

Systolic and diastolic learning: an analogy to the cardiac cycle

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Abstract

IT HAS BEEN OBSERVED THAT THE ACTIVE-PASSIVE classification of adult learning can be viewed in terms of a systolic-diastolic model. This model represents an analogy to the cardiac cycle and the work done by the heart during these two phases of the cycle. The determinants of systolic and diastolic learning can be compared to the determinants of cardiac function: preload, afterload and contractility. Similarly, dysfunction in these two phases of learning can be compared to cardiac dysfunction from a pathophysiologic perspective.

Learning in adults can be classified as active or passive. For example, participation in a problem-based learning seminar is active and can be distinguished from reading and listening to a lecture, which are passive. Both types of learning are important. Active learning allows individuals to organize facts and opinions through debate and discussion and promotes longer-term retention and critical thinking. Passive learning in a lecture setting allows individuals or groups of individuals to acquire facts with considerable efficiency, at least in the short-term. One of us (D.L.S.) has observed that active learning can be viewed as “systolic” and passive learning as “diastolic.” This model is an analogy to the cardiac cycle and the work done by the heart during these 2 phases of the cycle.¹ The determinants of systolic and diastolic learning can be compared to the determinants of cardiac function during these 2 phases. Furthermore, dysfunction in learning can be compared to dysfunction of the heart from a pathophysiologic perspective. Although the terms “systolic” and “diastolic” learning have been used in discussions, we are not aware of any other publications on this subject or of any evaluations of learning activity that incorporate these concepts.

Systole is the active contraction phase of the cardiac cycle, the phase during which the heart performs its principal function, the ejection of blood into the pulmonary and systemic circulations. The delivery of blood to these circulations, measured as stroke volume, is an important indicator and demonstration of cardiac function. Thoughtful and active participation in discussions, an example of systolic learning, is educational stroke volume. Like the first heart sound, a great teacher or an interesting patient can initiate systolic learning. Like the normal second heart sound, the timekeeper in a seminar ends systolic learning for that cycle. In a dysfunctional state, a droning lecturer may end systolic learning prematurely by snapping off the lights (which, in the analogous cardiac situation, would be signified by a loud and early second heart sound) and signal educational failure with the S3 of the projector switch.

The principal determinants of systolic function of the heart are preload, afterload and contractility. Preload refers to the volume of blood that has filled the ventricle during diastole. In the adult learning situation, educational preload can be thought of as the acquired knowledge base necessary for active discussion and exchange of ideas. As cardiac preload increases, so does stroke volume up to a certain maximum level. In learning, stroke volume may be thought of as the contribution a person makes during active discussions and exchanges of ideas. Although the relation between cardiac preload and stroke volume is curvilinear, it is not known whether the relation between educational preload and educational stroke volume is linear, reaches a plateau or is biphasic. Many medical schools fall into the trap of as-



Education

Éducation

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suming that a large preload, in the form of years and years of pre-clinical lectures, is optimal. More likely, excess preload in the learning situation may lead to the dysfunctional state of “congestive learning failure,” in which excess factual information is lost in useless compartments (analogous to edema; see Table 1).

Afterload refers to the wall tension against which the ventricle must contract during systole. In turn, wall tension is determined mainly by the pressure in the blood vessels into which the heart ejects each stroke volume. As afterload increases, stroke volume decreases if all other variables are constant. In the adult learning situation, educational afterload can be thought of as the “social tension” or “social pressure” that inhibits the student from participating freely in active discussion. Like the pressure in the blood vessels against which the heart contracts, social pressure is the sum of all opposing pressures outside the learner. These pressures may originate from other learners, from the teacher or facilitator, from the educational philosophy in the environment or from inanimate components of the learning environment such as lighting or the layout of chairs in the room. A modest amount of afterload is present in the normal learning situation. Excess afterload may restrict self-directed, problem-based learning. At the extreme, over-emphasis on examinations and information storage, along with the concomitant belittling of students who cannot regurgitate facts, may resemble severe aortic stenosis and may be associated with markedly decreased overall learning performance (systolic and diastolic dysfunction, Table 1).

Contractility is the innate ability of the fibres of the heart muscle to shorten, which translates into a shrinking of the cardiac chambers during each heart beat. Contractility in turn depends on normal development of the heart muscle and the influences of nerves, hormones and drugs. In the learning situation, educational contractility can be

thought of as the innate ability and willingness to express ideas in the context of a discussion, to solve problems and to evaluate oneself. This ability depends on normal development of verbal and strategic skills and, ironically, on the same factors that affect cardiac contractility (the influences of nerves, hormones and drugs).

Diastole is the relaxation phase of the cardiac cycle, during which blood fills the cardiac chambers so that it can be ejected during the next systole. Diastolic learning may be thought of as the more passive type of learning. Diastolic volume (or pressure) is an important indicator and demonstration of cardiac function. Similarly, volume of knowledge acquired is an important indicator and demonstration of adult learning. Diastolic and educational volumes are meaningful not simply in terms of storage, but also in terms of potential ejectate (at the right time, in the right place). The principal determinant of diastolic function is the compliance of the heart, the volume of blood received during diastole divided by the associated pressure increase. A more compliant chamber allows for greater diastolic filling without an associated increase in pressure. An increase in pressure is limiting because it opposes further filling. In the learning situation, diastole can be thought of as the activities used to acquire and organize a knowledge base, such as listening, reading or reflecting. However, like cardiac diastole, diastolic learning is not entirely passive. Active relaxation is also required, to allow blood or knowledge to fill the appropriate chambers. And not all of diastolic learning is related to the immediate content area. Activities such as sports, love and fellowship may be considered part of this phase of learning. Compliance in diastolic learning may be defined as the degree of openness of the mind or the receptivity of the individual to new ideas and information.

Systolic and diastolic function are linked through heart rate. Cardiac output — total blood flow per minute — is

Table 1: Diagnosis and treatment of some pathologic states in systolic and diastolic learning

| Pathologic cardiac state | Educational equivalent | Educational consequence | Educational intervention |
|---|---|--|---|
| Excess preload | Excess core knowledge | Congestive curriculum failure, factitious edema, swollen heads | Unload the curriculum by replacing core knowledge (information to be memorized) with core problems (to be solved) |
| Life-threatening dysrhythmia | Irregular responses (especially belittling ones) to learners who ask questions or provide wrong answers | Learners ask questions to which they already know the answers | Reward — and never humiliate — learners' questions and answers |
| Excess afterload from stenosis of the outflow tract | Content-oriented examinations | Steering away from clinical problem-solving and toward memorization of ephemeral facts | Conduct formative as well as summative evaluations of actual clinical performance; teach self-evaluation |
| High-output failure | Service volume and frequency in excess of time and capacity for learning | Learners stop reading and mistake doing for thinking | Consider service and educational needs separately |



the product of stroke volume and heart rate. As heart rate increases, cardiac output increases to the point where diastolic filling time limits preload. Similarly, a life-threatening dysrhythmia limits cardiac output in part by decreasing diastolic filling. In the adult learning situation, cardiac output can be compared to total useful contribution to a discussion, and heart rate can be compared to the cycle time (the time for a period of speaking and active problem-solving relative and a period of reading, listening and reflecting). If the cycle time is too short (tachycardia), the quality of the learning experience for the participant concerned (and probably for other participants) declines. Similarly, a dysrhythmia induced by irregular external responses from a teacher can cause the same phenomenon (Table 1).

Therefore, just as there is an optimal balance between the systolic and diastolic phases of the cardiac cycle, there is also an optimal balance between systolic and diastolic learning.

Cardiac function is often expressed as the ejection fraction, the ratio of stroke volume (a measure of systolic func-


tion) to end-diastolic volume (a measure of diastolic function). Similarly, learning may be described as the ratio of systolic learning to diastolic learning. If systole is too short and diastole too long, the pulse of learning may be too slow. The systolic-diastolic model of learning serves as a reminder to educators and learners to incorporate both types of learning in their educational programs.

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