GENERALIZATIONS TO BE DRAWN FROM RESULTS OF RESEARCH ON TEACHING AND LEARNING

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INTRODUCTION

The last two decades have seen a world-wide burgeoning of systematic investigation of various aspects of the teaching and learning of physics, including connections to basic aspects of cognitive development. The growing volume of literature illuminates our efforts and improves our practices, and the accumulation of insight is readily apparent in presentations being made at this conference.

Rather than examining specific subject matter, adducing statistics, or reporting detailed protocols, however, I would like to take this opportunity to assert some generalizations I distill from accumulating knowledge and observations. Some of these generalizations are purely qualitative, and some are certainly not new to experienced teachers or to most members of this audience. Even though I might not be able to document every one of these assertions with specific protocols or statistics, I believe them to be strongly supported by evidence and observation. They provide a kind of synthesis or qualitative "meta-analysis" of some of our existing insights.

I do not pretend to put forth a complete or exhaustive list. In the following, I select a few of the generalizations I believe to be especially important. I suggest that few, if any, of these generalizations are adequately articulated to our university colleagues who teach physics but are not versed in our kind of research. Nor are these generalizations adequately impressed on student teachers or on new entrants to the teaching profession. If we wish to see the results of our researches more widely and effectively applied at various levels of physics instruction, I submit that we must convey, to a broader audience than that reading our specialized literature, not only the hard core results on learning specific items of subject matter but also some of the broader generalizations I try to indicate.
EXTRAPOLATING FROM ONE’S OWN LEARNING EXPERIENCE

When I try to suggest to my university physics colleagues that research is revealing significant student learning difficulties and that recognition of these difficulties challenges many of our deeply embedded instructional practices, a very common response from such highly competent physicists is: “But I learned this material in such and such a way, and this is how I present it to my students”. This is a deeply ingrained but highly fallacious attitude. I urge that it be challenged with the following generalization:

scientists should not extrapolate their own learning experiences to the majority of their students. only a very small fraction of our students learn from the same experiences, or as rapidly, as we did.

Those of us who became professional physicists were, by and large, members of the small fraction of students who do not happen to experience many of the difficulties discerned in the larger fraction. We must develop better techniques for benefiting the larger fraction without hindering the smaller one. Simply extrapolating from our own learning experiences is not the way to achieve this.

Although such extrapolation is especially widespread among professional scientists, it is by no means limited to this group. Teachers at all levels, after having finally mastered the concepts or modes of reasoning, sometimes tend to lose sight of the difficulties they themselves experienced and proceed to extrapolate from a later position displaced from actual student experience.

LISTENING TO WHAT STUDENTS SAY THEY ARE THINKING

Another frequent mode of response from professional colleagues on hearing about various learning difficulties revealed in research is: “Oh yes, in these circumstances the students were thinking so and so”. And such assertions are usually made in virtually immutable conviction as to their correctness. Experience in research on student thinking, however, suggests the following, more realistic, generalization:

when students make errors and you conjecture what they are thinking (without having asked leading questions and carefully listened to what they actually say), you will be wrong in your conjectures almost every time.

We must try to convince teachers at every level of the necessity of backing away from such purely subjective conjectures. It is important that they learn (for instance, from the example of good research protocols) how to ask questions without giving everything away and thus inducing learners to give answers that reveal to the teacher the actual thinking (if any) that is taking place.

The saving grace in our researches turns out to be the fact that, contrary to the uninformed contentions of some egalitarian thinkers, every student is not uniquely different from every other student in experiencing certain fundamental learning difficulties. In probing for pre- and misconceptions, in probing difficulty with abstract modes of logical reasoning, we repeatedly find clusters of many students exhibiting the same difficulty and describing their reasoning in almost the same words. It is this fact that makes it a realistic goal to utilize the fruits of such research in the improvement of instruction.

Teachers should make every effort to improve, through skillful questioning, their own empirical knowledge of how students are thinking under various circumstances instead of jumping to unwarranted conclusions as to what they think (or guess) that students are thinking. Furthermore, conscientious pursuit of such insight and refraining from careless