Developing an effective string education system is the goal of educators and researchers alike. In order to do this educators need to be made aware of how students learn, what student attitudes affect learning and retention, and how effective programs address the many issues facing string educators. The purposes of this paper are to describe research related to the aptitude, attitude and achievement of individuals in string teaching/learning situations, to present research that describes interference to string learning such as injury, and to describe effective string programs both past and present. The paper is divided into three sections. The first section presents research related to string teaching while the second section focuses on string learners from preschool through adult. The third section describes both current and historical string programs.

The goal of school string programs is to improve string instruction. Effective string teaching begins with the individuals involved in the teaching/learning relationships: teachers and learners. The aptitude, attitude, and achievement of the individuals involved in the learning process all contribute to the effectiveness of string teaching and to the level of string learning. In addition to individuals, exemplary string programs provide a model for improving string teaching and learning. The purposes of this paper are to describe research related to the aptitude, attitude and achievement of individuals in string teaching/learning situations, to present research that describes interference to string learning such as injury, and to describe of effective string programs both past and present. Because technique and skill development have been reviewed elsewhere, such studies were not included in this review.

The paper is divided into four sections. The first section presents research related to string teaching while the second section focuses on string learners. The third section relates information regarding professional orchestral players, and the last section describes both current and historical string programs.
String Teachers

String education begins with the string teacher. It is the string teacher’s responsibility to present relevant information in a way that facilitates student learning. Teacher attitude can affect the type of string programs offered in the schools, and it is the teacher who establishes priorities in rehearsals. Research into string teaching has explored teachers’ opinions, rehearsal strategies, effectiveness, preparation, confidence, and their ability to recruit students to string programs.

Teacher attitudes and perceptions affect orchestra scheduling in the schools. Frost (1997), in a survey of 234 high school orchestras, determined that teacher attitudes and perceptions and other factors were significantly related to the type of orchestra program offered (string orchestra or full orchestra). Teacher variables included: (a) attitude toward a full orchestra experience for string students, (b) attitude toward a full orchestra experiences for woodwind, brass and percussions students, (c) perception of support of the administrative support for full orchestra, (d) self-evaluation of qualifications to teach full orchestra, and (e) the flexibility within the teaching schedule to allow for full orchestra rehearsals. Other factors investigated were string student enrollment, teaching assignments, area of specialization, school size, and type of program offered. Many significant correlations were reported, confirming that teachers’ attitudes and perceptions influence the type of program offered.

Preparation and attitude affect teacher willingness to teach orchestra in the schools. In a survey of 465 school/string orchestra teachers, Jenkins (1996) asked respondents to describe their job status, training and attitudes toward string teaching. Seventy-four percent of those surveyed had a string background. Ninety percent had taken an undergraduate string class, and 83% had taken string lessons since completing undergraduate studies. Of the respondents with non-string backgrounds, two-thirds volunteered to teach student orchestras and 97% reported positive attitudes toward teaching. While these non-string subjects indicated a need for more string specific methodology, 99% enjoyed teaching strings, and 87% indicated cooperation between string and band programs in their school. Over 61% of the total number surveyed did not consider a string background essential to successful string/orchestra teaching as long as such teachers work to correct their deficiencies.
The attitudes of band directors toward orchestra also have an effect on the offering of orchestra programs at different levels. Frost and Rohrer (1990) surveyed 47 public school band directors to determine how they rated the importance of symphonic orchestra at elementary, middle/junior high, and high school levels. Philosophically, the band directors supported the concept that symphonic orchestra was an important part of the curriculum at all levels. While no significant differences were found, in general the band directors surveyed were more supportive of symphonic orchestra at the high school level than at the elementary or middle/junior high school levels.

String teaching effectiveness is directly related to the priorities and techniques established in string rehearsals. Erwin (1993) sought to determine if teaching content and instructional strategies were stable within and across rehearsals. Content variables included intonation, rhythm, technique, interpretation and other. Instructional strategy variables included singing, gestures, playing, basic conducting, multiple conducting, verbal instruction, verbal imagery, mobility and other. Also included in the study were pacing and whether the director addressed the whole group, part of the group or an individual. “The majority of teachers were rapid in their pace of strategies but maintained slower pacing in the teaching of elements of content and in the changing from the full group to a section or an individual student.” (p. 2726) The multiple conducting variable occurred frequently, and demonstration and verbal imagery occurred in less than 3% of rehearsal time. Erwin concluded that teachers were stable in the rehearsal behavior they exhibited.

In developing rehearsal strategies, string teachers need to prioritize the various tasks to be accomplished in string education. The purpose of Kotchenruther (1999) was to describe the rehearsal priorities of 12 middle school string teachers. Participants’ overall rehearsal priorities were determined through interviews, rehearsal observation, and through their evaluation of student performances. It was found that middle school string teachers prioritize fundamental criteria the highest, followed by physical criteria, then expressive and interpretive criteria.

Lyne (1991) used qualitative techniques to develop a theory of string class pedagogy. The model of teaching sequence that evolved included teacher assessment, diagnosis, and prescription. “Areas of learning which were examined in the sequence were students’ playing technique, understanding of musical concepts, and level of intrinsic motivation with regard to classroom pacing.” (p. 2063) What emerged
was a method for teacher self-examination.

The National Standards (Music Educators National Conference, 1994) outline achievement standards for all music students. These National Standards include 9 achievement standards for what students need know and be able to do to be considered musically educated. Riveire (1998) investigated how teachers were incorporating National Standards into string classes with particular emphasis on improvisation. In a survey of 158 randomly selected string teachers it was found that the teachers’ attitudes were generally highly positive, but their confidence in teaching and performing improvisation was somewhat lower. Moderate correlations were found among high attitude rating, high self-confidence in performance skills and improvisation teaching. Emphasizing basic technical skills and time limitations were two reasons given by teachers who did not emphasize improvisation in their teaching.

Individual personality characteristics have an impact on a string teacher’s effectiveness. Russell (1981) designed and validated two forms of the Inventory of Music Education Behaviors in order to investigate the leadership styles of orchestra conductor-educators and orchestra members. While drawing no conclusions concerning the perceived leadership styles, Russell noted preliminary findings that included a hierarchy of styles, strength of styles and the relationship between conductor and orchestra perceptions of leadership style.

Preparation and education have an impact on the effectiveness of string teaching. Allard (1992) compared the effectiveness of 12 specialists and 9 non-specialists who taught beginning elementary strings. Classes taught by specialists had higher performance quality. Specialists were assigned more students, but the correlation between number of assigned students and performance quality was low. No difference was found between specialists and non-specialists in overall getting ready time, tuning time, music organization, percent of non-performance teaching time or percent of performance time used in the classroom.

While most of the research on string teaching effectiveness focused on large ensemble settings, the effectiveness of string teaching in a private studio setting has also been investigated. Gustafson (1986) investigated the psychological behavior between four violin teachers and their students in a one-on-one setting. Four violin teachers and four of their students participated in the project. The students ranged in age from 11 to 17 years. Videotapes of lessons were made in conjunction with a seminar that was organized for private studio
teachers to discuss their work. Episodes of interaction between teacher and student were videotaped and analyzed in light of Freud’s theories of defense mechanisms of the personality. In the analysis the author and the teacher involved discovered how the teacher’s own defense mechanisms affected lesson content the teacher’s response to student defenses and reactions. “All four teachers reported that the concept of the psychological defenses had alerted them to the possibility of latent personal agendas unfolding in the private lesson.” (p. 138)

Pre-service teachers are those in teacher training programs that prepare them to be effective in the classroom. While an emphasis is placed on improving teaching effectiveness, concern is also placed on developing student self-efficacy and occupational identity. Barnes (2000), in a survey of 18 preservice teachers, found that while ratings of teaching effectiveness increased over the course of an academic year, levels of self-efficacy (a belief in one’s capabilities) decreased slightly. However, changing levels of self-efficacy did not influence teaching effectiveness scores.

L’Roy (1983) used a Symbolic Interactionist framework to explore the development of occupational identity of 165 undergraduate music education majors. The approach used in this study confirmed that role development resulted from the interaction of students, faculty and the training environment. Students’ development of occupational identity was hampered by their lack of commitment to specific work-related skills and to a clearly defined body of knowledge. Among the many specific findings were that there were significant differences in the development of occupational identity among band, choral, and string students. According to L’Roy, “Students who had had teaching experience reported a stronger perception of themselves as music educator and the also expressed a stronger commitment to continuing in music education in comparison to those who had not” (p. 239).

One of the concerns that is faced by pre-service teachers is getting a string teaching job. Kopetz (1980) examined use of non-job related criteria (sex, applied instrument, and type of institution attended) in selecting first-year instrumental music teachers for a job interview. It was found that recruiters do use non-job related criteria in making interview decisions.

Pre-service teachers provide researchers with an excellent resource for discovering student attitudes that can impact on teaching concerns. One of the concerns faced by teachers is the ability to recruit students to string teaching. Gillespie and Hamann (2000) surveyed 153 string music education students at 17 universities to identify potential
strategies to attract orchestra students to string teaching. Respondents suggested that teachers be role models, demonstrating their love for music and teaching, “relating positively, giving special teaching opportunities and support to students interested in teaching, discussing the rewards of teaching and challenging students musically” (abstract).

**String Learners**

**Undergraduate**

The second part of the teacher/learner dyad is the learner. Discovering how students learn is an important component of developing effective teaching strategies. Age is an important factor in exploring student learning processes. Therefore, research into student learning of music, specifically string music, will be presented here according to age groups: undergraduate college/university students, preschool/early childhood, and secondary school students. Studies that compare learners from multiple age groups will be presented last.

Undergraduate students, both music majors and non-majors provide a convenient population for investigating how students perceive specific music phenomena. McDonald (1999) investigated how string performers, music majors, and non-music majors rated four performances for overall musicianship or the appropriate use of vibrato. In general the most musical performers used vibrato on significantly more notes, and their vibrato rates were slightly faster. Among the other findings, “non-music majors discriminated the least musical performances less effectively than did music majors and string performers.” (p. 1387) Vibrato and perceived musicianship were strongly correlated.

With 120 undergraduate subjects, Rentz (1992) addressed the following questions: “(a) Do musicians and non-musicians attend similarly to instrument families in an orchestral excerpt? (b) Do musicians and non-musicians change their aural focus on instrument families with similar frequency? and (c) Are musicians and non-musicians able to estimate the amount of time they spent in each category over the six-minute period.” (p. 186) Non-musicians focused longer on brass and percussion. Musicians focused on strings longer and selected strings more frequently. Musicians also demonstrated more ability to focus on three or more families of instruments simultaneously than did non-musicians.
Geringer and Madsen (1998) sought to ascertain if musicians demonstrate consistent listening patterns across good and bad vocal (soprano and tenor) and string (violin and cello) performances. The 48 music student raters consistently distinguished between good and bad performances and most often identified intonation as the element needing improvement, with tone quality second. Significant differences were found across the four timbres used with soprano consistently being rated the highest, while tenor, violin, and cello received similar ratings.

In addition to focusing on how students respond to particular music phenomena, researchers have also investigated how students are influenced by others in their expressed responses. Furman and Duke (1988) examined how statements of preference by group members affected the responses of individual group members. Ten pairs of musical excerpts from popular music and from orchestral music were used as treatment. In 8 of the 10 pairs either pitch or tempo or both was either increased or decreased by 12% in one of the pair, and subjects were asked to indicate a preference for one item within the pair. Subjects were tested in groups of four, but three of the four in each group were confederates in the experiment. The confederates were instructed in advance to give unanimous preference responses according to a predetermined list. When the excerpts were of popular music, no significant differences were found between music major and non-music major responses. However, when the experimental excerpts were orchestral, non-music majors’ publicly stated preferences were significantly affected by the preferences of the confederates.

Researchers have also explored personality as a factor of instrument played. Kemp (1981) used Cattell, Eber, and Tatsuoka’s Sixteen Personality Factor Questionnaire form 16PF (1970) to determine personality differences among 630 British college and university music students divided into five groups: strings, woodwind, brass, keyboard, and singing. Only a small number of group differences were significant. The only significant finding for string players was that string players were rated as more aloof than the composite profile while keyboard players and singers were rated as more outgoing.

A number of researchers have focused on performance related injuries among university music students. Manchester and Flieder (1991) reviewed the medical charts for all students with performance related upper extremity problems who attended a university-level music school in the Northeast from 1986-1989. Among their findings were that “those who play string and keyboard instruments are at higher
risk for hand injury than those who play woodwind and brass instruments, regardless of gender.” (p. 13) Women experienced a higher injury rate than men in this study. Muscle overuse syndrome accounted for 50% of the diagnoses reported, tendinitis accounted for 16%, other musculoskeletal diagnoses accounted for 16%, and neurologic disorders (carpal tunnel syndrome, digital nerve compression, ulnar nerve compression) accounted for 9% of the diagnoses reported. Treatments included partial rest, heat, ice, medications (such as non-steroidal anti-inflammatory drugs), exercises, more frequent breaks, and alterations in technique.

Roach, Martínez, and Anderson (1994) investigated musculoskeletal pain among university students who played musical instruments at least 7 hours per week and those who did not. They also explored the relationship between the instrument played and the site of reported pain. Subjects were 90 instrumentalists (19 violinists, 67 pianists, 13 guitarists, 17 percussionists, and 14 horn players) and 159 non-instrumentalists. Subjects completed a questionnaire regarding presences and location of joint pain within the preceding four weeks. While instrumentalists were no more likely than non-instrumentalists to report joint pain in the preceding month, they were twice as likely to report upper body pain and shoulder pain, and three times more likely to report elbow, wrist or hand pain. “Compared with all the subjects who did not play the instrument: the students who played the guitar were 13.8 times more likely to have elbow pain and 5.7 times more likely to have wrist pain; those who played the violin were 6.3 times more likely to have upper-back pain and 6.5 times more likely to have shoulder pain.” (p. 125)

Zeigler (1997) investigated tinnitus (ear noise) among college music majors and non-majors. On the 556 surveys returned, more music majors than non-majors reported developing tinnitus. Among the music majors reporting tinnitus, percussionists had the highest incidence of tinnitus with string players reporting the lowest incidence. “The most frequently listed cause for tinnitus was exposure to excessive noise, and nearly half of the music majors surveyed reported developing tinnitus from ensemble rehearsals” (p. 2128). While most students indicated that they do not currently practice hearing conservation, they also indicated they are likely to take precautions in the future.
Preschool and Suzuki

Suzuki instruction is a method most often associated with string teaching and begins with very young children. Therefore, string researchers have conducted a number of studies regarding Suzuki instruction and its effects on music learning of children. Specific Suzuki techniques are not presented here. Rather it is the effect of Suzuki on student achievement and attitude that is presented here.

The purpose of Nelson (1985) was to identify the relationship between aesthetic responsiveness and age for music performed by subject on the violin. Forty-six violin students between the ages of 3 and 16.5 with at least 3 months Suzuki training participated. Results indicated that age is the primary factor in the development of aesthetic judgments in children.

Suzuki training not only affects the behavior of students, but it also influences the behavior of teachers. In a study of 80 3- to 5-year old children divided into five groups (individual Suzuki, group Suzuki, creative movement, organized preschool, and no organized preschool) Scott (1987) sought to determine if Suzuki violin lessons, Creative Movement classes and/or preschool classes had any effects on attending and perseverance behaviors. Behaviors of students were determined by analyzing videotapes of classrooms, lessons and two tasks designed by the experimenter. From the observations it was determined that subjects receiving Suzuki violin lessons (group and individual) demonstrated more on-task behavior, tended to have higher scores on each of the experimenter-designed attention tasks, and spent significantly more time on the perseverance tasks than either of the other two experimental groups (creative movement and preschool). Teachers of subjects receiving both individual and group Suzuki violin instruction demonstrated significantly more teacher approval than did the preschool or creative movement teachers.

Stamou (1998) investigated the effect of Suzuki String instruction on the aptitude and performance achievement of beginning Suzuki string students. Forty-three beginning Suzuki string students and 73 general music students were pre- and post-tested using Gordon’s Primary Measures of Music Audiation. No significant differences were found though the Suzuki students’ pre-test PMMA scores were predictive of their string performance achievement after 22 weeks of instruction.

Barrett (1994) found that high socioeconomic status (SES) was a significant predictor of high scores on the PMMA for students between the ages of 6 and 8 from widely divergent economic backgrounds.
Suzuki training was also found to predict higher scores on the PMMA. However, no positive correlation was found between the musical proficiency of students with Suzuki training and PMMA scores.

In a study of pre-school children that did not involve Suzuki training, Gibson (1986) found that four-, five-, and six-year old children can demonstrate their understanding of music interpretation using non-verbal techniques. Using auditory stimuli, subjects were required to group stimuli into categories of interpretation. Stimuli included speech, singing and cello playing. All three groups of subjects’ mean scores were significantly above chance.

School-Aged Children

Because of an interest in developing and maintaining effective school orchestra programs, many researchers have focuses on school-aged children. The research that will be presented here focuses on four areas of concern: selection/retention of string students, improvement of rehearsal behavior, attitudes/preferences, and individual musical development. Technique and skill development research in string education were not included here. Rather, the studies presented here focus on perception, motor development, perseverance and injury for school-aged string students.

Recruitment of quality students remains an ongoing concern for school orchestra directors. Martin (1979) developed a technique for identifying potential orchestra members. Four areas were investigated: (1) musical abilities, (2) musical interests and activities, (3) personality, and (4) home background. Of the areas investigated, music ability as measured by Wing’s Tests of Musical Intelligence in combination with experience in playing an orchestra instrument and a measure of competence on the instrument were recommended as promising for predicting orchestra membership.

Stancarone (1992) investigated the efficacy of using aptitude, behavioral/attitudinal and academic achievement measures to select students for string instrument instruction. Stancarone found that, of the ten tests used, the standardized academic achievement test and the music aptitude test were the best predictors of string instrument success (r=.47 and r=.46 respectively). When the ten measures were analyzed according to the three categories, the aptitude set was the best individual predictor (R=.59) while the combination of aptitude and achievement measures yielded the highest overall prediction (R=.67).

Perkins (1999) related participation in public school orchestra
programs to Maehr’s theory of personal investment. Subjects were 1315 volunteer 6th through 12th grade orchestra students. Using the Spectrum String Education Participation, students indicated their personal incentives for participating in orchestra: (a) reasons for joining, (b) membership, (c) perceived available options, and (d) organizational structure. Perkins found that students join orchestra because of a desire to make music, the influence of the teacher, extrinsic activities, musical ability, extrinsic available options, and family influence. Students’ personal incentives were recognition, social, ego, task and extrinsic. Relationships were found between personal incentives-membership and both available options and organizational structure.

Once quality students are recruited, the problem for orchestra directors becomes the retention of students. Papinchak (1992) surveyed 39 string teachers, 192 string students, 191 parents and 176 peers to determine factors that affect retention among middle school string students. He identified 10 areas that may have an effect on retention: student is satisfied with instrument selection; pride in playing a string instrument is encouraged; parent wants student to continue playing; the student receives periodic progress reports; the student feels good playing in concerts; the teacher enjoys teaching strings; parents try to attend concerts; best friends are also in strings class; teacher provides individual help as needed; the school has a good strings program.

Research into retention sometimes focuses on identifying the reasons that students choose not to continue in orchestra programs. Allen (1982) surveyed 437 students to determine reasons for student withdrawal from junior high and high school orchestra programs. Among the factors that contributed to students dropping out were (1) changing teachers, (2) peer influence, (3) conditions of the instrument, (4) schedule conflicts and (5) music reading ability.

Morehouse (1988) identified 16 attitudinal predictors of student dropout and retention in beginning string instruction. Student attitudes toward string instruction were assessed using the String Student Assessment Measure (SSAM) developed by Morehouse in an earlier study. Teacher attitude toward students was assessed using the Minnesota Teacher Attitude Inventory (MTAI). Forty-seven Texas string teachers and 1229 beginning string students participated in the study. Sixteen variables were found to significantly predict student drop out and retention in beginning string instruction: (1) attitude toward strings as a class; (2) attitude toward music played; (3)
expected overall school grade; (4) attitude toward string teacher; (5) attitude toward string classmates; (6) string teacher MTAI raw score; (7) attitude toward string instrument chosen; (8) attitude toward playing in concerts; (9) ownership of instrument; (10) general overall negative string class experience; (11) perceived parent support; (12) sex of student; (13) private string lessons; (14) attitude toward practicing; (15) expected string class grade; and (16) perception of improvement in playing.

Hurley (1992) investigated motivation and achievement in relation to student decisions to continue/discontinue participation in a string instrumental music program. Interviews were conducted with six fourth-grade beginners, six sixth-grade students who were continuing string instruction, and nine sixth-grade students who had discontinued string instruction. Hurley concluded that among the many factors that influence student motivation, “the impact of ‘cost of participation’ on task values ultimately influenced the achievement behavior of choice.” (p. 2727)

Mowrey (1993) used the Myers Briggs Type Indicator along with basic information and exit questionnaires to find out what influence selected personality variables have on the attrition rated among sixth- and eighth-grade string orchestra students. Mowrey concluded that there is a significant difference in how students that persist and students who drop out perceive information and that students with less well-developed perceptive ability are more apt to drop out.

Hallam (1998) investigated the relationships between time spent learning, ability factors, and aspects of perseverance on instrumental student outcomes. One hundred and nine children ages 6.6 to 16.3 years old that were learning to play either violin or viola participated in the study. The best predictors of overall musical achievement were length of time leaning (beta weight .78) and ability to understand instructions (.23). Quality of achievement was best predicted by teachers’ ratings of musical ability. Dropping out was best predicted by ability to understand instructions and intention to practice. “It seems that it is the child’s own attitude to practice and their intention to undertake it which is ultimately of importance in whether they continue to play or not, rather that the support of parents, teachers, or friends.” (p.127).

Research into rehearsal focuses on the behavior of the individual student within an orchestra rehearsal, string class or string ensemble rehearsal. Horn (1982) in a survey of 164 second-year fifth- and sixth-grade students of clarinet, trumpet and violin, found that there is a
difference in rehearsal behavior according to the instrument played.

Thomas (1989) explored the effect of positive and negative reinforcement on the on-task behavior of students in a beginning string class. Positive reinforcement tended to yield higher attentiveness behavior than negative reinforcement though negative reinforcement did not tend to lower attentiveness once attentiveness was established. Fluctuation of teacher approval/disapproval rates had no effect on the amount of on-task behavior.

Salzberg and Greenwald (1977) investigated the effect of a point system on attentiveness and punctuality in two string instrument classes. In class one, practicing increased from 74% to 92% and in class 2 practicing increased from 54% to 85%. Punctuality increased to 100% (from 46% to 51%) when the point contingency was in effect. Subjects were 21 seventh-grade students enrolled in the second year of string instruction in a university laboratory school.

In a qualitative study, Johnson (1991) described musical experience from the perspective of students within a secondary orchestra rehearsal. An analysis of the data revealed three multidimensional aspects of musical experience:

(1) Psychosocial with five dimensions Playing music should be enjoyable Desire for recognition Competition versus cooperation Perceived student attitudes Pragmatic issues

(2) The teacher’s role with four dimensions Perceptions Rehearsal strategies Teacher expectations An expressed need for additional teachers

(3) musical awareness with three dimensions. Experiential knowledge Conceptual/technical knowledge Musical responsiveness

Two studies have focuses on children’s attitudes toward music and toward playing musical instruments. Nierman and Veak (1997) investigated children’s attitudes toward playing wind and string instruments. While no relationship was found between musical aptitude and attitude, the method of instruction and socioeconomic status combined to affect children’s attitudes. Mooney (1994) investigated the effect of gender, ethnic background, educational placement, prior music training and socioeconomic status on the music attitudes of students in the strings on a Saturday morning program in New Orleans. Mooney also investigated parent attitudes and student and parental background variables. Students and parents
in the program were found to be highly motivated and approved of program content and methodologies. Also, no differences in student or parent attitude were detected for school placement, ethnic group, age, gender, residence or socioeconomic background.

Researchers have focused on the preferences of children not necessarily involved in orchestra or string music for various types of music that include string music. Webster and Hamilton (1982/83) investigated the effect of group peer opinion on musical preferences of fourth-, fifth-, and sixth-grade students. In addition to the four generic styles of classical, rock, folk-country, and jazz, additional effects included rhythmic quality (marked or unmarked) and violin timbre (presence or absence). Students were not easily influenced by peers. A clear preference was found for excerpts with marked rhythmic quality and non-violin timbre.

Holton (1991) analyzed children’s responses to musical examples played on acoustical and synthesized instruments to determine if children preferred acoustical or synthesized timbre and if this preference was affected by experience playing an instrument, six, grade, or school. Holton concluded that children prefer to listen to synthesized timbre rather than acoustical. Of the acoustical timbres, string and band instrument timbre was most preferred, followed by band instrument timbre and string instrument timbre.

Experience with music performance in different venues may affect student attitude toward music. Carmody (1989) examined the effects of playing in a chamber music ensemble on junior high string players’ ability to play in tune and on their attitudes toward music. Carmody found that those students involved in a chamber music experience improved more in both intonation and positive attitude than students with only large ensemble experience.

Another area that can affect student attitude toward music is participation in private instruction. Hamann and Frost (2000) wanted to determine the relationship between practice habits and attitudes of string students who study privately and those who don’t. Students who study privately tend to practice longer and more efficiently. They set aside certain portions of the day for practice. They practice for the challenge, but also to gain approval or position. Students who study privately will practice even if it interferes with their homework, social, or family activities. They will practice even after they are physically exhausted.
The ability of school-aged to identify elements of music such as tempo change has concerned many researchers. Wang and Salzberg (1984) investigated 7- to 18-year old string students’ ability to identify tempo changes in synthesized performances of familiar string literature. The number of correct responses given by the subjects had a significant curvilinear relationship with both years of musical training and with age. Although the musical variables of speed, style, and direction of change contributed significantly to the regression model above and beyond individual differences and style, these three variables accounted for only one third of the variance.

Coordination, particularly motor development should be a concern of string orchestra educators. Baer (1987) examined the relationship between music aptitude and motor development and between instrumental music achievement and motor development. Low moderate correlations were found between musical performance achievement and motor development (+.26) and between music aptitude and motor development (+.33). Of particular interest to string teachers is that higher correlations were found between musical performance achievement and motor development for string instrument players than were found for wind and percussion instrument players.

Finally, teachers need to become familiar with the existence of performance related injuries among school-aged string players. Lockwood (1988) surveyed 113 orchestral students in the Houston High School for the Performing and Visual Arts and instrumentalists of the Houston Youth Symphony. Among the findings was that players of large string instruments reported more problems than players of small string instruments. Females reported more problems than males (68% of females to 47% of males). The rates of reported problems in Lockwood’s study were similar to rates reported by professional musicians in Fry (1986). Lockwood recommended that “teachers need to take special care to foster proper technique, especially in girls, and to teach their students that pain is a symptom of injury that is potentially dangerous to their careers....The data also suggest that the proper education of music teachers should include an upper extremity conditioning program, tailored to the specific demands of the instrument, designed to be taught to students as an integral part of learning to play.” (p. 132).

Shoup (1995) investigated performance related problems among high school and junior high musicians. Four hundred twenty-five band and orchestra students were surveyed. About one-third of the students
reported having at least one musculoskeletal performance-related problem since they started playing their instrument with half reporting the problem as current. However, the problems were not severe, and students rarely needed to miss rehearsals or quit playing their instruments for more than a week. Shoup also reported that “Although a large percentage of the students warmed up and took breaks, an alarming 44.0% believed in playing through pain....This attitude may tend to encourage and prolong musculoskeletal performance-related problems” (p. 104).

Professional Orchestra Musicians

While only a few of the students in school orchestra programs become professional orchestral musicians, it is important for string educators to understand the challenges faced by professional musicians. Understanding the development of performance competency allows the string teacher to be a more effective educator and to communicate more accurate information and encouragement to students who express and interest in professional musicianship. In a qualitative study, Heaney (1994) sought to find out what variables of a string education tend to help in the development of outstanding orchestral performers. After identifying the intrinsic and extrinsic variables and processes involved in developing performance competency, Heaney proposed models for string learning, string education and string research.

Lipton (1987) surveyed 227 professional orchestra musicians and asked the musicians to rate themselves and each of the four orchestra sections (strings, woodwinds, brass, percussion) on a series of 7-point scales in regard to stereotypes and personality traits. Strings and brass were consistently on opposite ends of the continua.

Edwards (1990) explored employment patterns of regional and major symphony orchestras with regards to black and non-black musicians. The second purpose was to describe background characteristics and experiences of black and non-black musicians in the 75 orchestras surveyed. Edwards found that fewer than 2 percent of the musicians employed were black, which showed little change in employment patterns since 1977. While the background experiences of black and non-black musicians were similar, few qualified black musicians were found to apply and audition for the available openings.

Performance related injuries can be of concern to professional orchestra musicians. Sanders (1996) analyzed physical injuries of musicians, particularly string players. Each injury is defined in medical
terms, and thirty-nine therapies for injuries are included. Bejjani (1988) used surface electromyographic (EMG) activity of various muscles to establish baseline parameters of performance of vibrato by professional violinists. These parameters could be used in future studies to investigate causes of musculoskeletal disorders in violinists.

Hearing loss is of particular concern to professional musicians. Woolford et al. (1988) summarized research to date on hearing loss among symphony orchestra musicians. Also, 59 Chicago Symphony Orchestra members were assessed for risk of noise-induced hearing loss in a study by Royster, et al. (1991). Fifty-two point five percent of the individual musicians had some indication of hearing loss. Violinists and violists showed more hearing loss in the left ear than in the right ear due to the left ear’s greater exposure to the instrument.

Multiple Age Groups

The research reviewed so far has been categorized according to single age groups. However, several studies have compared musical development and attitude of more than one age group. Kauffman (1987) examined the effect of six factors - retention interval, musical experience, compositional genre, compositional style, repetition of the musical event to be remembered, and isolation of the music to be remembered - on memory of musical stimuli. Among the findings was that compositions in the woodwind genre were recognized better than symphonic music, string quartets or solo piano music.

Schultz (1995) wanted to determine whether perception of talent would affect ratings of musical performance (Mozart’s Violin Concerto in A Major). Performances by students depicted as talented were rated significantly higher than performance by students depicted as hard working. Nature-nurture beliefs did not affect ratings.

Wapnick, Mazza, and Darrow (1998) investigated whether dress, stage behavior, and physical attractiveness would affect judges’ ratings of violinist’s performances. Performers who were rated high on stage behavior and on dress benefited from audiovisual evaluation over audio-only evaluation. Violinists who were low on stage behavior and on dress were not rated differently in audiovisual and audio-only presentations. Performers who were rated as attractive received higher ratings in both audiovisual and audio-only presentations, which confirms earlier research on attractiveness.
Johnson and Kelly (1995) focused on listening patterns among junior high students and undergraduate and graduate collegiate music majors. Participants listened to excerpts from five orchestral pieces and indicated which instrumental family they were attending to: strings, woodwinds, brass, percussion, or all. There were no important differences between junior high students and undergraduate students. However, graduate students spent significantly more time listening to strings and less time listening to all than either undergraduate or junior high students, contradicting previous research findings regarding the tendency of older students to focus on gestalt rather than specific elements when listening to music.

Performance anxiety is a concern to string players of all ages. Steptoe & Fidler (1987) assessed 146 musicians in three groups (experienced professional orchestral players, music students, and members of an amateur orchestra) for performance anxiety. “Performance anxiety was lowest in the professional group and highest among students. In all three groups, performance anxiety was related to neuroticism and everyday fears notably fear of crowds and social situations....Catastrophizing was positively linked with performance anxiety in all groups, while realistic appraisal of the performance situation was used most commonly by those with moderate levels of stage fright.”(p. 241) Factor/self-statements under investigation were catastrophizing, positive thinking, mixed strategy, blasé attitude, realistic appraisal, and audience sensitivity (approaches to dealing with stage fright).

Neftel, et al. (1982) investigated the effect of beta blockers in acute anxiety and on the technical-motor performance of 22 performing string players. Heart rate was significantly lower under beta blockade than under placebo (p< .001). Also, stage fright, as measured before performances, was not affected by beta blockade, while stage fright during the concert (as measured after the concert) was significantly reduced by beta blockade.

Orchestral programming may be of interest to music educators. Price, Yarbrough and Kinney (1990) used college theory and composition faculty opinion and major American symphony orchestra programming practices to determine relative eminence of American composers. A moderate relationship (.46 to .49) was found between perceived eminence and programming selection. Faculty were asked to identify 243 different composers whom they felt deserved to be designated among the top 10 living American composers; of those so designated, only Copland, Carter, and Crumb mentioned by more than 50% of
respondents. Researchers also investigated the programming practices of selected professional orchestras. Music by 51 different living American composers was programmed with only Copland, Schuman and Druckman performed on more than 4 programs by more than 4 orchestras.

**String Programs**

In order to better understand how to improve string instruction, string educators can learn from the examples set in other school programs. Before exemplary studies can be evaluated, string researchers must establish a baseline of what is currently offered in string education. Gillespie and Hamann (1998) surveyed 652 schools to gather descriptive information regarding school orchestra programs. Among the findings are that larger schools are more likely to offer orchestra instruction, the majority of students and teachers are white, more than two-thirds of the students who begin a string instrument continue to graduation, and twenty percent of orchestra students are in the upper 10% of their graduating class even though they make up only 5% of the student population.

String program effectiveness can also be evaluated using tools from other disciplines. Tully (1989) used fourteen characteristics of effective schools (as identified in a previous study) to compare successful instrumental music groups with less effective instrumental performing groups. Ninety bands and orchestras from Massachusetts, New Hampshire, New York and Rhode Island participated. Twelve of the 14 variables from the original study applied to instrumental music performing groups (p. 1208).

1. Clearer understanding of (musical) academic and behavioral goals
2. Higher level of order and discipline
3. Higher expectations for achievement
4. More caring
5. More public recognition for student achievement
6. Stronger parental support
7. Stronger community support
8. Higher allocated rehearsal time
9. Higher teacher contact time
10. More time on (instrumental music) task
11. Greater variety of teaching styles
12. More opportunities for student responsibility

Townsend (1999) described beginning string classes in Indiana middle/junior high schools using five criteria: principles of Discipline Based Music Education, research and related data contributed by expert music education theorists, general education theorists and the business world, and views regarding randomly selected Indiana string education practitioners. Of particular interest in this description was the use of DBME components within many of the examined curricula.
and that DBME could help establish a framework for helping students to attain the 18 proficiencies in the Indiana 1994 Music Curriculum Guide.

Two researchers have developed tools to evaluate string program instruction. Masear (2000) developed a tool to evaluate elementary string programs for students in grades 3 to 6. The test items were based on the National Standards for music and studies done by string pedagogues and researchers. Braithwaite (1983) developed a model with which to evaluate string programs in four areas: retention, performance, cognitive achievement and attitude. The model included elements of self-evaluation within the string program, evaluation by external or supervisory agencies, and establishment of competency standards for string programs. The model created a means for comparing programs and was found to be adaptable to other music programs such as choral and band.

String programs have been investigated in order to examine how successful schools address social problems such as inclusion and diversity. Ensley (1988) examined the characteristics of and methods used in four successful string programs all of which involved significant numbers of Hispanic students. Among the conclusions were that the programs were inclusive so that all interested students had the opportunity to study strings. Also, the successful programs included Hispanic music which, due to a lack of published music, had to be arranged by the teachers. It was not necessary for teachers to speak Spanish, but developing relationships with the Hispanic community was important.

Many music educators would expect performing arts magnet schools to include all forms of musical training, so Neal (1986) identified and assessed 27 performing arts magnet programs for inclusion of string programs. Findings were that only half of the performing arts schools assessed offered string programs; there was a lack of comprehensive string curriculum among the programs; the string students required in-depth musical and academic training; and the programs were located in urban settings and funded locally.

Historical research can give clues to string educators on designing effective string programs. Howe (1994) described the contributions of Julius Eichberg (1824-1893) who taught string education and vocal music in Boston. Among his many accomplishments, Eichberg founded the Boston Conservatory, published string method books, composed operas and choral works, and edited music textbooks. Gardi (1996) outlined the expansion of vocal string, instrumental and keyboard

In a pair of studies, Smith (1997, 2000) appraised string education at the school district level rather than by string program. Smith (1997) examined access to string instruction in American public schools. Among her findings were that “String instruction was offered most often in average-socioeconomic-level, medium-sized, urban districts in the Eastern, North Central, and Northwest Music Educators National Conference divisions, and in average-socioeconomic-level, large, metropolitan districts in the Southern, Southwestern, and Western divisions. String instruction was offered least often in low-socioeconomic-level school districts regardless of location or size.” (p. 650) Smith (2000) described string programs in 60 school districts where more than 25% of the children fell below the U. S. Census poverty level. Among the findings were that 43% of the districts provided school district funds for music and supplies. Twenty-eight percent of the districts used outside funding to pay string teachers’ salaries. Fifty-four districts offered high school orchestra, 51 districts offered middle school string classes, and 42 districts offered elementary string classes.

Several studies have appraised school music programs of various states in the United States. In a survey of 446 principals, Wadsworth (1981) developed criteria to determine the current status of school music programs in Iowa. Among his seven recommendations for improvement of Iowa music programs was that “all schools should provide string instruction.” (p. 2016) Morris (1984) focused on a comparison of string instrumental music programs in New York, Philadelphia and Boston. While acknowledging the variations in progress among the evaluated programs, Morris concluded that relative vigor of the programs was affected by social, political and economic change and the commitment and dedication of music education administrators and educators. King (1991) compared participation in secondary school music classes with curriculum reform in Virginia from 1979-1988. While some programs experienced decreased enrollment, one division that developed a secondary music appreciation class and added a string program experienced an increase
International music programs also provide relevant information for string educators to examine. Waldie (1993) profiled the current state of public school music education in the province of Manitoba. While much of the discussion focused on the overall music program, two findings were directly related to string education. The number of guitar and keyboard programs appears to be growing while orchestra/ string programs are declining.

Chen (1993) documented the development of string education in Taiwan with particular emphasis on development since 1951. During this period, Taiwan experienced an increasing number of gifted music classes, music departments, orchestras, and chamber music groups. The author made two proposals to further Taiwan’s growth in string education: a complete and independent music education system and a scholarly professional string organization.

Through a series of interviews Borges-Scoggin (1994) identified problems in string instruction in Brazil. Among the topics explored were: little music tradition, availability and quality of basic instruction, undergraduate and graduate instruction, shortage of prepared teachers, inaccessibility of instruments and materials, and limited opportunities for secure, decent paying jobs.

Finally, community programs also provide students with a means of obtaining a quality string education. Chung (1990) explored via case study the Boston Symphony Orchestra’s Youth Activities Programs, a series of arts enrichment programs designed for elementary and secondary public school students that include philosophical foundation, program and outcomes.

Schafer (1983) identified youth orchestras in Pennsylvania. He then analyzed administrative structure and examined opinions and attitudes of participating students. Involved students generally perceived the youth orchestra as helpful in improving musicianship, and in providing social interaction and an opportunity to perform quality literature. While instrumental music teachers generally support the concept of a youth orchestra, they reported concerns regarding student participation and communication between youth orchestra leadership and the school instrumental music teacher.

Blaker (1996) surveyed schools in the National Guild of Community Schools of the Arts that advertised having Suzuki violin programs. Survey questions focused on four aspects: (1) size of faculty, (2)
student enrollment, (3) characteristics of Suzuki teachers in the program, and (4) characteristics of the program itself. After the average data are presented, an ideal Suzuki program within a Community Music School is defined.

If effective string education begins with effective string teachers, programs to develop future string educators should be investigated. Smith (1995) examined undergraduate string teacher education in American colleges and universities. Institutions in the North Central Division require the most separate strings techniques and methods courses, require the most contact hours per week, and have the largest number of string education specialists teaching the courses.

Smith (1994) examined practices in Florida colleges and universities to determine types of string teacher training in music education curricula and to what extent future music teachers are being prepared to meet string and orchestral competencies. Eleven of the fifteen schools surveyed required at least one semester of string skills/techniques. Only three of the fifteen schools required a semester course focusing on string methods/pedagogy, but only one of the schools required the course for all instrumental education majors. One school combined skills/techniques and method/pedagogy into one class. In her investigation of string teacher performance competencies, Smith found that only four schools required their students to master most of the competencies. With regards to teaching competencies, only four schools required students to master some competencies with only two requiring demonstration of mastery in laboratory situations.

Chenault (1994) compared the status of music education programs in North Carolina and compared his findings to those reported in The Status of Arts Education in American Public Schools. Among high school respondents it was reported that string performance groups were infrequently offered and strings were not included in elementary and middle/junior high school results. Chenault concluded that North Carolina music programs were similar to those sampled in the national study.

In two separate surveys, Cooper (1994) identified the most important areas for the core curriculum of instrumental music education courses according to band directors and teachers of band methods courses. Among the findings related to strings, school band directors indicated that topics such as “History and Philosophy of Music Education” “String Methods,” “Choral Methods,” “Research in Music Education,” and “Learning Theories,” could be eliminated from the band methods course. Seventy-four percent of the respondents believe that
instrument method courses (woodwind, brass, percussion, strings) should focus primarily on a combination of performance and teaching skills. Respondents also expressed a need for more (and earlier) field experience, higher admission standards and more rigorous expectations.

Developing an effective string education system is the goal of educators and researchers alike. In order to do this educators need to be made aware of how students learn, what student attitudes affect learning and retention, and how effective programs address the many issues facing string educators. This paper has summarized those studies related to people and programs in string education. While much has been accomplished, there is yet much to be discovered about how children learn and how teachers can most effectively assist the education process.

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