

Institutions of higher education and research in India: do they need to take interest in school science education?

As education policy documents have repeatedly stressed, the challenge facing school education in India is of quality. Experience from around the world indicates that the quality of education depends critically on having well-prepared and motivated teachers. The role of the universities in school education is generally thought to be the preparation of school teachers. However, universities and research institutions in India have typically played a minor role in teacher preparation, which has taken place largely outside the university. Teacher education in India, like engineering and medical education, has been hived off from mainstream university education into the professional stream. Teacher education has expanded massively over the last few decades to meet the enormous expansion of the population attending schools. Most of this expansion has been in the private sector – over 90% of the secondary teacher education colleges are now privately owned. Recently, the Justice Verma commission on teacher education described teacher education institutions as ‘closed spaces’ outside university campuses and identified their isolation as a major problem. The isolation of teacher education from mainstream university education has indeed taken deep root and is endemic to the entire education sector.

The rapid growth of a separate professional stream of education in isolation from the university, is prone to commercialization with its attendant loss of quality and integrity. Second, organic links with university-based knowledge disciplines are vital to introducing innovation in teacher education, as in other professional streams. There is a third important reason why isolation from universities is particularly debilitating for teacher education.

Professional streams such as medicine and engineering draw critically on the various branches of science and mathematics, but have a distinct and substantial body of knowledge of their own that is developed from and undergirds professional practice. While education does not quite enjoy the professional status of these streams, it too aspires to a distinct identity. The field of education has its own body of knowledge whose components range from philosophical reflections about the aims of education to

empirical and theoretical studies of the place of education in an individual’s development and in social change, to principles of pedagogy. However, unlike in the case of medicine and engineering, university knowledge disciplines are located at the very core of the educational enterprise. School education is education not only of the child or the human being, but also education of subjects: language and literature, art, science, mathematics and social science. It is for this reason that the isolation of education institutions from university-based knowledge disciplines can be crippling.

The majority of school (and college) teachers are subject teachers, typically teaching one of these subjects – science, mathematics, social science or language. As education has developed as a field in its own right, a generalized notion of pedagogy that can apply to the teaching of any subject has taken root in the curricula for teacher preparation. The notion of pedagogy as a collection of techniques, which can be applied to the teaching of any subject dominates teacher preparation. However, separating pedagogy from content undermines the teacher’s capacity to teach subjects like science and mathematics effectively. The separation of teacher education from the university has served to widen the separation of pedagogy from subject matter.

In the 1980s, Lee Shulman, an American educationist, wrote an influential article questioning the separation of pedagogy from content (Shulman, L. S., *Educ. Res.*, 1986, **15**(2), 4–14). He pointed out that effective teaching of a subject requires the teacher to understand the subject matter deeply. Shulman coined the term ‘pedagogical content knowledge’ to signify ‘that special amalgam of content and pedagogy that is uniquely the province of teachers, their own special form of understanding’. Pedagogical content knowledge or PCK is now an important part of many teacher education curricula across the world, including India. Shulman’s work is a landmark in education research and has led to a more precise understanding of what teachers need to know in order to teach effectively. In the field of mathematics education research, the notion of PCK has been elaborated in greater depth by several researchers, who have inferred the

knowledge demands made on the teacher by studying actual classroom practice.

Those who *teach* mathematics need to know mathematical content in a different way from those who *use* mathematics such as engineers or scientists. Teachers need to understand, for example, that using representations of fractions as shaded parts of a rectangle may create hurdles in understanding improper fractions. Teachers may need to evaluate the suitability of an alternative procedure for division using different partial quotients, which is presented, for example in the most recent NCERT textbook. Knowledge that supports these tasks includes such elements as knowing why algorithms work, having a repertoire of representations of a mathematical concept, and knowing the affordances and limits of particular representations of concepts (Ball, D. L. *et al.*, *J. Teacher Educ.*, 2008, 59(5), 389–407). Teachers need to know the hurdles that familiarity with arithmetic creates for the learning of algebra and ways to bridge arithmetic and algebra (Subramaniam, K. and Banerjee, R., In *Early Algebraization: A Global Dialogue from Multiple Perspectives* (eds Cai, J. and Knuth, E.), Springer, 2011, pp. 87–107). They also need to know how concepts in school science and mathematics provide a foundation for more advanced concepts in higher education. Reflecting on concepts at the school level from an advanced standpoint illuminates the big ideas that they need to focus on in their teaching.

While research in science and mathematics education is filling in the jigsaw puzzle of what teachers need to know in order to teach effectively, teacher education institutions have limitations in absorbing these insights in reshaping their curricula. The curricula and faculty expertise in these institutions have been built assuming that subject content is already known to prospective teachers from their previous education. B Ed students practice preparing lesson plans or using pedagogical techniques in real classrooms, but do not reflect deeply on the content that they are teaching. Recent revisions of the teacher education curriculum include deeper engagement with subject matter and foundational aspects of the subject. However, it is unlikely that teacher education institutions will be able to muster the intellectual resources needed for such engagement.

This situation is partly a result of the way university education itself is structured. The curriculum of higher education institutions is shaped by the requirements of careers in the industry or in research, but rarely by the requirements of school teaching. Indeed, university departments would be surprised at the suggestion that they must address the requirements of school teaching. Is not the content of school subjects too elementary, and have not those who enter university already mastered them? Is not the business of the university only to concern itself with the frontiers of knowledge, not with its backwaters?

This view reflects a profound disconnect between the university and school education. As a result of such beliefs, future teachers have no opportunities to revisit their subjects from the vantage point of advanced disciplinary knowledge either in the university or in teacher education courses. This can be corrected only if the universities and similar institutions located at the apex of the education pyramid, take responsibility for all stages of education including school education. The abdication of responsibility for early education weakens school learning, eventually weakening the university itself.

In India, a weakened university system has been buttressed from time to time by building elite higher education and research institutions such as IISERs and IITs outside the university system. My comments about the neglect of school education apply equally to such institutions. In designing their curricula, institutions like IISERs and IITs accord primacy to the requirements of research or industry, but neglect the knowledge that is needed for teaching. Indeed, students entering such institutions rarely expect to take up teaching as a career partly because the institutions fail to project teaching as an option.

Even though the teaching profession is not attractive in monetary terms, it can be very fulfilling both intellectually and emotionally. Interacting with young and growing students, and playing a role in their development can be very gratifying. A classroom setting in which students can express themselves freely can be intellectually challenging, keeping one not only close to a subject that one likes, but also allowing one to explore hitherto unexplored ideas and connections. It is this sense of challenge and excitement that higher education institutions must communicate to those of their students who are temperamentally inclined to teaching. This can happen only when the institution and its faculty take a genuine interest in school education.

Thus, much is to be gained for science and mathematics education at the school level if institutions of higher learning take a deep interest in school education. Research and outreach programmes in subject-based education can be initiated and grown through the creation of inter-disciplinary centres. Over time, these will begin to impact school education by not only providing insights through research, or materials through the outreach activities, but also by growing a generation of leaders who combine deep knowledge and understanding of both education and the content of science and mathematics and can bring about profound change in school education.

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