QUALITY OF THE TEACHING PROCESS AS AN EXPLANATORY VARIABLE IN LEARNING GYMNASTICS SKILLS IN SCHOOL PHYSICAL EDUCATION

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Abstract

The aim of the study was to seek explanatory factors for learning gymnastics skills in school physical education. One hundred four 7- to 16-year-old students from 19 teaching groups and 23 teachers participated in measurements over 3 years of follow-up. A group of tests measured the skills in apparatus gymnastics and motor abilities. Videotapes were used to observe the teaching events. The focuses for observation were divided between the factors for input, process, and feedback. Factor analysis, regression analysis, and automatic interaction detector (AID) analysis were used in data processing. In the explanatory model for the factors in a teaching event, most explanation was on the quality of practice to improve gymnastics skills. It was possible to compensate for qualitatively weak feedback in teaching with a good transfer effect, and to compensate for a weak transfer effect with good feedback. The competence of the teacher can be emphasized significantly through, for example, the scholastic management of physical education and pupil awareness. This combination guarantees the individuality and continuity of teaching.

Keywords: *gymnastics, physical education, skills, teaching, quality.*

INTRODUCTION

The development of the motor ability and sports skills of pupils has been considered important in the physical education (PE) curriculum. The importance of different forms of sports has been emphasized for pursuing life-long physical activity and for the versatile development of fitness and motor abilities. Examining teacher and student behavior during physical education lessons means the evaluation of school physical education and teacher training. In research into school physical education, the process of teaching and its results are generally examined independently of one another. A qualitative assessment of the factors in teaching provides knowledge about the nature of physical education. Through process-product research, the explanatory factors for learning skills can be sought.

Physical education effectiveness research is mostly based on a process-product setting where relationships between teacher behavior and student achievement and the efficacy of different teaching methods are studied. The tasks in effectiveness studies have generally been skills in different sports. The length of the teaching unit and the number of lessons have been the function of the relative ease or difficulty of learning a task. The total teaching time of the lessons has varied from a single 15-minute lesson (Yerg and Twardy, 1982) to 15 hours of instruction over a series of lessons (De Knop, 1983).

The entry level has been one of the most important variables in studies with short-term duration. In Yerg's (1977,

1981a) studies, 75% of the total variance of the final level of achievement in the task was explained by the entry level of the performance. The variance was lower in other studies: 46% in Piéron and Piron's (1981) study and 31% in Yerg and Twardy's (1982) study. In long-term studies, the importance of the entry level is less significant. De Knop (1983) found in a 15-hour follow-up that the amount of entry level skill explained by the final performance varied according to different aspects of the performance: 17% for the skill test, 18% for motivation, and 56% for the technique. At least a small amount of the connection between the entry level and skill improvement can be explained by the findings according to which high-skilled students spend more time on-task than moderate or low-skilled students (Graham, 1987a; Grant, Ballardt, and Glynn, 1989; Landin, 1995; Shute, Dodds, Placek, Rife, and Silverman, 1982; Telama, Varstala, Heikinaro Johansson, and Utriainen, 1987).

Most effectiveness studies have corroborated the importance of the time spent practicing the criterion task or the number of practice trials. De Knop's study (1983) found the time allocated for practice to be related to teacher effectiveness. In other studies (e.g. Piéron and Piron, 1981; Metzler, 1983; Phillips and Carlisle, 1983), this connection has not been replicated. Just being in class longer does not guarantee greater achievement. What students actually do during a lesson is more important (Da Costa and Piéron, 1992; Piéron and Piron, 1981; Yerg, 1977, 1981a). Phillips and Carlisle (1983) reported that teachers in the more effective group provided their students with more than twice the amount of engaged skill learning time than the less effective teachers.

In Yerg's (1977) study, the influence of practice was greater than the teachers' knowledge or personal skill of the subject matter. On the other hand, practice without feedback is not necessarily effective. In Yerg and Twardy's (1982) study, practice negatively influenced the pupils' outcome in lessons where teachers remained passive observers.

The amount of time students spend practicing at an appropriate or successful level is positively related to student achievement, and inappropriate or unsuccessful practice is negatively related to achievement (Ashy, Lee, and Landin, 1988; Buck, Harrison, and Bryce, 1990; Dugas, 1984; Piéron, 1983; Silverman, 1985a, 1990, 1993). The quality of the student engagement is more important than total practice (Ashy et al., 1988; Silverman, 1990; Solmon, 1992). Compared with the low learning group, the high learning group demonstrated a higher success rate for specific students (Piéron, 1983). Phillips and Carlisle (1983) observed that success during engaged skill learning was also found more often in the classes of more effective teachers.

Several studies have considered the clarity of teachers' presentation along with the amount of time teachers spend actually instructing a class as variables. Werner and Rink (1989) found, however, that inaccurate and global teacher statements do not aid learning. Graham (1987b) and Piéron and Graham (1988) demanded that research efforts in this area need to focus more on the variables closely related to the quality of the teacher's presentation, rather than on simple measures of time. Variables such as clarity, appropriate instruction, and the use of demonstration may lead to a better understanding of the function of a teacher's instruction in enhancing student learning. Masser (1993) found that biomechanically correct instruction consisting of words that related to body parts and were a part of a young learner's vocabulary promoted learning motor skills and helped in maintaining that improvement over a period of several months. Gusthard, Kelly, and Rink (1997) have found qualitative measures in teacher clarity and task presentation valid as process estimates of student achievement. Divergent results have been reported concerning the relationships between teacher feedback and learning outcomes. Studies that have shown a

connection between teacher feedback and student achievement have not proved feedback to be a major predictor of achievement (Eghan, 1988; Silverman, Tyson, and Krampitz, 1992). Yerg (1983) observed that the direction of feedback was relevant to skill improvement. Feedback for a single student referring to total movement was positively related to student achievement, and on the other hand, detailed informative feedback was negatively related to the student outcome on the same criterion.

Several studies have shown a facilitating role for teacher feedback. When students are learning a beginning balance skill, teacher feedback was found to positively influence student learning (Yerg and Twardy, 1982). The positive feedback was higher for more effective teachers in the volleyball unit (Phillips and Carlisle, 1983). In the study of tennis teachers, feedback accounted for 11% to 16% of the total variance of the final level in accuracy or skill and technique measures (De Knop, 1983).

Pellet and Harrison (1995) pointed out that feedback effects are limited if the difficulty of the task does not match the performance capabilities of the learners. According to Rink (1993, 1996), feedback is useful in adjusting the appropriateness of a task to a learner. This strategy is very useful for large group instruction. Da Costa and Piéron (1992) stated that the accuracy, faultlessness, and appropriateness of teacher task presentation and feedback were characteristic of the most effective teachers. Proficiency in the subject taught combined with the communication skills needed is the best guarantee for success in teaching.

In future research, concentrating on the quality of student practice could give important knowledge about skill learning. The role of a teacher should be to facilitate learning: developing a positive learning environment, creating more powerful learning relationships among teachers and students, and maintaining the cognitive processes of students at a high level are actions that improve learning (Lambert, 1996; Rink, 1996).

The purpose of this study was to determine the quality of the elements in a teaching event and seek the explanatory factors for learning skills in physical education lessons. The main ideas were a long follow-up time and the wide inspection of the concept of a teaching event. The motor skills studied were basic skills in apparatus gymnastics.

METHOD

Setting and Participants

The research was carried out as a 3-year follow-up in connection with the Intensive Physical Education Research Project (Nupponen, Halonen, Mäkinen, and Pehkonen, 1991).

A multiphase and nonprobability sampling were used to select participants. The schools were selected from six municipalities in Lapland participating in the Intensive PE Research Project, including five primary and three secondary schools from rural areas and cities. In the 1st year of follow-up, all the students in the first, third, fourth, and seventh grades in the respective schools participated in the measurement of gymnastics skills and motor abilities. The number of students participating in all six measurements during the 3-year follow-up was 280 (132 girls and 148 boys). In 3 years, a 23% subject attrition was observed. There was no difference between the attrition group and the other subjects in the pretest of gymnastics skills.

The analysis of the teaching event for apparatus gymnastics was based on the respective lessons given at the participating schools. The lessons took place in the school gyms, and the teachers were asked to give the lessons according to the school curriculum, as the teachers would normally. Both teacher's and student's actions were observed during gymnastics lessons in 5-minute periods. Recordings were made with a video camera and a cordless microphone for the teacher. The observed students were selected randomly from the student list of

the teaching group. During the 2nd and 3rd years of follow-up, the same students were observed as during the 1st year. Within the 3-year follow-up, each student had an average of 3.3 5-minute periods (variation from 1 to 8) in the data. The entire material consisted of 343 5-minute periods. Because of the big variation in the number of observation periods per student, the periods were assigned to represent cases, while the test scores of motor ability and gymnastics skills were entered under these periods. The complete matrix included 268 periods. The number of students included in the material was 104 (47 girls and 57 boys). During the 1st year of follow-up, the study included 19 teaching groups. During the 3 years, 23 teachers (12 female and 11 male) participated in the study. The number of PE classes was 78.

Tests and Data Collection

A group of tests that included four basic movement patterns measured the skills in apparatus gymnastics. These movements were body bending and stretching, rotating, jumping, and balancing. The test movements were underswing shoot dismount, hip circle, roll, cartwheel, support vault, and handstand. The level of the achievement in gymnastics skills was evaluated on a scale of 0 to 5. The scale describes the stages of learning (Fitts, 1964; Fitts and Posner, 1969) where 0 means an *unsuccessful trial*, 1–2 represents *the cognitive phrase of learning*, 3–4 *the associative phrase of learning*, and 5 *the autonomous phase of learning*. The skills were measured when the motor abilities were measured in which the focuses were muscle strength, flexibility, balance, and motor control. The tasks were standing 5-jump (it was used to measure explosiveness of leg extensor muscles in horizontal direction), flexed arm hang (for measuring relative strength and upper body muscular endurance), 30 second sit-ups (measures the strength and endurance of the abdominals and hip-flexor muscles), forward trunk flexion (measures the flexibility of the hamstring and lower back muscles), sidewards jumping (for measuring movement speed in lower extremities), one leg static balance (has been used to assess postural stability), figure-8 ball dribbling (measuring the ball handling and eye-hand and eye foot coordination), and target throwing (measuring the over arm throwing accuracy and spatial ability). The body build measurements were for height and weight.

The variables were standardized for comparison. To enable a comparison of time and gender, standardization was carried out over the entire measurement time to all the materials. The conversion factors for motor ability created by Nupponen (1997) were also used in this material. Variables for development were the differences between the pretests and the posttests. Body build was described using the body mass index (BMI).

The focuses for observation of the teaching event were divided between the factors for input, process, and feedback. There were four dimensions for observation for each of the three areas. The factors for input were observed in the instructions given by the teacher, the organization, the progress of skills, and the appropriateness of the tasks during teaching. The process factors observed were the perceptual behavior of the student, the quality of practice in skills, and the activities of the teacher in support of the short- and long-term memory of the student. For feedback, the factors consisted of the clarification of the quality of *corrective and* reinforcing feedback, the activation of the internalized feedback system, and the continuity of feedback.

The student was the focus of observation. The teacher's activities were evaluated on a scale of -1, 0, +1, where -1 refers to *preventive or detrimental behavior*, 0 is *neutral*, and +1 refers to *events that promote learning*. The measurements of the quality were completed by measuring the time-on-task for each student observed. The evaluation was made by the researcher who had over 20 years experience in teacher training.

Data Analysis

Factor analysis with the principal axis method and oblique rotation was used to reduce the number of observed variables. A four-factor solution was selected for interpretation. The factors were named Practice, Teaching, Feedback, and Transfer. Models for causal relationships, nonlinear connections, and interactions were described using automatic interaction detector (AID) analysis (e.g., Sonquist, Baker, and Morgan, 1971). In the first model, the dependent variable was the change in gymnastics skills in the 3 years described by the pretest and posttest differences. The independent variables were student gender, school level, motor abilities, body build, and the factors of the teaching event. In the second model, the dependent variable was a residual variable, which was formed with stepwise regression analysis. In this analysis, the proportion of body build and motor ability was cut off from the change in gymnastics skills. The independent variables in the second model were student gender, school level, and the factors of the teaching event.

Parallel observation measured the reliability of the assessment of gymnastics skills. The correlations between the scores of two observers varied from .72 in cartwheels to .96 in hip circles. The stability of test scores during the 3 years was examined with a simplex model of the LISREL method. The constancy coefficients of the summation variables of gymnastics skills varied from .87 to .93. The goodness of fit for gymnastics skills was .985. The results were the same for boys and girls.

Video observation measured the observation reliability of the quality of the teaching event. The congruence percentages between two independent observers were counted with parallel tests in 20 5-minute periods. Retesting with a 2-week time interval was used to define the stability of observation. The congruence percentages in parallel testing varied between 50% and 90%. In the retesting, the percentages ranged from 65% to 100%. The lowest percentages were observed in the variable on the quality of practice and the highest in the variable on corrective feedback. Reliability was also examined at the level of factorial summation variables, in which reliability was counted with intercorrelations of two measurements. In parallel testing, the correlation in the variable practice was below .50. The other correlations can be considered satisfactory (Table 1).

Table 1. *The Parallel and Retest Reliability of Quality Variables in Teaching Event, Factorial Summation Variables (N = 20).*

Variable	Parallel test	Retest
Practice	.47	.64
Teaching	.79	.79
Feedback	.54	.88
Transfer	.58	.64

RESULTS

In the first explanatory model for gymnastics skills, the clearest connections to the development of gymnastics skills were obtained for body build, muscle condition, and flexibility. There were no explanatory factors for the teaching event in this model (Table 2).

According to the AID tree, it is possible to compensate with good motor abilities for the problems in the development of gymnastics skills that result from being overweight. The best

improvement in skills was achieved by a group composed of primary school pupils whose entry level in gymnastics skills was weak or average and whose body mass index was low or average.

Table 2. *β5-Coefficients and Percentage of Explained Variance in AID Analysis, Dependent Variable: Improvement in Gymnastics Skills in 3-Year Period (First Model).*

Predictor	β5
BMI	.186
Muscle condition	.082
Flexibility	.078
Motor control	.047
Entry level in gymnastics	.059
School level	.075
Percentage of the explained variance	52.7%

In the second model, the percentage of the explained variance for the change in the residual variable for improvement in gymnastics skills remained at 18.3%. The number of significant (percentage of explanation more than 1%) predictors was five (Table 3). The quality of practice had the highest explanatory power to improve gymnastics skills. This variable included the quality of student practice trials and the appropriateness of the task. The factor Teaching, consisting of instruction, organization, progress, short-term memory, and perceptual behavior variables, had no explanatory power in the model.

Table 3. *β5-Coefficients and Percentage of Explained Variance in AID Analysis, Dependent Variable: Residual of Improvement in Gymnastics Skills in 3-Year Period (Second Model)*

Predictor	β5
Practice	.094
Feedback	.035
Transfer	.032
Student gender	.015
School level	.007
Percentage of the explained variance	18.3%

The tree-figure was created for a closer inspection of the causal relationships. The five predictors of the model divided the data nine times. The most important predictor for the improvement in gymnastics skills was Practice, which divided the data twice. In the subgroups, the division was made with Feedback and Transfer. The inspection of the extreme groups showed that the greatest improvement in gymnastics skills was achieved by a group with qualitatively good practice and receiving good or poor feedback. The weakest group consisted of primary school boys with low

quality of practice. Qualitatively poor practice was a greater detriment for boys than for girls, and it was a more common problem for boys in secondary school than it was in primary school. Feedback and Transfer had an interesting interaction in the explanation for improvement in gymnastics skills. It was possible to compensate for qualitatively weak feedback in teaching with a good transfer effect and to compensate for a weak transfer effect with good feedback.

In some subgroups (students with qualitatively good practice and primary school boys with poor practice), feedback had a nonlinear connection to the improvement in gymnastics skills. Qualitatively moderate feedback meant lesser improvement in skills than good and poor feedback.

DISCUSSION

The connections of the qualitative variables of teaching to the improvement of the skill level in apparatus gymnastics indicated the optimal level of difficulty and the quality of practice for a task as having the strongest explanation for progress in skills. These qualitative variables also correlated strongly among themselves and formed the dimension of Practice, named in factor analysis. For students, the time used for practice in appropriate tasks has been proved positive for the development of skills, while the time used for tasks that are too easy or too difficult is negative in relation to development (Ashy et al., 1988; Buck et al., 1991; Dugas, 1984; Piéron, 1983; Silverman, 1985b, 1990; Silverman, Kulinna, and Crull, 1995).

The time spent on practicing motor skills has proved to be an important explanatory factor in motor skill development (Da Costa and Piéron, 1992; Piéron and Piron, 1981; Yerg 1977, 1981a). A teacher's expertise in subject matter has been proved to be in teaching so that a teacher with good expertise provides more tasks for the students and adjusts the difficulty level suitable for students' abilities (Hastie and Vlaisavljevic, 1999; Rink, 1993; Schempp, Manross, Tan, and Fincher, 1998). The movement tasks, which are suitable for the abilities, represent movement responses with good quality, and the quality of the performances is more important for the progress of skills than the quantity (Ashy et al., 1988; Silverman, 1990; Solmon, 1995).

The connections between feedback and the progress of skills have been parallel to the connections between practice and development. There is a big difference in the amount of feedback between a teacher and a student in a PE class. The teacher provides feedback on average 60% of the time during a gymnastics class, but a student receives feedback 1% of the time of a lesson. The aim of the feedback is to affect the development of skills. Feedback is positive for the level of skill of a student, when feedback is aimed at the overall structure of the movement. Feedback aimed at details of the movement negatively affects the skills (Yerg, 1983). The qualitative assessment of teacher's instructions is an adequate predictor in student skill learning (Gusthard et al., 1997).

Although the quality of practice was more clearly related to the development of gymnastics skills in this study, it must be remembered that, without quantity, there can be no quality. This can best be seen through the so-called funneling effect: the time used for the active practice of skills multiplies when attention is paid to the number of lessons for gymnastics in the curriculum, the amount of gymnastics offered during a lesson, and the activity of the students.

The first explanatory model for apparatus gymnastics strengthened the links between the structure of body and motor abilities and the development of gymnastics skills. The body mass index, muscle condition, and flexibility explained more than 30% of the variation in the improvement of the skills in apparatus gymnastics. The AID analysis tree revealed that overweight students in gymnastics

lessons were a problem group. Comparable results have been obtained in earlier cross-section research (e.g., Holopainen, 1990; Pehkonen, 1984). Cross-referencing on the AID tree revealed that good flexibility and motor control improved the situation of overweight students.

The dimension for a teaching event, which includes the factors for input (giving instructions, teaching arrangements), did not prove to be an interpreter in the development of skills. Although previous studies about the significance of presenting a task partially conflict, studies (e.g., Graham et al., 1983; Phillips and Carlisle, 1983) that show giving instructions not to explain learning are more numerous than those showing such significance. Piéron and Graham (1988) have called for concentration on teaching variables for assessing quality instead of quantity. Probably, the factors in teaching are a practice-like variable: there has to be quantity in order for quality to exist. In the issues related to giving instructions and the arrangements for teaching, the expert-novice setting could produce clearer results than the setting for this study.

The curvilinear link in the quality of feedback to the development of skills in some groups is an interesting phenomenon. Qualitatively good and poor feedback mean better development of skills than average feedback. This could arise from the scoring in the observation instrument: average feedback means the same as no feedback. Thus, strict professionalism in school physical education is not as important as the eagerness of the teacher. For the student, it is important that his or her effort is noticed and commented upon. The most important meaning for feedback in promoting learning lies in the fact that perceiving the students makes the quality of their practice more effective (Silverman et al., 1995). Expert feedback also often has the characteristic of finding mistakes, which may be better suited to sports training. The observations made in this study on the limited possibilities of students with weaker starting levels to receive information support these perceptions. Recent studies (Chiviakowsky and Wulf, 2002, 2005) have shown that learners prefer to receive feedback after they believe they had a good rather than poor trial. The results demonstrated that learning is facilitated if feedback is provided after good trials (Chiviakovwsky and Wulf, 2007).

The most important interpreter in motor skill learning is to provide tasks that are suitable for the abilities of the student. Providing these tasks demands two types of expertise from the teacher: subject mastery and acquaintance with the pupils are a strong combination. The precision, correctness, and appropriateness of the instruction and the feedback are characteristic of the most effective teachers. Subject expertise combined with the communication skills needed are the best guarantee of success in teaching (Da Costa and Piéron, 1992). The meaning of the feedback as an interpreter of learning disappears if the difficulty of the task does not match the abilities of a learner (Pellet and Harrison, 1995). With the help of feedback, the suitability of the task difficulty is also possible. Feedback that is directed to all students in the class has the greatest significance (Rink, 1993, 1996).

Providing optimal difficulty level tasks demands kinesiological mastery and sensibility in noticing the student's abilities. In the education of classroom teachers, there could be a cause for raising the level of biomechanical mastery of gymnastics and other sports. The teaching practice should be arranged in such a way that the student teacher can become acquainted with the pupils: the same class during several years of studies.

The interaction of feedback and transfer in developing skills brought different teaching strategies to light. With the help of the progress of teaching, the teacher who constructs skills based on earlier learning gets good results, even though feedback during teaching may be weak. This type of teaching probably suits very large groups in which individual feedback would otherwise be difficult. In

small groups, in which the possibilities of giving feedback are better, the significance of the transfer effect is not as big as in large groups. The combination of a strong transfer effect and qualitatively good feedback is not effective in teaching skills perhaps because, in that case, teaching takes time from learning.

In physical education classes with a large number of students, the meaning of the learning environment is emphasized. Skill progression is possible with the help of different equipment. Places of performance with standard measurements in a competitive sport are seldom suitable for children. The role of a teacher should be a facilitator of the learning: developing a learning environment, creating relationships between the students and teachers, and keeping up the cognitive processes of students are actions that promote learning (Lambert, 1996; Rink, 1996). Treating the learning environment and skill progression most positively affect the development of skills of very young children and pupils with a weak starting level (Hebert, Landin, and Solmon, 2000; Sweeting and Rink, 1999).

Together with the physical environment, the development of the learning atmosphere is a task for a PE teacher. A feeling of safety diminishes the fears in skill-learning situations. Safety can be increased with the solutions, in which the student can choose tasks suitable for his or her abilities. The assistance and feedback provided by other students can also be seen as a means of a social education. In school physical education, the prevailing method of teaching is traditionally teacher-led. It consists of a chain: demonstrate, explain, provide practice, and correct mistakes. However, the results of learning skills refer to the significance of other types of approach. In this study, the constructive concept of learning gets abundant support. The most important interpreter of learning is to offer tasks that meet the ability of the student. The initiative of a student can be seen in his or her working through an offered task that emphasizes the conscious control of learning a skill. This does not mean that the teacher is unnecessary in the teaching process or that his or her professionalism has no meaning. The competence of the teacher can be emphasized significantly through, for example, the scholastic management of physical education and student awareness. This combination guarantees the individuality and continuity of teaching.

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