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Factors Contributing to Diagnostic Skill Competency of String Teachers

The purpose of this study was to determine which factors contribute to the competency of string teachers' diagnostic skills. Participants were 49 pre-service and in-service orchestra/string music teachers from three geographical divisions as defined by MENC (1984): Eastern (Massachusetts), Southern (Louisiana), and Western (Arizona and California). A researcher-developed survey was organized in three sections: General Information, the Questionnaire, and the Diagnostic Test. Eleven possible contributing factors were examined. Participants' diagnostic skills were assessed through a researcher-developed diagnostic test. Eleven Two-Way ANOVAs with repeated measures were computed for data analysis. Significant differences were found among subjects by analysis situation, by degree, and between in-service and pre-service teachers.

Learning to play musical instruments in classroom situations occurs as a result of interaction among several internal and external factors. If any of these factors is dysfunctional, the pleasurable experience of making music on a musical instrument transforms into a dull, uninteresting, and sometimes painful experience preventing the student from fully enjoying and understanding music as an art form. Often this undesirable outcome causes a student to consider quitting music classes, thus cutting off an opportunity to become a life-long learner and music admirer. In order to prevent such a negative development, it is important to fully understand the nature of the factors involved in learning to play musical instruments and how they relate to each other.

In simplified form, the internal factors that facilitate the playing

of musical instruments can be understood through the sensory-motor coordination of three elements: the senses (more accurately ears and eyes), brain (more accurately motor cortex), and fingers (more accurately digits that are located in fingers). Ears and eyes receive aural and visual stimulus from the outside world while the brain transforms those stimuli into meaningful information. The motor cortex, a strip-like region of the cortex positioned at the very top of the brain, is pivotal to the generation of movement. Signals from the motor cortex trigger digits located in our fingers, and cause fine movements of the fingers that are critical for playing musical instruments (Greenfield, 1997).

In instrumental music classes, some additional external factors may influence learning. Student access to instruments, degree of student practice, parental support, and class meeting scheduling conflicts are external factors that may affect student achievement. However, it seems that the major influence on student learning is the overall competence of the teacher (Gillespie, 1991).

A competent string and orchestra teacher, as defined in the *Standards for Preparation of School String and Orchestra Teachers* (ASTA with NSOA, 1997), is expected to possess knowledge and skills as a musician, educator, and professional. As a musician, a teacher is expected to perform at an advanced level on at least one string instrument and to be proficient on other string instruments, to demonstrate orchestral conducting skills, and to exhibit aural discrimination/diagnostic skills, as well as develop an understanding of the prevention of performance injuries. As an educator, a teacher is expected to exhibit effective rehearsal techniques for string and full orchestra, and to show an understanding of a variety of pedagogical approaches for teaching string classes along with an understanding of different learning styles and special needs. As a professional, a string orchestra teacher is expected to participate in ongoing professional development, to continue to interact with other music educators, to maintain active involvement in professional associations, and to advocate effectively for a strong school orchestra program.

According to aforementioned ASTA with NSOA standards, one of the major skills that string teachers are expected to demonstrate as musicians is an ability to aurally discriminate/diagnose errors in students' playing. The importance of this skill has been recognized by teachers as well. On a list developed by 201 public school music teachers, the highest rated music teacher competency was the development of aural skills to detect errors in performance (Taebel, 1980). When asked to rate the extent of the influence on the development of their students' performance

skills, teachers rated diagnostic skills among five of the most influential factors (Gillespie, 1991). Major protagonists of string education in schools agree that competent diagnostic skills are integral to successful string teaching (Smith, 1970; Rolland, 1974; Bornoff, 1989).

Smith (1970) argued that string teachers should not only be able to play string instruments, but should also recognize problems related to string playing as well as learn how to correct them. Smith believed that many problems in students' playing could be avoided if string teachers were trained to recognize errors and to remediate them in a timely manner. Rolland (1974) pointed out that handling playing problems in young students required great sensitivity and special skills on the teacher's part. Bornoff (as reviewed by Howell & Howell, 2003) insisted on the utilization of *manual assistance*, a technique in which the teacher gently touches the student's wrist, thumb, or fingers and makes adjustments from the first day, thus preventing errors from evolving into problems that can be difficult to correct.

Competent diagnostic skills are closely related to another skill that string orchestra teachers are expected to demonstrate as musicians, and that is knowing how to prevent performance injuries. Many musicians struggle with painful physical conditions that are directly related to their playing. Those conditions, collectively known as *repetitive-motion injuries*, are most prevalent among string instrument players (Horvath, 2000). Even though the highest rate of injury was found in string players between 35 and 45 years old, severe problems are more common in people under 35, and may start as early as high school age (Fishbein & Middlestadt as reviewed by Horvath, 2000). Many of those injuries are directly related to poor posture, improper instrument hold, and muscle imbalances (Horvath, 2000). String teachers' competent diagnostic skills may play a key role in prevention of playing injury at early ages. Havas (as reviewed by Perkins,1995), whose approach heavily concentrates on prevention of performance injuries, insists on the importance of a teacher's ability to recognize and analyze the problem in students' performance before injury occurs.

Diagnosing errors, especially in instrumental music performances, is not an isolated aural or visual process. While many errors can be identified by visual recognition, such as visual recognition of problems in instrument position, left hand position, and bow arm movements, the aural element also contributes greatly to the error diagnostic process. A teacher must be able to match aural stimulus with the visual stimulus instantaneously and be prepared to make adjustments as necessary (Siddnell, as reviewed by Stuart, 1979).

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The two most important courses for development of string teachers' diagnostic skills according to Smith (1995) are string techniques and string methods courses. String techniques courses are courses designed for music education majors to develop basic performance skills on all four bowed orchestral string instruments. String methods courses are courses designed to acquaint future string educators with string teaching methods, material, and different pedagogical approaches.

Smith (1995) surveyed the undergraduate music education curriculums and content of courses at American universities, and found that most music education preparatory programs required only a one-semester combined string techniques/methods course in the curriculum for instrumental music education majors. In addition, she found that one third of schools in the sample did not require choral music education majors to take any string teacher training courses. This is a disturbing finding, especially if one takes into consideration that one out of three people teaching strings in the public schools are not principally string players (Gillespie & Hamann, 1996; Hamann, Gillespie, & Bergonzi, 2002).

Smith's study also provided a list of the most frequently used textbooks in string techniques/methods courses across the six geographical divisions as defined by MENC. A thorough survey of four textbooks on this list (*Teaching String Instruments Classes*, Green, 1966; *Teaching Strings*, Klotman,1988; *The Suzuki Violinist*, Starr, 1976; *The Teaching of Action in String Playing*, Rolland & Mutschler, 1974) revealed that only two of them emphasized diagnostic skills as an important concept. (*Teaching Strings*, Klotman, 1988; *The Teaching of Action in String Playing*, Rolland & Mutschler, 1974).

The research into the relationship between teachers' diagnostic skills and their students' performance abilities have been inconsistent. Woods (as reviewed by Gillespie, 1979) discovered a positive relationship between wind teachers' diagnostic skills and performance competencies of their students. Gillespie (1991) on the other hand, found no significant relationship between the diagnostic skills of string teachers and their students performances in simple detache bowing. In addition, participants in this study identified 22 different factors that contributed to their students' performance competency. Teachers felt that factors such as

While the purpose of diagnosing performance problems, both visually and aurally, is primarily to categorize the problem and to determine what needs to be done to improve the situation (Hunter, as reviewed by Doerksen, 1999), in order to permanently solve the problem, the analysis of the causes and consequences of the problem are necessary steps in the process of remediation. A teacher's skillfulness in all four steps of the problem remediation process, (identifying the problem, determining what caused the problem, analyzing the possible consequences of the problem, and offering an appropriate remedy/correction of the problem), may not only help individual students improve their playing, but also help teachers build successful string programs while saving valuable rehearsal time. Cavitt (2003) found that error correction may consume almost half (49%) of all rehearsal time in band rehearsals. While a strategy appears to be important in a problem remediation process, a review of several diagnostic skill training devices (Froseth, 1978; Gillespie, 1987) revealed no emphasis on creating such a process.

Instrumental music teachers' ability to accurately diagnose errors is a characteristic associated with effective teaching. How do teachers develop this ability? Is the teachers' college preparation the most important contributing factor, or does their experience in the "real world" of teaching force them to develop this skill? Can professional development such as attending conferences, seminars, and workshops help individuals develop this skill?

If teachers' diagnostic skill abilities can be linked to the factors discussed above, greater emphasis could be placed on them in music education preparatory programs. On the other hand, if diagnostic skills are not related to those specific criteria, other factors should be examined.

A review of related literature revealed that studies in the area of music teachers' diagnostic skills can be classified into various categories. A considerable amount of research has been dedicated to the examination of content in undergraduate string teachers education programs at American universities (Smith, 1995), and to the status of string programs in the public schools (Hamann, Gillespie, & Bergonzi, 2002). Even though those studies don't address diagnostic skills directly, they explain the position of those skills in university curricula, as well as discuss the state of string programs in public schools. Therefore, the findings of those studies are a valuable source of information for the present study. Another category of studies has been concerned with the relationship between teachers' diagnostic skills and their students' performance abilities (Woods, 1979; Gillespie, 1991). The last category of string research includes the studies that were concerned with the contribution of

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Several studies examined teachers' experience and diagnostic skills training as contributing factors to competent diagnostic skills. Standley & Madsen (1991) found that the amount of teaching experience could be a factor in the contribution of development of competent diagnostic skills among string teachers. However, Doerksen (1999) suggested that experience alone did not make a teacher "expert." Brand and Burnsed (1981) found no statistically significant relationship between instrumental music teachers' experience in teaching and their diagnostic skills competency. McCoy (as reviewed by Doerksen, 1999) reported that the amount of teaching experience could be the variable that contributed to the competency of music teachers' diagnostic skills.

Several researchers agree that diagnostic skills can be developed. Diamond and Collins (1967) explored the benefit of utilizing 8mm loop films in teaching error identification skills to a group of pre-service and in-service teachers. A comparison of the means of pretests and posttests revealed that the posttest mean was significantly higher than the pretest mean for both groups. For error detection training within the two groups of novice string teachers, Stuart (1979) used a combination of videotapes, recordings, slides, textual materials, and class discussions. Analysis of the data indicated that the group receiving detection training performed at significantly higher level than the other group, as measured on the error detection test. Gillespie (1987) used a self-created video, *Violin Bowing Diagnostic Training Program*, for the training of 10 graduate students and in-service teachers, and 21 pre-service teachers. Comparison of the means of pretest/posttest scores indicated significantly higher posttest scores for individuals at all levels.

Several studies, conferences, symposia, and documents issued by professional organizations such as ASTA and MENC urge string teachers to attend conferences, seminars and workshops in order to develop their teaching competencies. Smith (1970) stated that the ultimate goal of an effective string pedagogy course should be to encourage students to learn and grow professionally. Public school teachers that participated in "String Teachers Preparation for the Twenty-First Century" at a National Symposium on String Pedagogy at Wichita State University (1996) agreed that teachers should develop an attitude of lifelong learning and seek ways to continue education through conferences, seminars, and workshops (Reed, 1996). *Standards for Successful School String/Orchestra Teaching* (ASTA with NSOA, 1997) urge teachers to

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continue to pursue opportunities for learning as musicians, and to participate in ongoing professional development to improve teaching effectiveness. While such professional pursuits are encouraged, there are no studies that investigate the influence of professional development on string teacher diagnostic skills.

The purpose of this study was to determine which factors contribute to the competency of string teachers' diagnostic skills. Eleven potential contributing factors were selected for this research:

1. Participants' standing as a teacher (pre-service or in-service)
2. College degree
3. Teacher certificate
4. Primary instrument
5. Number of semesters of string methods courses
6. Number of semesters of string techniques courses
7. Whether string methods and string techniques were combined into one course
8. Emphasis on development of diagnostic skills in those courses
9. Private lessons
10. Attendance and participation in conferences, symposia, and workshops
11. Years of teaching experience

The rationale for selection of those eleven factors was based partially on findings of similar studies, and partially on the recommendations of professional organizations, symposia and conferences.

METHODOLOGY

Subjects were pre-service teachers (n = 18) and in-service teachers (n = 31). Pre-service teachers were junior and senior level undergraduate music education majors at a large Western University. In-service teachers were experienced teachers from three geographical divisions as defined by MENC (1984): Eastern (Massachusetts), Southern (Louisiana), and Western (California and Arizona). The breakdown of in-service teachers by state was: Massachusetts 4, Louisiana 7, California 9, and Arizona 11.

A researcher-developed survey was organized in three sections: General Information, Questionnaire, and Diagnostic Test. In the General Information and Questionnaire sections, the respondents were asked to circle one answer that best applied, while in the Diagnostic Test section

the participants were asked to respond to the items in writing on a provided space.

The General Information section contained four questions. The items pertained to subjects' experience, degree, certificate status, and primary instrument. The Questionnaire section of the survey contained seven items which pertained to the subjects' acquisition of string methods and string techniques courses, private lessons, attendance at conferences, symposia and workshops, and years of teaching experience. The responses to the items of the General Information and Questionnaire sections were used as independent variables in the data analysis. The Diagnostic Test portion of the survey contained four photographs showing common errors (problematic situations) that frequently occur at the beginning level of instruction on each of the four bowed string instruments (violin, viola, cello, and double bass). The problems presented were: poor posture and improper instrument hold for a violin, left hand wrist "fold" for viola, the "violin bow grip" for cello, and the improper height and angle of the instrument for a double bass. Using still photographs as a way of assessing teachers' diagnostic abilities over pictures in motion (videotape of a problematic playing situations) was selected because the ability to recognize an error, often called a *photographic eye*, is of a particular importance in a classroom situation where teachers usually have no more than a few seconds to assess the problem (Diamond & Collins, 1967).

Respondents were asked to carefully observe each picture (problematic situation) and assess the problem situation in four steps. The four steps were: a) diagnose the problem, b) determine the cause of the problem, c) describe possible consequences, and d) prescribe the remedy. Only one line was provided for each answer because in a real classroom situation teachers are expected to give short and precise explanations, often not longer than one sentence.

In scoring the test, one point was awarded for each correct identification of a problem, one point for the correct definition of the cause of a problem, one point for each correct description of possible consequences, and one point for each correct selection of a remedy. A score of sixteen points was the highest possible test score. A fully correct answer was awarded one full point. Answers that were partially correct, or that were possible answers in the evaluator's view, were awarded 1/2 point. All other answers and no answer at all earned zero points.

Sixty surveys were mailed to in-service teachers in three states: California (20), Louisiana (20), and Arizona (20). These teachers were asked to administer the surveys to their teacher-colleagues during the

music faculty meetings in school districts. Twenty-seven surveys were returned: nine from California, seven from Louisiana, and eleven from Arizona. An additional ten surveys were distributed by the researcher to in-service teachers in Massachusetts during a summer workshop. Four surveys were returned. Twenty surveys were administered to junior and senior level undergraduate students in music education (pre-service teachers) at a large Western University during the 2002-2003 school year. A return of 18 surveys was obtained. Thus, a total of 90 surveys were distributed, and a total of 49 surveys were returned for a return rate of 55%.

RESULTS

Data were analyzed using a Two-Way ANOVA with repeated measures. Independent variables in analyses were defined as the categories from the 11 items of the survey. An additional independent variable in each of the analyses was "situation" identified as a repeated measures, which was the analysis of the four pictures using the four criteria steps. The dependent variable was the score of the diagnostic test. Eleven Two-Way ANOVAs with repeated measures were computed.

In the first analysis the independent variables were the two group of teachers (pre-service and in-service) and the situation. The dependent variable was the score on the diagnostic test. No significant difference, $F(1, 45) = 3.06$, $p = .08$, was found by group. A significant difference, $F(3, 135) = 40.24$, $p = .001$ was found by situation. A significant interaction effect, $F(3, 135) = 3.20$, $p = .025$, was found by group and situation. A significant interaction was found such that scores of in-service teachers were higher on the diagnostic test sections labeled "cause," "consequences," and "remedy" as compared to pre-service teachers' scores. In-service teachers' scores were higher on all three of those test sections indicating that their detection skills in those areas were higher than the detection skills of pre-service teachers in same areas.

In the second analysis, the independent variables were degree (music education degree, degree in performance, both degrees, and other) and situation. The dependent variable was the score on the diagnostic test. There was a significant difference, $F(3, 45) = 4.46$, $p = .007$, by degree. A significant difference, $F(3, 135) = 10.34$, $p = .001$ was found by situation. There was no significant interaction effect, $F(9, 135) = 1.9$, $p = .31$, between type of degree and situation. Participants with dual degrees (performance and music education combined degree) had a significantly higher overall diagnostic test score than participants with a performance degree only. However, the mean test score of participants

with dual degrees was not significantly higher than the mean score of the participants with only a music education degree.

In the third analysis, independent variables were participants' teaching certificate status (teaching certificate, emergency certificate, and neither) and situation. The dependent variable was the diagnostic test score. No significant difference, $F(2, 46) = .66$, $p = .52$ was found by teaching certificate status. A significant difference, $F(3, 138) = 5.8$, $p = .0008$, was found by situation. No significant interaction effect, $F(6, 138) = .28$, $p = .94$, by teaching certificate status and situation was found.

The fourth data analysis was computed using participants' primary instruments (one of the four bowed string instruments and other) and situation as independent variables. The dependent variable was the diagnostic test score. No significant difference, $F(1, 45) = .09$, $p = .76$, was found by primary instrument of the participant. A significant difference, $F(3, 135) = 29.43$, $p = .001$ was found by situation. No significant interaction effect, $F(3, 135) = .76$, $p = .51$, was found by primary instrument and situation.

In the fifth analysis, the independent variables were number of semesters of string methods courses (none, one semester, two or more semesters) and situation. The dependent variable was the diagnostic test score. No significant difference, $F(2, 46) = 1.08$, $p = .34$, was found by the number of semesters of string methods courses. A significant difference, $F(3, 138) = 26.87$, $p = .001$, was found by situation. No significant interaction effect, $F(6, 138) = .91$, $p = .48$, was found by number of string methods courses and situation.

The sixth Two-Way ANOVA with repeated measures was computed using the number of semesters of string techniques courses (none, one semester, two or more semesters) and situation as independent variables. The dependent variable was the diagnostic test score. No significant difference, $F(2, 46) = 2.54$, $p = .08$, was found by the number of semesters of string techniques courses. A significant difference, $F(3, 138) = 28.88$, $p = .001$, was revealed by situation. No significant interaction effect, $F(6, 138) = .32$, $p = .92$, was revealed by the number of semesters of string techniques courses and situation.

In the seventh analysis, the independent variables were string methods/string techniques courses combined or separate (combined in one course or taught as separate courses) and situation. The dependent variable was the score of the diagnostic test. No significant difference, $F(1, 39) = .00$, $p = .99$, was found by string methods/string techniques courses combined or separate. A significant difference, $F(3, 117) = 31.80$,

$p = .001$, was found by situation. No significant interaction effect, $F(3, 117) = .68$, $p = .56$, was found by string methods/string technique courses combined or separate and situation.

The eighth analysis used emphasis on the development of diagnostic skills in the university courses (no emphasis, somewhat, yes) and situation as independent variables. The dependent variable was the score of the diagnostic skills test. No significant difference, $F(2, 41) = 12$, $p = .29$, was found by emphasis on the development of diagnostic skills in the university courses. A significant difference, $F(3, 123) = 19.55$, $p = .001$, was found by situation. No significant interaction effect, $F(6, 123) = 1.2$, $p = .29$, was revealed by emphasis on diagnostic skills development and situation.

In the ninth computed analysis, independent variables were private lessons on bowed string instruments (never, yes-for six months, yes-for more than six months) and situation. The dependent variable was the diagnostic test score. No significant difference, $F(2, 46) = .67$, $p = .51$, was found by private lessons on bowed string instruments. A significant difference, $F(3, 138) = 22.89$, $p = .001$, was found by situation. No significant interaction effect, $F(6, 138) = .69$, $p = .65$, was found by private lessons on bowed string instruments and situation.

In the tenth analysis, independent variables were respondents' participation in string teaching related to attending conferences, symposia, and workshops (never, one time, two or more times) and situation. The dependent variable was the diagnostic test score. No significant difference, $F(2, 46) = 2.2$, $p = .12$, was found by participation in string teaching related to attending conferences, symposia, and workshops. However, there was a significant difference, $F(3, 138) = 20.86$, $p = .001$, by situation. There was no significant interaction effect, $F(6, 138) = 1.66$, $p = .133$, by participation in the string teaching related to attendance at conferences, symposia, and workshops and situation.

The eleventh analysis used number of years of teaching experience (less than one, one to three, three to six, more than six) and situation as independent variables. The diagnostic test score was used as the dependent variable. No significant difference, $F(4, 44) = .06$, $p = .65$, was found by the years of teaching experience. A significant difference, $F(3, 132) = 27.54$, $p = .001$, was found by situation. No significant interaction effect, $F(12, 132) = .66$, $p = .77$, was found by the years of teaching experience and situation.

As a Post-Hoc analysis procedure, means of the overall scores for teachers by group (pre-service and in-service) as well as standard deviations were computed. When looking at the mean scores of subjects,

it should be noted that the highest possible score was 16. The mean score for the pre-service teachers was seven and the mean score of in-service teachers was eight. Again, taking into consideration that the highest possible score on the diagnostic test portion of survey was 16, one could conclude that the means for both groups of teachers were rather low (50% or less). Standard deviations among these two groups were also similar with SD = 1.7 for the pre-service teachers, and SD = 2.8 for the in-service teachers.

DISCUSSION

String teachers' ability to recognize the errors in students' performance, and to prescribe adequate remedies has been recognized as a fundamental component of successful teaching by scholars, researchers, string pedagogues, and practicing teachers. Measures for the development of those important skills have been often debated at the conferences and symposia of professional organizations. The recommendations from those meetings have been sent to universities with teaching preparatory programs and teachers in the field for implementation. However, only a few researchers have evaluated some of the variables (diagnostic skill training, teaching experience and musical abilities) as possible contributing factors to the competency of the teachers' diagnostic skills. The present study attempted to determine if any of the eleven proposed factors contributed to the competency of string teachers' diagnostic skills. All earlier studies that dealt with assessment of teachers' diagnostic skills concentrated only on problem identification and remedy prescription as steps of evaluation. In this study, participants' diagnostic abilities were assessed through four steps: problem identification, defining what caused the problem, description of possible consequences, and prescription of an appropriate remedy.

In the first analysis, it was found that scores of pre-service and in-service teachers were the highest, and almost identical in the first assessment situation (identification of the problem). However, the scores of pre-service teachers in assessment cause, consequences, and remedy were significantly lower than the scores of in-service teachers for the same situations. This suggests that emphasis needs to be placed on the development of future teachers' ability to determine causes, consequences, and remedies, not only identification of the problem. Similar results were reported by Sang (1982), who recommended that more emphasis be put on the prescriptive component of diagnostic training programs.

In the second analysis, it was found that participants with dual

degrees (music education and music performance) had a significantly higher total test score than participants with music performance degrees only. However, the total test score of respondents with dual degrees was not significantly higher when compared to the score of subjects with music education degrees only. This implies that the courses that are required for the music education degree are more relevant to the development of the diagnostic skills than the courses that are required for the performance degree.

In the third analysis, the possession of the teaching certificate as a possible contributing factor was examined. No significant difference in diagnostic scores was found by this variable. This finding suggests that, while the requirements for a teaching certification may develop many skills that help teachers become successful educators and professionals, the courses required for this certificate do not play a major role in the development of string teachers' diagnostic skills.

No significant relationship was found between the instrument played by the respondent and his/her diagnostic test scores in the fourth analysis. The development of playing skills does not necessarily lead to the development of error detection skills. Diamond and Collins (1967) also found that error recognition must be taught, and that experienced performers were not able to identify the vast majority of errors until they received training in the area of error identification.

In the fifth analysis, it was found that the number of semesters of string methods courses did not significantly influence teachers' diagnostic skills. Smith (1993) defined string methods courses as those designed to acquaint students with string class methods and materials. This definition of the string methods courses and the findings of the present study suggest that a majority of those courses may not encompass diagnostic skills and remediation processes sufficiently. Smith also listed the textbooks that were in most frequent use in string methods courses in all six geographical divisions as defined by MENC at the time of the study. Careful observation of some of those textbooks revealed that only two of them (*The Teaching of Action in String Playing*, Rolland & Mutshler and *Teaching Strings*, Klotman) pointed out common problems and suggested remedies as part of the text. Smith's findings also revealed that *The Teaching of Action in String Playing* was used at 29 universities (out of 149 universities in the sample) and *Teaching Strings* was used at only 27 universities (out of 149 universities in the sample). Connecting these findings with the findings of the present study, it is possible to conclude that the absence of the relationship between string methods courses and diagnostic skills test scores may be ascribed to the lack of

emphasis on diagnostic skills development in those courses, or perhaps the lack of an appropriate text that covers this topic in the textbooks that are available.

The influence of the number of semesters of string techniques courses on teachers' diagnostic skills test scores was examined in the sixth analysis. It was found that string techniques did not significantly influence teachers' ability to recognize mistakes in students' performance. According to Smith (1995), string techniques courses are designed to develop students' basic performance skills on all four bowed string instruments. Smith's study also provided the list of the topics that were generally covered in those courses. The list included the following topics: correct posture, correct instrument hold, correct bow hold, tone production, bowing and fingering patterns, and tuning procedure. There are no topics that are closely related to error detection skill development such as identification of common problems, recognition of the problems and suggestions for remediation. This suggests that in those courses, as was the case with string methods courses, the diagnostic aspect of teachers' training was seemingly not included. Smith (1970) suggested that future string teachers should not only learn the basic rudiments of playing on string instruments, but should also be trained to recognize major faults in playing and learn how to correct them. Smith (1970) strongly urged designers of teachers' preparatory programs to provide students with a list of the most common problems on all four instruments, and a summary of effective solutions for remediation of those problems. Even though there is a twenty-year gap between the two studies, it appears that such steps are still needed in the string methods and string techniques courses today.

In the seventh analysis, an examination of the manner in which string methods and string techniques were taught was conducted. Whether taught as separate courses, or combined in one course, the manner in which string methods/techniques were taught had no significant influence on teachers' diagnostic skills test score. The implication of this finding is that with no change of the content of those courses, their role in the development of diagnostic skills will remain marginal, whether taught as combined or separate courses.

Based on the results of the eighth analysis, the perception of whether there was a strong emphasis, mild emphasis, or no emphasis at all on diagnostic skills in string methods/string techniques courses did not influence the diagnostic abilities of the participants in this study. Diamond and Collins (1967) created 8mm loop films to measure and develop the skills of undergraduate students in identification of common

errors in clarinet playing. Diamond and Collins found that the use of the film as a training device was effective, and that error training was necessary. Gillespie (1987) used a self-developed videotape training device, *The Violin Bowing Diagnostic Test and Training Program*, for the assessment and training of participants' diagnostic skills.

The ninth analysis examined the influence of taking private lessons on bowed string instruments on participants' error detection skills. No significant influence was discovered between error detection skills and private lessons. This finding suggests that skills developed in private lessons are not related to the development of teachers' diagnostic skills.

Attending conferences, symposia, and workshops does not play a major role in the development of teachers' diagnostic skills, as discovered in the tenth analysis. From this finding, it is possible to conclude that whether participants attended those events or not, those professional meetings did not contribute to teachers' diagnostic skills competency.

In the eleventh analysis, the years of experience were not found to have significant influence on the development of teachers' diagnostic skills. This may suggest that length of teaching experience does not influence diagnostic skills per se. Brad and Burnsed (1981) also found no relationship between experience and diagnostic skills, and suggested that acquisition of those skills may not occur with development of other skills.

In a final Post-Hoc analysis, it was revealed that, based on mean scores, pre-service teachers were only able to correctly address diagnostic skills issues less than 50% of the time, and that in-service teachers were only able to correctly address the same issue 50% of the time. While some significant differences did exist between the two groups overall, neither group demonstrated particularly strong diagnostic skills ability. This suggests that both pre- and in-teachers' diagnostic skills are rather weak. Gillespie (1987) also found that participants in his study had low diagnostic test scores. Future studies should examine why the test scores of orchestra teachers are so low in the first place.

Summarized, the findings of this study indicated that: a) test scores on problem identification for both pre-service and in-service teachers were higher than on problem cause, consequences, and remedy, b) in-service teachers had significantly higher test scores in the situations pertaining to the assessment of cause, consequences, and remedy than pre-service teachers, c) participants with dual degrees had significantly higher test scores than participants with only a music performance degree, but not significantly higher than respondents with music education degree only, and d) that overall, diagnostic skills mean scores for both groups of teachers were low. No other factors were found to be

significant.

Results of this study suggest the following implications for teacher preparatory programs and teachers in the field: a) diagnostic development skills need to be addressed independently from other skills, b) in diagnostic skills training, strong emphasis needs to be directed toward the development of teachers' ability to determine cause, consequences, and remedy of the problem as well as problem identification itself, c) string methods and string techniques courses should place greater emphasis on the error detection/problem solving portion of the curriculum, along with an examination of the textbooks used to reinforce those skills, and d) a dual degree that combines performance and music education courses should be further studied as a way to help enhance diagnostic teaching skills of performance majors.

The recommendations for future studies in the area of string teachers' diagnostic skills are: a) more research should be done in the area of string teachers' diagnostic skills in general, b) the scope of the research should go beyond assessment of the teachers' diagnostic skills and their influence on students' performance skills, c) the discovery of the factors that positively influence teachers' diagnostic skills would be of particular benefit to teacher preparatory programs and working teachers; therefore, a similar study with some other possible influential factors should be conducted, and d) the question of why the test scores of in-service teachers were higher in the area of cause, consequences, and remedy identification than the scores of pre-service teachers in the same areas should be examined in future studies.

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