Communication and Motor Skill Learning: What We Learn From Research in the Gymnasium

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This paper examines communication and motor skill learning from the perspective of research on teaching. Research design for laboratory motor learning, applied motor learning, and research on teaching physical education are discussed. In addition, the contributions of each research type to our knowledge of motor skill learning are considered. A series of studies are presented, and it is concluded that teachers are important in structuring and communicating expectations to students. The role of teacher feedback in helping students learn motor skills, however, may be less than previously thought.

The focus of this special issue, "Communicating Information to Enhance Motor Skill Learning," is important because both pedagogical researchers and motor learning researchers are addressing the topic. Each area has much to learn from the other, and the starting point of this special issue hopefully will help integrate and synthesize the available research on this topic.

Communication often is thought to be a key to structuring and modifying (by providing feedback) learning situations to promote student learning. In actual instructional situations, communication generally is presented at three different times: (a) before practice, often as an explanation and demonstration; (b) during practice, as feedback; and (c) after practice, as a review or for group feedback. Each of these aspects of communication generally have been studied in isolation from the others, and the situations in which they have been studied range from psychology or motor learning laboratories to "real-life" classroom and physical education situations. In research conducted in elementary and secondary classrooms, it has been found that clear presentations are important for learning and that nonevaluative, task-relevant feedback is related to student learning (see Brophy & Good, 1986, for an overview). In addition, motor learning researchers have suggested that feedback and learning are related (see Magill, 1993, for an overview).

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Over the past few decades researchers have assumed that the feedback–learning relationship was strong. There are many instances in which this variable was deemed important to learning a motor skill. For example, a review by Bilodeau and Bilodeau (1961) stated “studies of feedback show it to be the strongest, most important variable controlling performance and learning” (p. 250). Nixon and Locke (1973), in a very influential paper, also included feedback as an important step in motor skill learning, and Graham and Heimerer (1981) suggested that effective teachers provide immediate, task-relevant feedback to help students learn. Those conducting descriptive research on feedback and research comparing teachers have assumed that the feedback–learning relationship was critical to learning a motor skill (Faucette & Patterson, 1990; Fishman & Toby, 1978; Godbout, Brunelle, & Tousignant, 1987; Paese, 1987; Piéron & Gonçalves, 1987; Rikard, 1991, 1992; Rink, 1983; Rink & Werner, 1987; Stewart, 1980) and often assumed more was better. Finally, as Magill (1994) indicates in his paper in this special issue, there is substantial evidence that teacher educators and authors of teaching methods textbooks have prominently discussed feedback as an important component of motor skill learning.

Given all the attention that feedback has been given as a component of motor skill learning, it is interesting that more recent research conducted in physical education classes—research on teaching as opposed to motor learning research—has suggested that the feedback may play a smaller role in motor skill learning in physical education classes than has been previously suggested (Lee, Keh, & Magill, 1993; Silverman, Tyson, & Krampitz, 1992, in press). The reasons why the feedback–learning relationship found in classroom research and many motor learning studies does not transfer to the physical education setting need clarification.

This paper will examine teacher communication and achievement in physical education. Specifically, I will focus on the differences in research methods in motor learning, applied motor learning research, and research on teaching. I then will present research on communication and achievement in physical education. This section will focus primarily on work I have conducted with colleagues and on the feedback–achievement relationship. Finally, I will present conclusions for both research and practice.

Research Methods and Communication

Traditionally, motor learning research has occurred in laboratory situations. Recently, a number of motor learning scholars (Christina, 1987, 1989; Magill, 1988; Singer, 1990) have suggested the need for more applied research to examine the transferability of motor learning research for learning skills in more real-life settings. Although a continuum of motor learning research was proposed by Christina (1987), it is my belief that this could go further to show how motor learning research and research on teaching interrelate and for what purposes each is best suited.

As shown in Figure 1, we can conceive of three different formats for investigating motor skill learning. In this representation, no hierarchy of research is implied. In addition, the arrows representing internal and external validity should be interpreted with the understanding that each type of research must be
Increased External Validity

Increased Internal Validity

Laboratory Motor Learning Research
- Laboratory setting
- Simple, isolated motor task
- One subject at a time
- Computer or researcher presents task
- Computer feedback

Applied Motor Learning Research
- Controlled non-laboratory setting
- Sport skill
- Individual or small group of students
- Task presentation provided
- Feedback or modeling provided

Research on Teaching Physical Education
- Physical Education setting
- Sport skill(s)
- Full class of students
- Teacher provides instruction
- Teacher feedback

Figure 1 — Types of research on motor skill acquisition. The initial ideas for this figure were generated from Christina (1987).

completed using a sound design and appropriate methodology. The levels of internal and external validity change drastically and unpredictably if inadequate research is considered the exemplar. As will be discussed, each level of research plays an important role in developing a theory (or theories) of motor skill learning. None is better or worse than the other. Each is just better or worse for understanding different aspects of learning.

Laboratory Motor Learning Research

Laboratory motor learning research has increasingly focused on simple, isolated, novel tasks in which one subject at a time undergoes a treatment and is tested, with instruction and feedback often presented by a computer (e.g., Magill & Wood, 1986). This type of research has high internal validity—lots of experimental control. In fact, at this level research can be appropriately designed to isolate a single variable, and the information gained from these studies can provide new information for theoretical understanding of the learning process. A difficulty may occur, as noted above, in applying this information to teaching situations that have multiple students and far less control.

Applied Motor Learning Research

Research that I have characterized as applied motor learning (e.g., Eghan, 1988; Goode & Magill, 1986) typically occurs with sports skills and in situations with either fewer subjects or much greater experimental control than is found in
the normal physical education class. In this instance, the teacher or person organizing the instruction may have 3 or fewer students at a time while implementing two or more levels of a treatment variable (e.g., augmented feedback vs. nonspecific feedback or different practice schedules), and then comparisons would be made for differences in skill attainment between treatments.

To some, this research is neither fish nor fowl. The study has been moved out of the laboratory and clearly is more applied than laboratory research, but it lacks many elements of a real teaching situation. By using small groups or individuals, or by controlling the exact number of practice trials, many factors that teachers must confront and that add variability are controlled. This type of research may be considered an intermediate step between laboratory research and research on teaching, but it may also provide less of a contribution to theoretical understanding of either learning or teaching.

Research on Teaching Physical Education

Research on teaching physical education occurs in natural teaching environments, with normal class sizes, and with the physical education teacher providing instruction and feedback. This situation is real-life teaching and reflects the normal physical education teaching environment—with the addition of researchers. In an ideal situation, multiple classes would be used for the study, and decisions about unit of analysis (typically the class or student) would depend on the variables being examined. By being in a natural environment, an additional degree of control is lost, and it may be difficult to implement strong treatments. Correlational designs, instead of experimental or quasi-experimental designs, may be the preferred method. In addition, interpretive research methods also may be used to gain insight into motor skill acquisition in physical education.

The boundary between applied motor learning and research on teaching physical education may not be clear. Depending on the position one took, an argument could be made that research using experimental teaching units (ETUs; Graham, 1983), with only a few students in each class, taught by student teachers, and occurring over a short instructional time frame could fall into either category. The categorization of the research is not nearly as important as realizing that trade-offs occur when different research approaches are used.

The most obvious trade-off, as indicated in Figure 1, is between internal and external validity. The ability to control experimental factors in the laboratory provides valuable information about the isolated variable. As Christina (1987) suggested, these experiments may provide information to inform researchers conducting applied motor learning research or research on teaching. Research conducted in the natural setting of the gymnasium, however, provides a degree of external validity that may have many implications for teaching. The array of variables that researchers may want to investigate occur in a normal teaching setting. Researchers may focus on an individual variable (e.g., feedback), but the variable is not isolated, as it would be in a laboratory study. The interaction of teaching and learning variables in the gymnasium permits verification of the transferability of results from laboratory and classroom settings while creating a literature that helps us understand effective teaching in the environment in which it occurs.
Communication in the Gymnasium: An Example

To discuss the factors that impact motor skill learning in physical education, I will highlight studies that colleagues1 and I have completed over the past few years. I am using these as examples, not to exclude other research but to show how research on teaching addresses the motor skill acquisition issue from a variety of directions. The studies presented are part of a multilevel research project to examine the variables related to motor skill learning in physical education.

The research occurred in middle school and junior high school physical education classes. Ten classes \((N = 202)\) students in the final sample) and their physical education teachers participated in the study. Each class was pretested and posttested on two skills (volleyball forearm pass and serve), and 7 days of instruction occurred between the pretest and posttest. All instruction was videotaped using two cameras and a split screen generator so that all student and teacher actions could be observed at a later time. The testing, teaching, and videotaping occurred over the course of a school year. At the completion of all testing and teaching, the videotapes were used to collect data on process variables that previous research had shown to be related to skill achievement in classrooms or in the motor learning laboratory.

Correlational research designs were used to examine the relationships of a variety of variables to student achievement. This approach allowed for individual studies of the relationships of variables to achievement. This approach also permitted the examination of interrelationships among variables and achievement. These interrelationships permit far more sophisticated understanding of motor skill learning in natural settings than does the isolation of any single variable. The variables, examined in the various phases of research that are pertinent to this discussion include presage and context variables (Silverman, 1988), organization and time usage (Silverman, Tyson, & Morford, 1988), individual student practice (Silverman, 1990), mediating effects of student skill level on practice–achievement relationships (Silverman, 1993), feedback to individual students and the interaction of feedback and student practice (Silverman et al., 1992), mediating effects of student skill level on feedback–achievement relationships (Silverman et al., in press), task structures and accountability (Silverman, Kulilina, & Crull, 1993), and an analysis combining variables to examine their contributions to student achievement (Silverman & Tyson, 1994).

As noted in each research report, specific instruments were developed or adapted to collect process data. Coders spent many hours in training and then viewed videotapes to obtain reliable and valid data. The data were used in individual studies and then, in some instances, were combined with other variables to examine the interactions with student achievement. Some variables were measured at the class or teacher level (presage and context variables, organization and time, task structures and accountability) and others at the student level (practice and feedback to individual students).

As noted above, this paper will focus primarily on the issue of teacher feedback to individual students. These data, however, should not be considered

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1I would like to thank all my coauthors who are cited in the research discussed here. Their help was invaluable in completing the research.
in isolation. Other phases of the database focused on other aspects of communication. The aspects related to organization and time, and task structures and accountability will be briefly presented and discussed prior to those on feedback.

The study of class organization and time (Silverman et al., 1988) found that, for one of the two skills that were taught, the time teachers spent presenting good or adequate explanations and demonstrations was positively correlated with student achievement. In that study, the time classes spent in skill practice with teacher feedback was strongly related to student achievement for both skills. In addition, when task structures and accountability were studied (Silverman et al., 1993), it was found that more explicit descriptions of student practice tasks and providing accountability for completion were related to achievement.

The results of both studies seem to suggest that certain aspects of teacher presentations to students help communicate the salient aspects of the skill, how to practice it, and how they will be held accountable for learning. These aspects of whole group communication, when examined by themselves, suggest that teachers can structure teaching and practice in ways that promote learning. The paper by Judy Rink (1994) in this special issue discusses these issues in much greater depth.

The result that practice with feedback is associated with motor skill learning suggested verification of the feedback–learning relationship: The relationship was positive, and therefore, feedback could be seen as a critical variable to learning. This interpretation would, however, be misleading. In the analyses completed in the Silverman et al. (1988) study, virtually all practice included feedback, the class was the unit of analysis, and the feedback measure was not tied to individual students or differentiated by type of feedback. In addition, other studies (see Lee et al., 1993, for an overview) recently have shown that feedback–achievement relationships were not materializing in applied motor learning studies and in research on teaching.

As part of the overall research plan, data on feedback to individual students was collected. A detailed instrument was adapted from the Fishman and Toby (1978) augmented feedback observation system using the results from physical education, motor learning, and classroom research to inform the adaptation. Coders collected data on multidimensional aspects of feedback including the skill (forearm pass or serve), type (e.g., positive, prescriptive, corrective), form (auditory, visual, tactile, or some combination), time (during, conclusion, or some time after skill performance), referent (whole skill, part of skill, or outcome), number of students the feedback was directed to (from individuals to groups of 3 students), and quality (good, moderate, or poor). Every incident of feedback to individuals or small groups (3 or fewer) was coded for each student over the course of all seven classes. Over 3,800 instances of feedback were coded.

For the purpose of data analysis, feedback categories were summed across the seven classes for each student and logical categories (e.g., all feedback) were created. When feedback was correlated with student achievement, only a few significant relationships were found, and these relationships were not consistent for both skills (Silverman et al., 1992). At this level of analysis, there certainly was not a substantiation that feedback and achievement were related.

To investigate the relationships of feedback to achievement further, it was decided to covary the feedback–achievement relationship with appropriate practice trials for each student. The study of student practice (Silverman, 1990)
had shown strong relationships between achievement and appropriate student practice. In designing a database to study teaching, the intention was to combine process variables. The ambiguity of the initial analysis and the results for time in practice with feedback in the previous study (Silverman et al., 1988) suggested that this approach might produce deeper understanding of feedback–achievement relationships.

When appropriate practice was used as a covariate, consistent relationships emerged for the two skills (Silverman et al., 1992). Feedback that was descriptive, corrective, or a combination of the two types of feedback (prescriptive feedback) related to achievement. These relationships were significant but only added 1–2% to the explained variance in achievement scores over practice. Although significant and consistent correlations were found, these relationships seem to play a small part in overall student learning.

These small relationships must be considered in the context of the overall study. First, it is likely that appropriate student practice is such a strong predictor of student motor skill learning that the feedback presented by teachers serves mostly to modify practice and influences achievement indirectly in this way. Time spent in practice with feedback is important in learning, but it is the type and quantity of practice that clearly is the overriding factor.

Second, the natural setting of these classes provided students with sensory feedback whether the teacher provided augmented feedback or not. These two aspects of feedback could not be separated, and sensory feedback occurred on every practice trial and was immediate. It may be that sensory feedback is so strong that the feedback provided by the teacher only adds small amounts to the overall learning experience. This, however, should not suggest that the teacher is not important in learning. The opposite is true. The teacher structures the class and provides opportunities for the student to practice at an appropriate level. Without the teacher arranging and modifying practice for individual students, appropriate practice and knowledge of results would not happen—and neither would learning.

It has been suggested to me on a number of occasions that the way to get at the sensory feedback–augmented feedback issue would be to design a study in which sensory feedback was not available to the student. One way to do this would be to organize students so that they practiced the serve and forearm pass from behind a barrier from which they could not see the result. The coordination required with the teacher and students would be tremendous, and the availability of subjects might be reduced as a result of this intrusion into the educational process. Assuming teachers would agree to participate, it might be possible to create this type of practice situation for the serve. For the pass, however, where practice often is repetitive, not seeing the results would require strategies that are not at all like actual practice used in physical education classes.

This issue returns to the trade-off between internal and external validity discussed earlier. When modifications are made to the teaching environment, making it different from actual teaching situations, what is learned, like some aspects of laboratory and applied motor learning research, may not be applicable to teaching. We learn information that informs the theory of learning, but the information may not inform the theoretical base for teaching. Individuals must decide when research goes too far in either direction to have meaningful results.
In this instance modifying the visual situation to remove sensory feedback changes the situation so much that external validity is greatly reduced.

Third, it is possible that the feedback–achievement relationship is not generalizable across student skill levels. Students of different skill levels may need different types or amounts of feedback, or they may use different cognitive processes to mediate the augmented feedback. Research suggests that entry characteristics influence what occurs in physical education (Graham, 1987; Grant, Ballard, & Glynn, 1989; Rikard, 1991; Shute, Dodds, Placek, Rife, & Silverman, 1982; Solmon, 1992; Telama, Varstala, Heikinarjo-Johansson, & Utriainen, 1987) and that relationships of process variables to achievement differ for subgroups of students (Silverman, 1985, 1993). When the feedback data were reanalyzed for the serve (Silverman et al., in press), many interesting relationships were found for high-skilled students, whereas for the forearm pass, relationships were found for medium- and low-skilled students. It should be noted that students received lower rates of feedback during forearm pass instruction, and it may be that differences in rates of feedback or the differences in skill (one being an open skill and the other being a closed skill) interact with skill level to influence the feedback–achievement relationship. Although Lee et al. (1993) have suggested that student skill level is a methodological problem in research of this type, research on teaching should include a focus on the student skill level issue and not control it by eliminating the range of skill found in physical education classes from future studies.

Fourth, as Magill (1993, 1994) has indicated, the type of skill may influence whether feedback is needed for learning. It is possible, since most of the practice occurred in front of the students for the bump and underhand serve, that teacher feedback enhanced learning of these skills to only a slight degree (the 1–2% seen). Other skills for which the position of body parts is not as apparent to the learner (e.g., an overhead serve) might require greater augmented feedback for learning.

Conclusions

As would be noted from the results presented previously, teacher feedback by itself may not be as important to motor skill learning as was once thought. Teacher structuring of the class for maximal student practice and the practice itself seem to be more important. In addition, in normal teaching settings, sensory feedback is immediate, and teacher feedback may largely duplicate sensory feedback. Teacher educators and supervisors should be cautious in giving prescriptions about feedback without considering other, perhaps more important, aspects of teaching. Certain types of skill-related feedback (especially prescriptive feedback and its component parts) may help learning to some degree and for some skills, but by itself such feedback contributes small amounts to learning.

How research is conducted may influence results of feedback research. Those conducting scholarship in this area and those using research as a basis for giving prescriptions to teachers should consider the environment of the research setting, how the results fit with other research results, and whether the evidence is strong enough to suggest robust, consistent relationships. To paraphrase the line from the popular song, “looking for answers in all the wrong places” can be misleading.
Finally, the communication between motor learning and pedagogy scholars should continue and grow. The expansion of interdisciplinary research on motor skill learning will result in an enhanced discussion. The subsequent theoretical development will be informed by the learning environment, levels of control, and various skills—from simple, isolated movements to a variety of complex motor skills. This multilevel approach to understanding motor skill development will bring far better understanding than will any individual approach.

References


