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Assisted Performance and the Zone of Proximal Development (ZPD); a Potential Framework for Providing Surgical Education

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ABSTRACT

Purpose: To apply educational models of the Zone of Proximal Development (ZPD) and approaches to assisted performance to existing knowledge about surgical skill acquisition, and thus provide a framework for potentially enhancing surgical education.
Summary: The stages of the ZPD appear to be consistent with existing psychomotor theories of skill acquisition. The fourth phase of the ZPD, where the performance of skills can deteriorate, and which can occur for a number of reasons such as ill health or absence from routine duties, is not well described in the surgical literature. Approaches to assisted performance may provide additional insights into the complexities of how to teach surgical skills, how to approach the process of hand-over of responsibility from teacher to learner, and the importance of enhancing teaching skills of surgical educators.
Conclusions: The ZPD and approaches to assisted performance would appear to provide a valuable framework for planning and assessing surgical education programs.

INTRODUCTION

There is a high level of interest internationally in examining and enhancing approaches to surgical education. In particular, there is a major focus on the importance of providing surgical skills training for both surgical trainees and established specialists (Lo & Chan, 1998). In this manuscript we will outline educational models designed by Vygotsky, and their application to surgical education. These models, called the Zone of Proximal Development (ZPD) and Assisted Performance, can be used to examine the phases of learning both a new discipline and particular skills, and understand and enhance approaches to teaching (coaching) and processes associated with the hand-over of responsibility between teacher and learner. Vygotsky's models have been validated in relation to outcome in a number of domains (Ratner, 1984; Belmont, 1989; Exner, 1990; Meijer & Elshout, 2001). Although the ZPD and assisted performance have not previously been applied to surgical education, other aspects of Vygotsk's and Piaget's theories have been applied to an undergraduate surgical education programme resulting in a significant improvement in the performance of basic surgical techniques (Qayumi et al., 1999). In this manuscript we will apply these models to existing knowledge about surgical skill acquisition, and thus provide a potential framework for enhancing surgical education.

Assisted performance and the four stages of the zone of proximal development

Assisted performance defines what a learner can do with help, with the support of the environment, of others and of the self. The contrast between assisted performance and unassisted performance identified the fundamental nexus of development and learning that Vygotsky describes as the zone of proximal development (ZPD) (Vygotsky, 1978). For any domain of skill, a ZPD can be created. In the ZPD, assistance is provided by the teacher, the expert, and the more capable peer. Distinguishing the proximal zone from the developmental level by contrasting assisted versus unassisted performance is of major importance in understanding approaches to education. It is in the proximal zone that teaching may be defined in terms of learner development. Vygotsky (see Vygotsky, 1956) stated that teaching is good only when it

> *"awakens and rouses to life those functions which are in a stage of maturing, which lie in the zone of proximal development".*

Consequently, teaching consists in assisting performance through the ZPD. Teaching can be said to occur when assistance is offered at points in the ZPD at which performance requires assistance.

Learning within the ZPD can be divided into four stages. Stage one is where performance is assisted by more capable others. The amount of outside regulation depends upon the nature of the task and the characteristics of the learner. In the early stages, the learner may have a limited understanding, the expert offers directions or modeling, and the learner's responses are acquiescent or imitative. Only gradually does the learner understand the way in which the parts of the activity relate to one another or understand the meaning of the performance. When some conception of the overall performance has been acquired, further assistance can be given by questions, feedback, and further cognitive structuring. The expert assists by grading tasks and by structuring tasks into sub-goals and sub-sub-goals in a similar way to task analysis (Anderson & Faust, 1973; Gagne, 1985). A profound knowledge of subject matter is required of teachers who seek to assist performance. Without such knowledge, teachers cannot quickly reformulate the goals of the interaction; they cannot map the learner's conception of the task goal onto the superordinate knowledge structures of the academic discipline that is being transmitted.

During stage one, there is a steady decline plane of teacher responsibility for task performance and a reciprocal increase in the learner's proportion of responsibility. This is described as the handover principle (Bruner, 1983). The developmental task of stage one is to transit from other-regulation to self-regulation. The teacher's task is to accurately tailor assistance to the learner by being responsive to the learner's effort and understanding of the task goal. The task of stage one is accomplished when the responsibility for tailoring the assistance, tailoring the transfer and performing the task itself has been effectively handed over to the learner.

Stage two is where performance is assisted by itself. In stage two, the learner carries out a task without assistance from others. However, this does not mean that the performance is fully developed or automatized. It contains the next stage in passing of control or assistance from the expert to the apprentice. What was guided by others is now beginning to be guided and directed by the learner. At the microgenetic level, adults consistently talk to themselves, and assist themselves in all ways possible.

Stage three is where performance is developed, and automatized. Once all evidence of self-regulation has vanished, the learner has emerged from the zone of proximal development (ZPD) into the developmental stage for the task. The task execution is smooth and integrated. It has been internalized and 'automatized'. Assistance from the expert or the self is no longer needed. Assistance at this stage could be disruptive. It is in this condition that instructions from others are disruptive and irritating; it is at this stage that self-consciousness may be detrimental to the smooth integration of all task components. Performance is no longer developing; it has developed

Stage four is where de-automatization of performance leads to recursion back through the ZPD. The lifelong learning by an individual is made up of these same regulated ZPD sequences, from other-assistance to self-assistance, recurring over and over again for the development of new capacities. For every individual, at any point in time, there will be a mix of other-regulation, self-regulation, and automatized processes. Even the competent expert can profit from regulation for enhancement and maintenance of performance. Indeed, enhancement, improvement and maintenance of performance provide a recurrent cycle of self-assistance to other-assistance. De-automatization and recursion occur so regularly that they constitute a stage four of the normal developmental process. What one formerly could do, one can no longer do. After de-automatization, for whatever reason, (environmental changes, stress, major upheavals, trauma), if capacity is to be restored, then the developmental process must become recursive.

The first line of retreat is to the immediately prior self-regulating phase. Recurring to the point in the zone where the learner 'hears the voice of the teacher' may be an effective self-control technique. However, in some cases no form of self-regulation may be adequate to restore capacity, and the restitution of other-regulation is often required. In this instance, the goal is to re-proceed through assisted performance to self-regulation and to exit the ZPD again into a new automatization.

Responsive assistance

In the transition from other-assistance to self-assistance and automatization, there are variations in the means and patterns of assistance to the learner. During the early phases, assistance may be frequent and elaborate. Later, assistance may be less frequent and truncated. Assistance should be contingent on and responsive to the learner's level of performance. Such assistance is responsive to the learner's level of performance and perceived need(s). Attempts by the expert to assess the learner's readiness for greater responsibility are often subtle and embedded in the ongoing interaction. A major variable may be the nature of the task or performance. If efficient production is needed, the expert will likely be more directive and less tolerant of errors, and may even take over performing the task. In such circumstances, the learner may be relatively passive, observing the expert carry out the task, and joining in to help at those points where the learner's skill(s) match the task demands. When the development of independent learner skill is defined as a goal, the pattern of assistance provided by the expert is more responsive, contingent, and patient. The expert graduates the assistance, responsive to the learner's performance level. Thus, an important pedagogical principle is that 'assistance' offered at too high a level will disrupt learner performance and is not effective teaching.

An important aspect of learning is the reciprocal roles played by the teacher/expert peer and the learner. Some learners are not ready to accept assistance and may try to ignore or limit the assistance offered by more capable others. They might dive into a task and assume that they don't need help. Furthermore, an expert may not always be willing to hand over responsibility to a learner. They may try to maintain control of the task even when the learner has obtained the necessary skills, thereby limiting the learner's opportunity to learn from further experience and feedback. Good teaching is a dynamic process that involves an unfolding relationship between people, where advice/help is seen as relevant and valuable. Furthermore, the emerging competence and independence of a learner is also valued and enhanced. As a learner acquires professional skills, he/she becomes progressively accepted as an equal and a colleague. Consequently, learning is associated with an evolution in the relationship between the teacher and the learner. This process involves a transfer of both responsibility and status. As the learner becomes expert, he/she needs to be more responsible for their own actions and acquire status equal to (or somewhat equal to), their immediate teacher.

Once independent skill has been achieved, 'assistance' becomes 'interference'. Consequently, effective teaching occurs when assistance is offered at points in the ZPD at which performance requires assistance. In order that the expert can provide assistance to the learner(s), there must be the correct ratio of experts to learners. This ratio will depend upon a number of factors including the complexity of the task(s) that the learner(s) must master. Effective teachers need an elaborate set of skills in assistance, and they need to be conscious in their application. Consequently, experts who wish to function as teachers need to be trained to assist performance. Expert teachers need to learn good expert pedagogical practices (Berliner, 1986; Wittrock, 1986). They must learn the professional skills of assisting performance and must master the subject matter they are to teach. If such skills are to be acquired, there must be an opportunity to observe effective examples and effective practitioners of assisted performance, opportunities to practice nascent skills, to receive various forms of feedback and to have the 'coaching' of a skilled expert in assisted performance.

There are various means of assisted performance, (modeling, contingency management, feeding-back, instructing, questioning, and cognitive structuring). Linguistic means of assistance often dominates teaching. However, that which is modeled is internalized and represented by the learner as an image, a paradigm-icon, for self-guidance.

Modeling

Modeling is the process of offering behavior for imitation. A person doing the modeling must be expert, in order that the correct image is internalized. A number of factors influence modeling including the presence of reinforcement for the behavior, whether the model is live or depicted and relationship factors. Modeled activities can be transformed into images and verbal symbols that guide subsequent performance. Active coding of modeled activities into descriptions or labels or vivid imagery increases learning and retention of complex skills. Different forms of modeling may be more effective depending upon the conceptual and verbal skills of the learner. Peer models are highly important sources of assisted performance (Sloat, Tharp, & Gallimore, 1977). Instructors of activities that are more obviously psychomotor must recognize that modeling is indispensable to assisted performance. The means of assistance are necessarily intertwined, occurring in combination and sometimes simultaneously.

Contingency Management

Contingency management is a means of assisting performance by which rewards and punishments are arranged to follow on behavior, depending on whether or not the behavior is desired. Many types of rewards can be offered such as social reinforcements of praise and encouragement, material reinforcements of consumables or privileges, and tokens or symbolic rewards (Tharp & Wetzel, 1969). Punishments are usually restricted to the loss of some positive opportunity or to brief, firm reprimands. In effective teaching, contingency management is focused overwhelmingly on positive behavior and positive rewards. Although contingency management is a powerful means of assisting performance, it cannot be used to originate new behaviors. Developmental advances are originated by other means of assistance; modeling, instructing, cognitive structuring and questioning.

Feedback

In self-regulation, providing for feedback is the most common and single most effective means of self-assistance (Watson & Tharp, 1988). Tharp and Gallimore (see Tharp & Gallimore, 1988) stated that

> *"One can imagine the collapse of performance on the tennis court, for example, if one were unable to track the flight of a ball after it was struck. This tracking information is used to regulate the next shot; without feedback, no correction - or even maintenance - is possible."*

In educational programs, feedback regarding performance is vital to every participant. Feedback can be provided in many forms, (data regarding performance, live observation of the learner's own performance on video, and by interaction with an expert who is a teacher). Feedback in any system does not refer to information traveling along an unconnected line. It implies the existence of a closed loop; that is, for information to be considered feedback, it must be fed to a system that has a standard, as well as a mechanism for comparing a performance to the standard. Simply providing performance information is insufficient; there will be no performance assistance unless the information provided is compared to some standard.

Linguistic Means of Assistance (Instructing, Questioning and Cognitive Structuring)
Instructing, questioning and cognitive structuring are specifically linguistic means of assistance. Instruction calls for a specific action. Questioning calls specifically for a linguistic response. Cognitive structuring does not call for a specific response; rather, it provides a structure for organizing elements in relation to one another. Instruction, like other forms of assistance, can be expected to occur only when teachers assume responsibility for assisting performance, rather than expecting students to learn on their own. If instructions become too authoritarian, they can provoke opposition. The measured use of instructing, however, does not create opposition (Tharp & Gallimore, 1976). The instructing voice ultimately can become that heard, regulating voice that becomes part of the learner's self-regulating mechanisms.

As instruction and questioning are both verbal forms of assistance, it is important that the teacher is able to distinguish between the two, and know how and when to apply them. In education, questioning is an essential tool, as questions call up the use of language and in this way assist thinking. Questioning calls for an active linguistic and cognitive response, and it provokes creations by the learner. There are two kinds of questions; those that assess and those that assist. The skillful teacher may incorporate enquiries whenever information is required about the pupil's knowledge or progress is needed to direct the course of assistance.

Cognitive structuring assists by providing explanatory and belief structures that organize and justify. Cognitive structuring provides an organization without calling for a particular action. Cognitive structuring has the widest ramifications, is the least likely to decompose, and yet is the most difficult form of assistance to put into practice. Cognitive structuring refers to the provision of a structure for thinking and acting. It is an organizing structure that evaluates, groups, and sequences perception, memory, and action. All action and mentation are organized into sets, within which evaluation, grouping and sequencing occur.

A good mix of the three types of verbal assistance, (instructing, questioning, and cognitive structuring), produces a lively and cooperative teacher-learner interaction. The expert teacher must be able to select and apply each form of assistance as required by the learning situation. This is because the responsiveness to the ZPD requires individualization according to the exigencies of the moment and the movement through the ZPD.

Teaching within the ZPD

The amount and type of assistance will vary with the experience and level of performance of the teacher. However, it should be noted that the skillful teacher/expert might always benefit from new competencies or improved performance in a particular domain. Consequently, even expert teachers have an interdependence on other experts who have a different/complimentary skill profile. The teacher has a ZPD for teaching skills, which requires assistance as in any other learning process. Consequently, an effective institution will assure assistance is provided to all of its teachers and experts, whatever their level of expertise. Teaching as assistance is an extremely complex skill that requires constant decision making, categorizing structuring and all manner of cognitive operations (Tharp & Gallimore, 1988). Such a process may include the use of self-examination of videotapes, floor training, workshops and courses and the use of consultants. A detailed account of the processes and stages of the development of higher-order teaching skills can be obtained by reading (Tharp & Gallimore, 1988). To be an effective consultant, the individual must be an expert in the skills and knowledge that is being taught in addition to being expert in teaching. Tharp and Gallimore describe this concept as integrating the two domains of knowledge (Tharp & Gallimore, 1988).

> *"Only an effective integration of these two domains will produce the expert pedagogue, and a precondition is an adequate knowledge of both domains."*

Surgical learning and the zpd

Table 1 outlines the association between stages of the ZPD, stages of acquiring psychomotor skills and medical terminology used to describe learning processes. Stages one and two of the ZPD may be long for some surgical procedures (Boeckx, Gruft, & Brosens, 1985; Dunphy, Sheperd, & Cooke, 1997; Trimbos, Hellebrekers, Kenter, Peters, & Zwinderman, 2000; Cox et al., 2001), and some procedures are of such complexity that not every surgeon may be able to master them (Graham & Deary, 1991; Murdoch, Bainbridge, Fisher, & Webster, 1994). These stages have been described in the medical literature as the learning curve (Dunphy, Sheperd, & Cooke, 1997), and in the psychomotor domain they include the cognitive and integrative stages of psychomotor development (Lippert, Spolek, Kirkpatrick, Briggs, & Clawson, 1975). During stage two of the ZPD, the surgeon is learning to carry out a task without assistance from others. However, the nature of the work dictates that more capable others, (an expert), should be present due to the potentially serious consequences of poor performance. Newly qualified specialists may be in either stage one or two for some surgical skills and procedures (Kopta, 1971).

Table 1 Psychomotor Skill Acquisition and the Zone of Proximal Development

Stage of the ZPD	Psychomotor Phases	Medical Terminology
one and two	cognitive and integrative/ associative	skill training the learning curve
three	Autonomous	competence
four		none routinely used

Consequently, they may require more capable/experienced specialists to be available in order to provide appropriate assistance for some skill(s) and procedure(s), until stage three of the ZPD is reached.

For surgery, stage three (analogous to the autonomous phase of psychomotor learning), represents a phase where the specialist is expert at all skills and components required for that surgical procedure, and has performed sufficient procedures to have encountered most or all of the problems that can occur during such surgery. The approach to surgical procedures cannot be totally automated, as there is anatomical variation, there may be variation in disease processes, some procedures are more complex and unexpected complications can occur during a surgical procedure. Whilst the execution of certain skills may be automated, the approach to a procedure is a conscious one, as the surgeon selects how and when to apply each skill or technique throughout the course of a procedure.

There are not many examples of a concept similar to stage four being acknowledged in the surgical literature (Wingard & Williamson, 1973; Seki, 1987). This is a significant concern, as important educational needs for established specialists may not have been identified. Stage four can occur in a number of situations such as where a specialist does not perform a procedure with sufficient frequency to maintain skills, where there has been an episode of ill health, or where a specialist has been on holiday or sabbatical. Under some circumstances self assistance may be sufficient for specialists who are in stage four, where they may hear the voice of their teacher guiding them through the procedure, or may picture their teacher's hands performing the task. However, in many cases the specialist would benefit from assistance from a more capable other. Additionally, new surgical procedures, new equipment and new approaches to procedures are regularly introduced into specialist practice. Consequently, surgeons will need assistance from more capable others, (experts) whilst mastering these new facets of their practice.

Each surgical procedure is composed of a number of techniques or skills. During the first two stages of stages the ZPD, these techniques and skills should be presented to the learner as goals or subgoals of the learning process, (task analysis). Some of these goals and subgoals can be achieved by working with non-human models (Webb & Peacock, 1980; Spencer, 1983; Baker, 1985; Nicks, Nelson, & Lang, 1986; Barnes, 1987; Barnes, Lang, & Whiteside, 1989). Recently, a number of surgical skill training centres have been established throughout the world in order to promote this kind of approach to skill development (Vaughan, 1998). Many surgical skills can be taught in a structured manner in such surgical skill laboratories (Lo & Chan, 1998). However, the development of other skills requires observation of procedures and performance of surgery on humans with appropriate assistance (Hamdorf & Hall, 2000).

The procedures, goals and sub-goals should be graded by level of complexity. The type of assistance should vary with the stage of learning and specific needs of the surgeon. Modeling during skill training or during an actual surgical procedure is a dominant form of assistance for surgical training. The learner observes an expert performing a task, and internalizes the image and sequence of events. Consequently, it is essential that the person doing the modeling is expert at the task (Cauraugh, Martin, & Martin, 1999). The image of the expert surgeon's hands during skill training or a procedure is transformed into an intra-psychological standard for comparison and feedback as the learner surgeon watches their own attempts at performing a surgical procedure.

In the psychomotor domain feedback is an extremely important form of assistance, being provided either immediately as augmented knowledge of results (Kaufman, Wiegand, & Tunick, 1987), or at a later date as quality assurance data regarding outcomes and complications. Feedback can also be provided in other forms such as live observation of the learner's surgical performance on video. Feedback must be part of a closed loop, where there is a mechanism for comparing performance to the standard. In surgical quality assurance, this standard is accepted levels of positive and negative outcomes, (benchmarks). Without such benchmarks for comparison, the learner cannot objectively assess their performance, and there is no standard by which to measure improvements. These benchmarks should consist of realistic aims, and not represent outcomes that were derived from a patient population that has been carefully selected to achieve an unrealistically high level of positive outcomes. Unrealistic benchmarks may inhibit learners from participating in quality assurance exercises, and may lead to unnecessary anxiety about performance. However, openness about the widespread need to improve performance and participate in quality assurance exercises should be encouraged.

Contingency management should be restricted to rewards, as surgical procedures are performed in an environment where a number of other professionals and learners are present, and negative comments may impact on the learner in ways that alter peer relationships and career development. It may be appropriate to restrict which procedures the learner can undertake if performance is poor. However, such information should usually only be known to the expert and the learner. Cognitive structuring is an extremely important form of surgical assistance, where a structure is provided for the learner for organizing the elements of each surgical skill and procedure in relation to one another. The relevance of anatomy, the use of each instrument and the application of each skill in an ordered sequence are related to one another.

Other forms of verbal assistance by questioning and instructing are important at the relevant point in each procedure. The skilled expert must vary the form(s) of surgical assistance that are provided to the learner depending upon the needs of each learner, the stage of development and the progress of each procedure. Self-regulation has an important role as the learner begins to regulate his or her own surgical performance. However, self-regulation must not be confused with leaving the learner to perform a complex task unsupervised. Self-regulation is promoted when the expert recognizes not to offer assistance at too high a level as it will disrupt performance and be perceived by the learner as interference. Although it is important to not provide assistance at too high a level in the surgical domain, it is also important to teach the learner different approaches and techniques that can be used during the execution of each task. Such a process provides the surgeon with greater flexibility when problems and complications are encountered. Thus the role of the expert surgeon who teaches learners is a complex and demanding one.

At the level of continuing professional education (CPE), there is little or no infrastructure in most institutions for teaching surgical procedures to specialists. Consequently, although many specialists will be in stages one, two or four of the ZPD for some procedures, there is no systematic approach for providing appropriate assistance. Assistance may be available on an ad-hoc basis. However, such assistance is often of short duration, consisting of a difficult case or a small number of cases that have a similar profile. This problem is more profound for the rural or single-handed practitioner who may not be able to approach a colleague for assistance on such an ad-hoc basis. Much surgical learning takes place during a visit to another institution or a course. Many visits to another centre result in limited surgical experience. The visiting specialist is competing for experience with learners in the host institution, and it may prove difficult to obtain the necessary licensure and hospital privileges to participate in surgery. Consequently, rural or single-handed specialists will rarely have entered stage three of the ZPD, before returning to their home base.

Courses are of fixed length, and usually take place over a small number of days. During such a course, there is a relatively large number of learners per faculty member. Practical components of such courses are short, frequently do not involve real patients, and a limited amount of assistance is available due to competition. For example, during a practical session there may be four or more learners per station, who frequently complete only a segment of some procedures. Follow-up assistance is rarely provided, and the learner returns to their place of work in the early part of stage one of the ZPD. Guidelines have been produced at a national and local level to govern aspects of the introduction of some new procedures, including training (Dunphy, 1993; Fraser & Petrucco, 1994; Society for Reproductive Surgeons, 1994). Although such guidelines may require a period of supervised learning, suitable experts are often not available, and such guidelines do not deal with the practicalities of providing assistance over a protracted period of time. Surgical Teaching

Medical systems do not routinely provide education in how to teach well. Those specialists, (either clinical or academic), who organize and run undergraduate, residency or CPE programs have not usually received a significant amount of education in how to teach, (assist performance). Teaching skills may frequently be acquired by "osmosis" from physicians who have not been formally educated in how to assist performance.

Sometimes, medical teachers are not expert in the subject they teach, as their clinical practice is not restricted enough to have mastered all of the skills and subject matter. Within medical education there is no systematic approach to integrating the "two domains" (Berliner, 1986) of expert teaching and expert medical/ surgical knowledge and skills. Unlike the nursing system, the medical system does not routinely produce "consultants" (clinical educators) who are expert teachers and are expert in a restricted area of clinical practice. Institutions frequently appoint "clinical nurse educators", whose role is to educate their colleagues. Medicine has not widely accepted/ recognized the importance of such a role (Roth, Schenk, & Bogdewic, 2001). Furthermore, teaching often takes place in a location that is separate from everyday practice, (grand rounds or courses), and not whilst specialists are practicing nascent skills. We believe that the theories outlined in both the ZPD and approaches to assisted performance emphasize the need to further develop programs to teach and/or enhance teaching skills to surgeons who are responsible for providing surgical education/ skill training at any level.

Summary

There is a high level of interest in further developing methods to teach surgical skills to trainees, and also to teach new skills to established specialists. The ZPD and approaches to assisted performance and teaching/coaching were outlined and then applied to existing educational theories and approaches associated with obtaining surgical skills. The stages of the ZPD appear to be consistent with existing psychomotor theories of skill acquisition, and approaches to assisted performance may provide additional insight(s) into the complexities of how to teach surgical skills, and how to approach the process of hand-over of responsibility from teacher to learner. These educational theories offer a model to explain how under certain circumstances there may be a diminution of the quality of performance of some skills by experienced practitioners, and how high levels of skill may be regained. These models also emphasize the importance of providing programs that are designed to enhance teaching skills of surgical educators. Although in this article we have applied the ZPD and approaches to assisting performance to surgical education, we believe that they may be of value in examining approaches to other aspects of medical education.

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