1.144
Students	0.815	0.786	1.074	0.829
Environment	1.889	1.450	1.593	1.309
Total	6.148	2.445	5.333	2.732

* Dependent t-test: t=3.721, $p < 0.001$

Scores on written narratives were also analyzed using dependent t-tests. As with the drawing scores, analysis was conducted on the total score as well as on the subsection scores of the DASTT-C checklist. Table 2 shows that mean changes from pretest to posttest decreased for the total score as well as for each subsection. Significant changes were found for mean changes in the total score ($p < 0.006$), the "Teacher" subsection ($p < 0.0001$), and the "Students" subsection ($p < 0.009$).

Table 2
Means and Standard Deviations on DASTT-C Narratives (n=27)

Checklist Section	Pretest	Pretest SD	Posttest	Posttest SD
Teacher	1.000*	0.620	0.444*	0.506
Students	0.630**	0.492	0.333**	0.480
Environment	0.444	0.577	0.407	0.501
Total	2.074***	1.385	1.185***	1.111

* Dependent t-test: t=4.130, $p < 0.0001$
** Dependent t-test: t=2.842, $p < 0.009$
*** Dependent t-test: t=3.024, $p < 0.006$

Identical procedures were used for STEBI-B data. As shown in Table 3, the means for the OE subscale increased significantly ($p <$ p.008) from pretesting to posttesting, and the means for the PSTE subscale increased significantly ($p < 0.0001$) by posttesting. Since it is inappropriate to add OE and PSTE scores together to derive a "total" STEBI score (Riggs & Enochs, 1990), no analysis was performed on total STEBI mean changes.

Table 3
Means and Standard Deviations on STEBI (n=27)

Subscale	Pretest	Pretest SD	Posttest	Posttest SD
OE	39.074*	4.402	41.667*	4.969
PSTE	42.111**	5.740	49.037**	6.454

* Dependent t-test: t=2.896, $p < 0.008$
** Dependent t-test: t=6.901, $p < 0.0001$

Pearson correlations were conducted on data to compare high and low PSTE and OE scores for both drawings and written narratives with STEBI-B scores. Results are shown in Table 4. Correlations ranged from none and slight (e.g., high OE and "Students" subscale from drawing samples) to very high (e.g., high OE and "Environment" subscale from drawing samples). Most negative correlations occurred for high OE and high PSTE scores. The reader should keep in mind that, hypothetically, increasing STEBI-B scores and decreasing DASTT-C scores should indicate similar types of self-perceptions in subjects and, therefore, negative correlations should be anticipated as subjects grow to believe in their ability to impact students through their science teaching (PSTE) and move away from more traditional/stereotypical methodologies (DASTT-C).

Table 4
Pearson Correlations Between STEBI PSTE and DASTT-C Scores

	DASTT-C Subscales Scores							
	"Teacher"		"Students"		"Environment"		"Total" Score	
STEBI Subscale	**Draw**	**Narr.**	**Draw**	**Narr.**	**Draw**	**Narr.**	**Draw**	**Narr.**
Pretest								
"High" OE*	-	-1.000	0.870	-1.000	-0.927	-0.577	-0.333	-0.943
"Low" OE**	1.000	0.408	0.408	-0.408	0.943	0.612	0.919	0.250
"High" PSTE†	-0.503	-0.917	-0.494	-0.367	-0.308	0.071	-0.580	-0.492
"Low" PSTE††	0.557	-	0.651	-0.156	0.752	-0.662	0.880	-0.489
Posttest								
"High" OE ∞	0.779	0.559	-0.127	0.592	0.775	0.395	0.740	0.743
"Low" OE ∞∞	1.000	-	1.000	-	-	1.000	1.000	1.000
"High" PSTE Δ	0.052	-0.277	0.971	0.693	0.693	0.000	0.545	0.240
"Low" PSTE ΔΔ	0.434	-0.270	0.000	-0.270	-0.772	0.836	-0.031	0.124

* n=4
** n=5
† n=4
†† n=7
∞ n=5
∞∞ n=2
Δ n=3
ΔΔ n=5

Discussion

Preservice Teachers' Drawings

The drawings made by the preservice teachers became less stereotypical from pretesting to posttesting with a mean change of 0.815 (see Table 1). If preservice teachers' perceptions become less stereotypical with appropriate methods course instruction, one should expect such a change. In terms of the subcategories of the "teacher," "students," and "environment," one might further expect each of these subscores to become lower (less stereotypical) between pretesting and posttesting. The results shown in Table 1 indicate this was the case for "Teacher" and "environment" but not for "students." The "Teacher" subscore changes were significant ($p < 0.001$). The "Students" subscore mean increased from pretesting to posttesting. As preservice teachers become more aware of the teaching process, the prevalence of "students" in their mental images will increase. Coupled with the preservice teachers' exposure to a single semester of methods classes and little exposure to students in actual classrooms, one would anticipate preservice teachers' images of students would tend toward the more stereotypical. This could explain the results reported here.

Preservice Teachers' Narratives

The narratives written by the preservice teachers became less stereotypical from pretesting to posttesting (see Table 2), and these changes were significant ($p < 0.0001$

for the "Teacher" subscore and $p < 0.009$ for the "students" subscore). This change was exhibited for each of the subscales of "teacher,""students," and "environment." One would expect preservice teachers' narratives to include more detail and information about their perceptions of themselves teaching science than would emerge from their drawings. For this group of subjects, however, this was not the case. Narrative scores for each subscale, as well as for the total score, were significantly lower than drawing scores for both the pretest (total score $p < 0.0001$) and posttest (total score $p < 0.0001$). This may have been an artifact of perceived lack of time to formulate ideas, compose them, and write them down. Even so, the overall trend of the change in narrative scores from pretest to posttest paralleled that for drawing scores, thus supporting results from the drawing data showing perceptions becoming less stereotypical over time. Little information could be gleaned from the narratives to enhance the drawings.

Preservice Teachers' Self-Efficacy

In terms of self-efficacy, one would hope to see preservice teachers' OE and PSTE scores increase between pretesting and posttesting. An examination of Table 3 reveals this was the case. The change in OE subscore means was significant ($p < 0.008$) as was that for PSTE subscore means ($p < 0.0001$). Of particular interest are the PSTE subscores derived from the STEBI. High PSTE scores tend to reflect feelings of one's ability to impact student learning, and are usually matched with teachers who employ more exploratory teaching methodologies, who see themselves teaching students in nontraditional ways such as through group work and hands-on work, and who are not always in a traditional classroom setting. In comparison, low PSTE scores tend to reflect feelings of one's inability to impact student learning, and are matched with more didactic, expository teaching approaches such as teaching students in more traditional modalities (Finson & Beaver, 1994; Riggs & Enochs, 1990). Students are seen more as being quiet absorbers of information who are arranged in rows facing the teacher within a controlled classroom setting.

Comparison of Drawing Scores with Self-Efficacy Scores

One could infer that a correlation would exist between someone's perception of themselves as a science teacher and their self-efficacy. This would logically lead to the inference that low PSTE scores would correlate with high stereotypical images revealed in both drawings and narratives of one's teaching, while high PSTE scores would correlate with lower stereotypical images. These inferences were examined by calculating correlations between PSTE and DASTT-C subscores.

According to this logic, a preservice teacher having a low PSTE score should also have higher stereotypical scores for DASTT-C element subscores in "Teacher," "Students," and "Environment." Conversely, a preservice teacher having a high PSTE score should also have lower stereotypical scores for the same DASTT-C element subscores, resulting in negative correlations for each DASTT-C element. To help in examining these possible relationships, preservice teachers' PSTE scores were designated as being "low" if they fell one standard deviation or lower than the PSTE mean, and they were designated as "high" if they fell one standard deviation or higher than the PSTE mean. Using these criteria, correlations were made on both the pretest and posttest data.

Pretest correlations tended to support the hypothesis noted in the foregoing paragraph (see Table 4). Correlations between PSTE and DASTT-C "Teacher" and

"Students" scores were moderate for both low and high PSTE scores, with those on the posttest being negative. Those on the "Environment" element were high and positive for individuals who had low PSTE scores and were low and negative for those individuals having a high PSTE score. When examining PSTE scores and total DASTT-C scores, correlations were positive and high for those individuals having a low PSTE score and were moderate and negative for those having a high PSTE score.

When the same comparisons were made using posttest data, results were more mixed. Low PSTE scores tended to correlate moderately and positively with DASTT-C "Teacher" scores, to have no correlation with "Students" subscores, and to correlate high and negatively with "Environment" scores. High PSTE scores had a slight or negligible correlation with "Teacher" scores, a very high and positive correlation with "Students" scores, and a moderate and positive correlation with "Environment" scores. These results are not what one would expect on the surface; however, one may hypothesize that preservice teachers having low PSTE scores might be almost entirely focused on themselves and therefore would not consider "Students" in their image of science teaching. They may be sensitive to the environment in which they see themselves teaching and would most likely see that environment as being in a very traditional (stereotypical) classroom setting. If true, this might account for the types of correlations derived in this study. For preservice teachers having high PSTE scores, their focus may similarly shift somewhat to the environment, thus accounting for the positive correlation between PSTE and DASTT-C "Environment" scores. Their focus may now include students, so DASTT-C "Students" elements may begin to emerge more regularly. This may account for the moderate and positive correlation between PSTE and DASTT-C "Students" scores.

Similar comparisons were made between PSTE scores and DASTT-C narrative scores. Pretest correlations of scores from low PSTE preservice teachers tended to be negative and ranged from very high for "Teacher" to low for "Students" to very slight for "Environment." Correlations of scores from high PSTE preservice teachers were slight and negative for both "Teacher" and "Students." DASTT-C elements were high and positive for the "Environment" element. The negative correlations might be attributable simply to subjects not writing much in their respective narratives. The positive high correlation for high PSTE subjects and their "Environment" scores are more problematic to explain.

Conclusions

The study hypothesis was that preservice teachers who become less stereotypical in their perceptions of their science teaching will also develop higher levels of self-efficacy. In general, the results of this study would appear to support the hypothesis. Acceptance of the hypothesis needs to be tempered with regard to several factors, however, as will be discussed below.

With regard to only using DASTT-C data, one should be able to use the instrument and gain some sense of the perceptions preservice teachers have of themselves teaching science. Of all three subscales in the instrument, the one proving to be most problematic is that for "students," since preservice teachers may tend to focus primarily on themselves and have not yet matured into merging their self-image with the image of being amongst students (Finson et al., 1999; Thomas, Pedersen, & Finson, 1999).

The results of this pilot test of the DASTT-C and its comparison with STEBI scores must be viewed with caution for several reasons. First, the size of the comparative groups was small. In one instance, the "high" PSTE group had only 3 and the "low" PSTE group had 5. The size of the entire section of the methods course was 27. This study should be repeated with larger numbers of preservice teachers before firmer conclusions can be drawn from it. Second, the DASTT-C itself may yet require some additional modification. Although the instrument has undergone numerous iterations over its development and refinement throughout the three years of its existence, there may be need for additional, minor modifications. Even minor modifications might result in different scores being derived through use of the instrument. Third, for various reasons alluded to previously, direct comparisons between an instrument like the DASTT-C and other instruments like the STEBI may not be appropriate, even though they each look at similar types of things. Considering these cautions, this pilot study appears to indicate the DASTT-C can be used effectively with preservice teachers to begin discerning their perceptions of themselves as teachers teaching science. This study further indicates that there may be some underlying relationship between such self-perceptions (as measured by the DASTT-C) and the self-efficacy an individual possesses with regard to science teaching.

Recommendations for Further Research

Further study of the DASTT-C will be necessary before the results of studies such as this one can be generalized to wider populations. For example, science educators may find it interesting to compare the self-images, as defined by the DASTT-C, between elementary and secondary preservice teachers. Similarly, the application of the DASTT-C between various cultural groups may be of interest, as might be its application to groups of different geographic locality (e.g., region of the U.S., other nations, urban or rural, etc.).

Additional difficulties may arise when attempting to compare DASTT-C scores with STEBI scores, particularly for the PSTE subscale. More refinement needs to be done in how to interpret DASTT-C scores and whether it is appropriate to (and if so, how to) compare them with scores from other instruments such as the STEBI. By themselves, both instruments provide valuable insights into the way preservice teachers see themselves with regard to science teaching. Any relationships between self-image and self-efficacy, although intuitively related, may be difficult to elicit from these particular instruments. Whether one can be used efficiently and effectively in conjunction with the other will require further work. Perhaps each instrument provides a slightly different picture of preservice teachers' perceptions, slightly different pieces of the entire self-image. Use of the two instruments together may be of benefit to science educators, even though the relationship between the two is not clearly defined. The same may be said for other instruments in existence as well.

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