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The American University system is undergoing a thorough revolution, as can be seen from the most casual perusal of the newspapers or from serious discussions.[1] A dozen irritated Canadians recently presented a series of essays which entertained the horrifying possibility that the present University is now so bad as to be irrelevant to education![2] For example, they ask if the University has degenerated to just a training school of necessary personnel for corporate industry requirements. "The Multiversity is a place in which the claim of institutional continuity and efficiency come to head-on collision with its educational aims; the latter are normally wiped off the map." (Reference 2, p. 74). Such criticisms are also found in the caveats of the serious drop-out and hippie critic of our establishment. Paul Krassner, The Mr. Yippie, recently suggested that the Yippies were the prototype of the totally-leisure class which could soon be the result of our technological advances. Perhaps a continuous commitment to life-long education would provide the "leisure civilization" with viable activities.

It is now generally admitted that an increasing larger portion of each professional career is required for "continuing education", "up-dating", or "maintaining proficiency". Considerable academic attention is being paid to the problem of Continuing Education, both by institutions traditionally oriented to that problem[3] and those not previously deeply concerned[4]. The overall supply/demand of engineers is germane to the discussion of continuing education for engineers. Only by 1950-54 (Reference 5, p.55) did the degreed enginners and scientists hired in defense R&D outnumber the nondegreed. Demand for advanced degrees also continues. About 46,000 new engineers went to work in 1965. Although less than an estimated (National Science Foundation) demand of 55,000 required, some of the net supply of 21,000 physical scientists apparently were diverted into engineering. Available statistics are inadequate to provide any finer detail, but it appears that the continuation of an adequate supply of engineers and scientists for defense R&D is possible, as in the past, through the action of the marketplace. This technique has succeeded in maintaining a reasonable nationwide balance between supply and demand in the years of rapid expansion of engineer/scientist activities since World War II. Thus the continued concern of an impending "shortage of engineers" may be unwarranted, although the annual engineer outputs from Japan (200,000) and Russia (130,000) are impressively larger than ours.

Dr. Fred Terman, Provost Emeritus of Stanford University, has been compiling cost data on U.S. engineering schools[6]. He suggests that a minimum size of 40 to 50 BS graduates per year in each major field is necessary for an economic operation. Terman's comparison unit is the cost per student semester hour. He finds no correlation of cost with excellence, only with size. By this standard half of the engineering schools in the U.S. are not large enough. Of the 180 accredited schools, half turn out 80% of the 32,000 BS degreess (Reference 7, p.44), 1966 data. For a U.S. population of 180 million, the existence of 90 schools (50%) with an annual degree production of more than 130 suggests an average population base of 2 million would be required before a new engineering school should be started in any given region. The disparity in size of school is even more pronounced with graduate degrees. 50% of the degree granting schools award 88% of the graduate degrees! While engineering schools are continually being started, BS production in engineering seems to remain about constant even with a 5% increase in total male University BS production and in male high school graduates. (Reference 7, p. 399, my trend line)

Thus efficient use of advanced technology by the University is required as competition for funds becomes more severe. Possibly for the first time, institutions of higher learning must establish "accountability" with their sources of income. "A recent off-the-record meeting was reported as follows: The state's budget director did most of the talking and the gist of his remarks was as follows: 'up to now you've had things pretty much your own way. You've received the funds you asked for, even though you did a poor job of justifying many programs. But from here in, things are going to be more difficult. You must develop more effective guidelines and standards.' The implication was clear that if the educators did not do a better job of evaluating their programs, others would". (Reference 8, page 11).

Other fascinating indices of academic productivity are available, such as the annual production of University degrees per faculty member. This index is astonishingly low, only one or two. A slow improvement was noted until 1950, but since then a definite decrease is apparent. The cost per student and the cost per degree have been rising together, not unlike the Gross National Product. The ratio of University students and annual degree production, however, has remained bracketed between 6 and 12 for nearly a century. An indicated solution is a higher student/faculty ratio. If the faculty is released from repetitive chores by using video-tape, multiplexed classes by TV, and programmed instruction, then their time is available for the all important personal counselling and evaluation.

Advanced technology has been used in academia only to a limited extent so far. Faculty and administration reluctance to change, the cost of advanced technological devices, and general uncertainty as to their usefulness have limited their application. Surprising to the outsider, the engineering professor himself is often reluctant to use new media even though his professional career is committed to developing such new technical devices. The two specific technical items often suggested for academia are computer aided instruction and televised teaching. Computer aided instruction (Reference 8, p. 135) is very useful for repetitive type training such as foreign languages, simple mathematics, and computer programming. It also has a good promise in other fields but requires careful and time consuming planning and programming. The University of California at Irvine is a new campus which was in an excellent position to adapt and develop computer aided instruction[9]. In the Spring of 1965, six months before the first student enrolled, Irvine installed the first of its computers to provide terminal-oriented, instructional-computing services. The intent is to provide opportunities for people to be assisted by computers. In 1968 the replacement 360 computer system provided improved services, not only for members of the Irvine community but also for those of neighboring Orange Coast College. Service is available from 30 terminals in several locations about the campus. 163 learning units covering 53 subject areas in eight disciplines are now available.

Television has been used and studied for at least ten years in the university community. The vast majority of relative effectiveness studies performed has revealed "no significant differences" in measured performance between students who were instructed via TV and those who were taught directly[10]. Table 1 lists the presently viable television networks and indicates their present respective sizes. Television can be used either to overcome the restriction of geography and small objects, as an overflow classroom situation, or to render visable to larger groups surgical and other close work. With student talkback, as in the existing Florida, Southern Methodist University, and projected Stanford and University of California Irvine systems, student involvement can be maintained at least for moderate class sizes. More important than the details of the talkback system is the personality of the professor. If he does not solicit and encourage student participation, any elaborate talkback system is of no avail. Disadvantages of the live television with talkback systems are that all students must participate simultaneously thus making for a stringent scheduling problem. The Colorado State University SURGE System video tapes the curriculum and then places these video tapes in receiver rooms at times convenient to the students. Conference audio links are provided during the week to the Professor. It will be interesting in the next several years to see whether the absence of talkback is crucial. At both Florida and Texas, projection techniques permit either conventional blackboard or table top projection of material. It is interesting to note that as more experience is gained in both of these systems, the professors use the table top to a greater and greater degree, shunning the conventional blackboard. It is hoped that this represents realization of the clearer projection possibility and not just laziness!

The reluctance in some academic circles to concede value to TV and other electronic media[11] may parallel the early days of U.S. colleges when faculties were reported to be slow to use books.[12] The continuing emphasis on lecturing may even reflect a reluctance to admit any value of books for student learning. In discussion of TV uses, much resistance stems from the widely held thesis that quality education is achieved by face to face encounters of the professor and the student in small classes. More than mere exchange of information and developing of skills seems to be involved. However, there is great difficulty in obtaining elaboration on just what this elusive extra factor is. Perhaps this educational plus is not clearly defined in the professor's own mind, that in-depth interviews might reveal that he is worshipping something that is rather amorphous and ambiguous. In fact, such a hypothesis provides a not unreasonable explanation of why so much of the resistance to innovation which appears to threathen this special quality education, is vague in purpose and direction. (Reference 11, p. 143) Some data also indicate that the younger faculty is more resistant to innovation than older!

TV makes the lectures available to the scrutiny of academic colleagues for the first time. Traditionally, professors do not enter another's classroom. Anyone interested in TV has noted that when newly approached about the suitability of TV, most professors will postulate that it may have some merit in other fields, but certainly not in theirs. The frequent faculty resistance to TV seems linked to a feeling that TV represents a threat to their very existence. (Reference 11, p. 136).

The current concept of a professor writing lengthy equations on the blackboard for a student to copy wearily leaves much to be desired. Without planned pauses and repetition for note-taking, learning can even be inhibited. (Reference 10, p. 26). Pre-prepared notes seem more useful. As writing something does seems to help a student stay awake and maintain interest the notes could have planned gaps for interpretative comments and criticisms. Class time would be better spent explaining material rather than repeating lengthy derivations.

The pioneer major TV systems at the graduate[13,14] level were the University of Florida's GENESYS and TAGER[15] of Southern Methodist University. Both were developed by Thomas L. Martin, Jr., and utilize point to point microwave (6-12 MegaHertz) transmission. The second generation of instructional TV systems will utilize the recently authorized Instructional Television Fixed Service (ITFS) broadcast channels in the 2500-2690 MegaHertz frequency range[16]. This frequency permits area coverage from one antenna to multiple receiving sites. Stanford is to be broadcasting by the time of publication of this article and the University of California at Irvine is planning an ITFS system.

For example, inter-institution links should use microwave which can provide dozens of channels for that specific path; transmission from one institution to many receiving sites in a general area would be a logical use of the ITFS frequencies. As there are only 31 ITFS channels available in each region, regional committees have been set up to exploit ITFS possibilities and screen educational applicants for the Federal Communications Commission. Sixty to eighty miles away, the same ITFS channel can be used by another institution. The frequencies of the 31 ITFS channels are shown in Table II[16]. Each channel group contains four channels, except H which has only three. In the Los Angeles area, the geographical spacing is such that three universities can share the eight A & B channels. Public and private school districts are allocated the other 23 channels.

The expense of conventional video television transmission has prompted a number of universities to try "blackboard by wire" systems. Blackboard by wire systems have a lower data rate and can be transmitted by conventional commercial phone systems. Transmission cost is reduced by a factor of five or more but the video contact from the professor is, of course, lost. For those professors who do not welcome being "on-stage" this may be no detriment, but it does seem to denigrate the contact from the professor to the student.

Professor Robert L. Walker of the University of Florida, Cape Canaveral, GENESYS, has suggested a time sharing arrangement whereby two or more professors transmitting by blackboard and wire would share a single video channel. It is expected in the future that picture phone or television transmission by phone lines may become feasible[17], perhaps in conjunction with blackboard by wire.

With the advent of many community cable systems for commercial TV, it is also possible to connect the University video output with this system to transmit classes to all sites connected with the cable systems. The problem of talk back then remains, and while it is possible to have conference calls on the present phone system, the current charges are outrageous, some $40 an hour for only five conferees. Connecting the University to the cable system entails costs in the order of $4,000 to $8,000 a mile, depending on whether the cables are underground or not.

For the far future there are many suggestions of using a system of continuously passing satellites as relay stations between transmitter and receiver.[18] The use of lasers is a possibility, but not before the next 15 or 20 years.

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TABLE I
EXISTING UNIVERSITY USE OF TV

UNIVERSITY	INITIATED	CHANNELS	COURSES	STUDIOS	STUDENTS	CLASSROOMS	SPEC	HOW FUNDED	CLIENTELE
University of Florida GENESYS	1965	2 network	40	4	450	7	microwave 1 way video 2 way video	University	Grad. Engr.
Southern Methodist Univ. Dallas, Texas	1967	4 Star	30	6	1200	42	microwave 1 way video 2 way video	Industry Contributions	Grad. Engr.
University of Rhode Island	1962	1 link Kingston to Portsmouth 14 miles	9			1	1 way video 1 way audio		Grad. Engr. Education
Ohio State University		1 link Columbus to Wright Field 60 miles				1	1 way video		Grad. Engr.
University of Connecticut			few	theater/ studio					Grad. Engr.
Purdue		2							Grad. Engr.
Colorado State	1967		12	2	400	20	videotape 2 way audio	University & NSF	Grad. & U' Grad. Engr.
Stanford	4-1-69	1 channel eventually 4			600		ITFS	Industry Contributions	Grad. Engr.
UC Irvine	1970	1 channel eventually 4					ITFS	Industry	Grad. Engr.
RPI	Now in feasibility study								
U. of Tulsa	Now in feasibility study								
S.U.N.Y.	10/67	Statewide link between ETV stations and State University of New York							
U.S.C.	Now in feasibility study								

TABLE II

CHANNEL GROUPS AVAILABLE IN ITFS

GROUP A		GROUP B		GROUP C		GROUP D	
Channel	Band limits MHz	Channel	Band limits MHz	Channel	Band limits MHz	Channel	Band limits MHz
A-1	2500-2506	B-1	2506-2512	C-1	2548-2554	D-1	2554-2560
A-2	2512-2518	B-2	2518-2524	C-2	2560-2566	D-2	2566-2572
A-3	2524-2530	B-3	2530-2536	C-3	2572-2578	D-3	2578-2584
A-4	2536-2542	B-4	2542-2548	C-4	2584-2590	D-4	2590-2596

GROUP E		GROUP F		GROUP G		GROUP H	
Channel	Band limits MHz	Channel	Band limits MHz	Channel	Band limits MHz	Channel	Band limits MHz
E-1	2596-2602	F-1	2602-2608	G-1	2644-2650	H-1	2650-2656
E-2	2608-2614	F-2	2614-2620	G-2	2656-2662	H-2	2662-2668
E-3	2620-2626	F-3	2626-2632	G-3	2668-2674	H-3	2674-2680
E-4	2632-2638	F-4	2638-2644	G-4	2680-2686		