

BOOTSTRAPPING A UNIVERSITY—THE CASE OF THE VIRTUAL UNIVERSITY OF PAKISTAN

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Abstract

Faced with a growing young population and having limited capacity in its conventional universities, Pakistan had to think of outside-of-the-box solutions. A compounding factor was the acute shortage of qualified faculty. A virtual university was considered as one way of supplementing the capacity of conventional universities while alleviating the problems of faculty shortage in existing institutions. The project was launched in 2002, and within a short period of just over a decade, the Virtual University of Pakistan has become one of the largest national universities and, along the way, has notched up an impressive list of innovative approaches to tertiary education.

KEY WORDS: e-learning, e-assessment, OpenCourseWare

1. BACKGROUND AND DRIVING FORCES

Pakistan is the sixth-most populous country in the world. According to the Pakistan Bureau of Statistics (2015), it has an enormous youth bulge with fully 68% of the population being below the age of 30. This poses huge challenges to the education sector, and the provision of services in order to achieve meaningful results remains an uphill task. In the tertiary education sector, there are a total of 183 universities or higher education institutions (HEIs) in the country, while the gross enrollment ratio stands at a low 10% (World Bank, 2015).

In the year 2000, the situation was even bleaker. There were only 59 universities in the country and the enrollment in tertiary education stood at an abysmal 2.3% (Atta-ur-Rahman, 2017). This serious lack of capacity in the existing institutions was further compounded by the acute shortage of qualified faculty in these universities. PhD-qualified faculty members amounted to < 25% of university academic staff. It was at this point that the government presented its development plan, "Vision 2010." As part of the plan, a complete overhaul of the higher education sector was envisioned along with several initiatives in the field of information technology (IT). A comprehensive IT Policy (Government of Pakistan, 2000) was developed after taking all stakeholders on board, and this policy included the establishment of a "virtual university" in the country. Provision of Internet-based services was in its infancy, and the IT policy also included the expansion of

fiber-based connectivity throughout the country as well as the acquisition and deployment of Pakistan's first communication satellite.

A feasibility study sponsored by the United Nations Development Program (UNDP) that was carried out in 1999–2000 indicated that an online university could prove beneficial in tackling the capacity and quality issues faced by conventional institutions. The study was presented to the Ministry of Science and Technology, which then commissioned the development of a project to establish the Virtual University of Pakistan.

While drawing up the project plans, it was envisaged that the university would be a formal distance-learning institution and not an "open" university. It would be designed to supplement the capacity of the existing conventional institutions. Both the capacity and faculty shortage issues were to be overcome by using information technology as a force multiplier, and the same technology would enable the delivery of education to every corner of the country. Whereas none of the existing universities could boast a full complement of qualified faculty members, it was clear that by considering all existing universities as one large talent pool, relevant expertise in many different fields could be identified. As such, development of courses to be offered by the virtual university would be possible, whereas mentoring would be provided by the university's own staff. The project was approved in 2001, and work formally started in October 2001.

2. DESIGN DECISIONS

The major design points that had to be addressed as part of the project plan were as follows:

- a. Course development
- b. Delivery of learning content
- c. Access issues for students
- d. Student-teacher interaction
- e. Assessment
- f. Management

However, there was an even larger problem looming in the background. This was the negative perception associated with distance education (DE), in general. The feasibility study had indicated that the public, in general, and even many academics did not consider education delivered at a distance to be comparable to conventional face-to-face education in terms of quality. The virtual nature of the proposed university compounded this negative perception by raising additional questions.

The historical approach to DE had been the correspondence model with study materials being mailed out to students, with assessment based on one or more assignments, and a final exam at the end of the term. This model [Allama Iqbal Open University (AIOU), 2017] was being practiced by the AIOU, Pakistan's first, and at that time, only, distance education university. The AIOU used the Open University UK's model (Open University, 2017a) to develop its courses. This meant that teams developed the courses rather than individual professors.

Furthermore, there were serious questions (Akhtar, 2015) being raised about the assessment methodology at AIOU, which gave a very large weightage to the term assignments. The system also used a large network of tutors, and students could have access to face-to-face sessions when needed. However, the quality of tutors varied greatly and trying to align student-tutor schedules was almost impossible. The introduction of information technology into the picture raised an additional question about the identity of students, especially if they were to be examined online.

2.1 Course Development

The first major design decision was the format to be used for the courses at the virtual university. The World Wide Web was barely a decade old, but the impact of hyperlinked text was huge and had immediately pervaded the distance education space. Traditional DE providers who had used printed or audio-video material had quickly moved to the web platform and transformed their learning materials into HTML. The adoption rate moved exponentially, and by the year 2000, fully 50% of its students were linked online at the Open University UK (2017b).

To remain as close as possible to the conventional face-to-face model, it was decided that Virtual University courses would be based on video lectures. At that time, there were only a handful of Internet Service Providers in Pakistan and the Internet was being used primarily for email over low-bandwidth dial-up connections. Because the low bandwidth would prove to be a huge hurdle for accessing rich multimedia content, a text version of the content was also going to be necessary for enabling equitable access across the country.

As mentioned earlier, the acute shortage of qualified faculty implied that if the new university were to hire faculty from existing institutions, it would be a zero-sum game with no net beneficiaries. It was therefore decided to invite qualified faculty members with acknowledged credentials, regardless of their institutional affiliations, to develop courses for the Virtual University without becoming university staff members. The selected resource persons would continue working for their parent institutions while the Virtual

University would offer the developed courses using information and communication technology.

The selection of professors for developing the initial set of courses was critical. The issue of DE being "nameless" and "faceless" would have to be tackled by identifying top-tier professors having excellent communication skills and then presenting them as the new face of distance education. The selection of well-known individuals for course development contributed significantly toward establishing the credentials of the new university.

2.2 Delivery of Learning Content

The effective and convenient delivery of learning content indicated that a web-based learning management system (LMS) would have to be deployed for the purpose. The LMS would have to provide convenient access to learning materials, both video as well as text, and allow for teacher-led or group discussions as well as student-teacher interaction.

The delivery of video lectures posed a special problem. The low bandwidth connectivity available at that time put constraints on what could be effectively achieved. The Virtual University also wanted its lectures to be viewed by as large an audience as possible so that a positive perception could be created about e-learning and the new version of distance education. It was therefore decided that in addition to the LMS, the university would also use free-to-air television for broadcasting its lectures. Since broadcast television had its own constraints in terms of broadcast schedules, it was also decided to make the video lectures available, for the cost of duplication, on CDs and DVDs.

2.3 Access Issues for Students

Internet penetration in Pakistan was in its infancy in the year 2000, and there were only about 130,000 Internet users in a population exceeding 160 million (International Telecommunications Union, 2016). Computers were expensive, and very few privileged individuals had access to desktop computers, let alone laptops. The setting up of a university that was to rely on information technology for all aspects of its operations was therefore an enterprise that required careful planning and execution.

The expansion in fiber connectivity that was being launched nationwide at the same time had the potential to alter the problem dimensions, but only after a certain period of time. Using broadcast television for the delivery of lectures had its own implications in terms of cost to the university and inflexible schedules for students.

It was decided to use a network of campuses to be termed as "virtual campuses" to provide easy and equitable access to students. These campuses would be equipped with computers and broadband connectivity that registered students could use to access the LMS. These virtual campuses would also provide a valuable social space, especially for

younger students. No additional cost for students was to be associated with the use of these campuses. Students who had personal computers with access to the Internet could study from home as well.

2.4 Student-Teacher Interaction

How effective student-teacher interaction was to be achieved was an important design decision. Although the video lectures and accompanying text material would form the basis of the primary exposition of knowledge, effective student-teacher interaction was necessary to provide proper mentoring and clarification of any questions that the students may have. It should be kept in mind that students in Pakistan did not have easy access to the Internet and even Google itself was only a couple of years old at that time.

Establishing a nationwide tutor network like the Allama Iqbal Open University, apart from being expensive, was a risk-prone exercise, especially from the perspective of quality. Although adequately qualified tutors could be identified in the larger cities, it was clear that students in remote and far-flung areas would remain at a disadvantage. As a design policy, it was decided that the educational experience of all students of the Virtual University would be identical, regardless of their geographical location. This meant that even if the tutors and students happened to be near to one another, perhaps even in the same building, all interaction would have to happen online.

This decision had other implications as well. Students as well as tutors would have to be proficient at typing, since they would have to pose their questions and answers by accessing the discussion boards of the LMS. Of course, the reality was that students and tutors were not keyboard experts and had a steep learning curve ahead of them, both in terms of typing as well as in mastering the various features of the LMS.

2.5 Assessment

This was the most critical design decision that had to be taken. The challenge to have academic credentials acquired through distance education accepted as equal to those obtained from conventional institutions required that the assessment process be as transparent as possible. In other words, paraphrasing from the legal counterpart of the statement, "assessment must not only be done, it must also be seen to be done."

There were two educational systems in practice for tertiary education in Pakistan. The first was the semester system, which was practiced on campus by many universities. There was also the system of large public examinations conducted annually by several older universities that were taken by students from colleges affiliated with these universities as well as "private" students who studied on their own. For these large public examinations, students registered with the university, either through their college or directly, and were

then required to sit for their exams at designated exam centers, where the invigilation and conducting staff was appointed by the university.

Since the Virtual University was to have a nationwide footprint, it was decided that the model of the large public examinations would be followed. Students would be required to appear physically at designated examination centers. Their identity would be verified by the conducting staff, who would then mark their attendance by obtaining signatures and only then would the candidates be allowed to sit for the examinations.

It had been decided at the course-development stage that the university would follow the semester system, and this implied that all semester examinations would have to be conducted in these exam centers. To simplify operations, it was decided that assessment in all undergraduate courses would comprise a midterm and a final examination. Assignments, quizzes, and other semester work would be duly assigned through the LMS, but the major part of the grade would be awarded based on these examinations. This design decision went a long way in overcoming the negative perceptions associated with online learning.

2.6 Management

Being a greenfield project, the Virtual University had no legacy of past records or archaic management systems belonging to a pre-IT era. As such, it was decided that the university would be managed through properly designed IT-based systems and paper records, and that snail-speed processes would be kept to a minimum, if not eliminated altogether. Some financial records would still need to be paper-based for audit purposes, but this was a small, doable task.

3. LAUNCH OF THE PROJECT

The Government of Pakistan approved the Virtual University project in August 2001, and after necessary administrative approvals, the project started functioning in October 2001 with just a few full-time staff members. An ambitious start-of-classes date was set for March 2002, and all efforts were made to meet the target date. On the basis of the design decisions, several initiatives were started in parallel.

It had been decided that the very first program to be launched would be a Bachelors program in computer science. The national curriculum had already been published by the young Higher Education Commission (another outcome of the educational reforms) and was adopted by the university. An effort was immediately started to identify the available gurus of the field and woo them into developing the required courses.

Because there was no course template available, the process was bootstrapped through long dialog sessions with these highly qualified individuals who threw quite a few

experiential factors into the discussion. A very experienced television producer was also part of the initial team, and he brought all of his expertise to the table. For example, the precise format of the video lectures came under intense discussion. Many of the professors, who were known for their classroom competency, believed that body language was an important component of the lecturing process. Some professors preferred to deliver lectures while standing and moving around the "stage," whereas others wanted to speak while seated. To enrich the lecture videos, extensive use of diagrams, slides, and even video clips was indicated, which were to be inserted in postproduction.

Another important factor that was extensively debated was the language to be used for lecture delivery. Pakistan was a bilingual nation at its birth in 1947. In addition to several regional languages, the official language was English, whereas the national language was Urdu. The medium of instruction at the school level was primarily Urdu, but English was taught very effectively and high school graduates were expected to have a reasonable command over the language. The medium of instruction in colleges and universities was English. Over a period of time, however, English language skills deteriorated, and when the Virtual University was being launched, it was no longer clear that students would be able to properly assimilate lectures delivered purely in English. However, the common tongue used by the population was a mixture of English and Urdu, and after extensive discussions, it was decided that lectures would be delivered in bilingual mode using both languages, the primary objective being the effective transfer of knowledge.

By December 2001, a production house had been selected through a public tendering process for recording the video lectures. Professors were engaged and course development began in earnest. As part of the development requirements, professors were required to provide lecture notes or handouts, a full set of assignments, and three to four sets of midterm and final examinations along with grading rubrics. The assignments and exams were to be used for startup purposes in the first semester, and it was expected that full-time university staff would then take over these aspects for subsequent semesters.

Selection of the LMS was the next major milestone. There were a few established international offerings at the time, but none of them had any support structure in Pakistan. Finally, a product was acquired, again through a public tendering process, from a company in Singapore that could provide support through its local partner. The LMS met all rudimentary requirements for content delivery and featured a threaded discussion board that was to be used for student-teacher interaction.

The fledgling university had acquired some office space for its project office in Lahore, and since the Pakistan Software Export Board (PSEB) had its Internet node in the same building, the office obtained access to the required bandwidth and set up its servers to host the university's website and the LMS. Staff was selected and hired to cover the basic

requirements of the university and the project office; accounting staff, IT professionals, and junior level academic staff were all engaged and housed in this office. University staff, such as the Registrar, Treasurer, and Controller of Examinations were also hired.

The provision of television airtime was negotiated with Pakistan Television, the national broadcaster, and they agreed to provide one hour daily for the Virtual University's lectures. Because the channel was a terrestrial channel and broadcast nationwide, the visibility of the Virtual University's courses was ensured, except for a very small time period, in every corner of the country.

The last piece of the puzzle was the establishment of campuses for students. As described earlier, these virtual campuses were simply to be computer labs connected to the Internet with some adult management available. No teaching staff was required because this aspect would be handled online by full-time university staff. The question was who would establish these labs and under what terms and conditions.

It was right about this time that the "dot com" bubble burst (Wikipedia, 2017). Many IT training centers had been providing trained manpower for the "body shops" feeding that web explosion. These centers suddenly found themselves without clients and, hence, no one to train. The large number of computer labs established by these centers suddenly became empty. Therefore, when the Virtual University invited applications from the private sector for the provision of computer labs to act as its virtual campuses, there were many applicants for this new opportunity.

With all the pieces in place, the Virtual University of Pakistan was formally inaugurated by the President of Pakistan on Pakistan Day, March 23, 2002, a national holiday. Within a period of only six months, courses had been developed, centers established, staff hired, and the LMS installed and populated with course content. The first cohort of 500 students began their classes in March 2002, from 28 virtual campuses established in 18 different cities of the country. The university was granted a Federal Charter in September 2002 that authorized it to deliver tertiary education anywhere within the geographical boundaries of Pakistan and even establish its campuses overseas. The Virtual University of Pakistan had become a reality.

4. EARLY YEARS

The Virtual University of Pakistan billed itself as a "formal" university with a well-defined academic calendar. Students were expected to follow the prescribed schedule of classes, although the schedule was kept flexible within a 24-hour time window. All activities of a conventional face-to-face university (such as assignments, quizzes, etc.) were conducted, and within a few weeks, the university was ready to conduct its first midterm examination.

Given the low bandwidth available in the early days, the role of television broadcasts was very important, but one hour of daily airtime was certainly insufficient for the needs of even a single program. It was decided that the university would establish its own dedicated television channels, and a separate project was developed and submitted to the government for funding. The project intended to use Pakistan's first and only communications satellite, PAKSAT-I, for broadcasting the university's television channels. Four channels along with state-of-the-art studios for course development were planned. The project was approved by the government and the university's first two channels went on the air in 2004. An additional two channels were commissioned in 2006, and the university became a licensed broadcaster. The special license obtained by the university limited its broadcasts for educational content only, and no commercial activity was permitted. This was done intentionally. Earlier experiments by the national broadcaster in trying to launch an educational TV channel with commercial content had ended in disaster, with commercial interests completely overwhelming the educational component.

The four channels initially operated from 8:00 to 2:00 AM, but eventually started broadcasting around the clock. The university finally had enough airtime for all its courses, but this luxury was short lived.

The apprehensions regarding students' IT literacy and typing skills proved not to be an issue. The excitement associated with the new technology and the completely different pedagogy motivated students enough to overcome the challenge. The queries received via email—a new communication method students were experiencing—were more about the content and LMS methodology rather than about any IT-related hurdles.

Students adapted to the LMS very quickly, but from the university's perspective, the limitations of the system started becoming apparent at a very early stage. The LMS did not provide for a gradebook or an account book, which were essential requirements for students registered in a four-year degree program. Similarly, there was no mechanism for handing out or receiving assignments; everything had to be done by email. The discussion boards provided by the system proved to be poorly suited to the task.

The "threaded" discussion boards provided by the system were fine-grained and associated a discussion session with each lesson or lecture. However, there was no limitation on where a student could post his or her questions because no locking mechanism was provided. As a result, students usually posted their queries on the very first discussion board available for each course, which always turned out to be the board for the first lecture. All other discussion boards remained empty or sparsely populated. Tutors had a very hard time trying to identify new questions that needed addressing; students with better connectivity were always able to post quicker; and queries from students coming over slow dial-up connections were usually lost in the noise.

The logistics involved in establishing exam centers in 18 different cities, appointing the invigilation staff, distributing question papers, conducting examinations, and then retrieving student answer sheets for grading in a manner that maintained the sanctity of the assessment process were quite complex, but did not prove overwhelming. The initial few examinations were distributed electronically via email but conducted on paper at the various centers. However, the need for a fully IT-based examination system became apparent very early in the proceedings.

5. EVOLUTION AND GROWTH

New programs were launched on a regular basis with IT and management disciplines in the forefront. The process of course development was better understood and became routine. With the induction of the university's own studios in 2004, the production quality received a quantum boost and more attention could be paid to the actual content being developed by the professors. The initial set of resource persons who authored and developed the courses comprised the very best that the country had to offer, and their presence on the public screen contributed significantly to the positive perception of the university. They established the gold standard that others had to follow.

The university established a philosophy of "easy entry, hard exit." Students who had obtained a minimum of second division (a legacy of the British educational system) in high school were assured of admission to the university. However, they would have to work very hard and in an extremely challenging environment if they wanted to graduate. An enormous amount of self-motivation was required on the part of students, and although dropout rates were high, a significant number of students were able to successfully complete their chosen programs.

The campus network of the university continued to spread. Standards that had been established in the early days were updated to follow the advancements in technology. The university also established its own campuses in the major cities and acquired land for the construction of its main campus near Lahore, Pakistan.

6. LMS

On the basis of the lessons learned during the early years, it was clear that a new LMS would be required with certain custom features so that student records could be properly linked to the university systems. The usual build-versus-buy debate eventually tilted toward the build option, and the university's own IT team was tasked with developing a fully customized LMS.

The new LMS went into operation in 2008 and was received enthusiastically by the student body. The new features made studying at the Virtual University much easier, and in

particular, the quality of student-teacher interaction was improved dramatically. Students now had access to their complete academic and financial records, and the entire process of submitting assignments was automated. Students could now submit their work through the LMS and also receive properly graded and commented assignments from their teachers.

A new moderated discussion board (MDB) was introduced that allowed student queries and their responses to be paired for easy access. Students could also zoom in to their own questions and the tutor's responses while still having the facility of seeing other students' interactions with the teachers. Because the entire system was IT-based, it was a straightforward task to archive all such discussions and allow students to access discussions for the same course from previous semesters. The same database proved very valuable in generating FAQs for the various courses and even in diagnosing any knowledge exposition issues that needing addressing.

The MDB design was asynchronous in nature. Students could post their questions at any time of day or night and received responses on a first-come, first-served fashion, with a promised maximum response time of 2 h during office hours. However, it was felt that students needed additional support. Synchronous tutorials were introduced in many courses, where tutors scheduled real-time audio sessions with students using third-party conferencing tools that were integrated into the LMS.

Other features introduced in the LMS included a comprehensive electronic Student Handbook, which laid out all relevant rules and procedures. All common student requests were automated and integrated with the university's management systems through a Student Services option. Many of these features led to improved efficiency and transparency in the university's operations, and wherever student requests could be handled automatically by the system without human intervention, they were programmed accordingly. The time and effort saved was significant, and university staff now only had to deal with a small number of exceptions.

7. EXAMINATION SYSTEM

As the number of courses offered grew and number of students increased, it became increasingly difficult to create an examination schedule that would suit all students and still allow the university to conduct midterm and final examinations in a reasonable amount of time. The student body had become fairly heterogenous and included young, full-time students, mature working professionals, with a fair number of stragglers thrown into the mix. The full-time students wanted gaps between their examinations, whereas working professionals preferred their examinations to be concentrated on weekends or in evening hours. Any schedule created by the university's Examinations Department could not satisfy

the requirements of all students, and every time the schedule was announced a lot of protest was heard from the student community. The conventional method followed by the large public universities and examining boards—of conducting one course examination at a time—could not be followed by the Virtual University because it operated on a semester system, and such an approach implied that examinations would stretch out over an unreasonable number of days, thereby disrupting the academic calendar. The experience of the early semesters indicated that examination centers were crowded for certain courses and nearly empty for others, which was a very inefficient utilization of the facilities. A radical new approach to the problem was indicated.

The university approached the problem by putting the students first. What if students could create their own, individual examination schedules (date sheets)? This would allow every student to sit for the semester examinations at their convenience. The concept was thoroughly discussed within the university, and it seemed that this was the only workable approach.

Once the principle had been decided, the implications of taking such an approach were determined. Allowing students to create their own date sheets implied that each student would have to receive a distinct-question paper to maintain the sanctity of the examination process. Distinct-question papers indicated that a question bank would have to be developed for the purpose. The academic departments insisted that meaningful assessment could not be done through multiple-choice questions (MCQs) alone; essay questions were also necessary. In order to reduce the overall duration of the examinations, exam centers would have to run at full capacity. These critical boundary conditions dictated the nature of the work ahead.

The key concepts in using this approach were identified as follows:

- a. Question bank
- b. Planning an examination
- c. Date-sheet creation
- d. Question paper generation
- e. Encryption and security
- f. Conduct
- g. Grading and result declaration

For each of the above concepts, a detailed analysis and design was done by the IT team, and a fully integrated system was developed and deployed.

7.1 Question Bank

The question bank is populated by the respective academic departments using both MCQs as well as essay questions. Each question is identified by its course, lecture, and topic. The database also includes the marks to be awarded, the time required to solve the question, and the grading rubric for essay questions.

The question bank is kept updated on a continuous basis. Questions carry a usage counter with them in the database. Once the counter exceeds a defined threshold, the question is retired and is not used in subsequent examinations. In parallel, the academic staff is required to submit a certain number of fresh questions during every week of a running semester.

7.2 Planning an Examination

The planning of an examination starts with gathering course registration information from the university's management system. This provides a gross count of the examination seats required in each city where the examinations are to be conducted. The Controller of Examinations also requests updated information from all virtual campuses that have the necessary hardware environment to be considered as potential examination centers. This information includes the type and number of computers available at the center along with connectivity details. The available capacity of each center is rated down by about 5% to provide backup machines in case of any equipment failure. On the basis of this information, selected campuses are designated as examination centers and the available capacity is used to determine the number of exam days and sessions required. This is done nationwide in every city where these campuses exist. Finally, the start and end dates for the examination along with daily session times are defined and declared.

7.3 Creating Date sheets

Once the centers have been designated and the dates and session times announced, the date-sheet creation module is opened for students, usually at least two weeks before the start of examinations. Students sign into their LMS accounts and are then provided access to the date-sheet interface. They can then choose the city and center where they wish to appear for their exams and for each registered course; they also select a date and session time. The printout of the date sheet carries a photograph of the student from university records and doubles as the Examination Entrance Slip. Entry is only possible on the proper date(s) and time(s) as displayed on the entrance slip.

The creation of the date sheets is done on a first-come, first-served basis. The system maintains a live count of seats at any center and displays the available number when students access the system. Students accessing the system early get their choice of dates and times, while late comers must select from the leftover seats.

7.4 Question Paper Generation

Academic departments define the parameters to be used in the generation of question papers for each course. The parameters consist of the lectures to be covered and the number of MCQs and essay questions to be included in any question paper.

Once the parametric definition of question papers is completed the process of question-paper generation is initiated. As a result of the planning and date-sheet creation processes, the system already knows precisely how many question papers would be required at which examination center on any specified date/time. The system then proceeds to generate the required number of question papers using a complex algorithm to ensure that all questions are distributed evenly over the included syllabus topics. The generated question papers are then collated into e-packets for each center/date/session time. They are further collated into bigger "day" bundles based on exam center and date.

7.5 Conduct

The bundles for any given date is downloaded the night before by the superintendents (head of invigilation staff) at each center, and the password for the bundles are provided to them separately, which are then loaded onto the local database server. Session packets cannot be opened at this stage.

On the day of the examinations, students, after having verified their identity and marked their attendance, are seated according to a predetermined seating plan. The session password is sent to the superintendent from the university a few minutes before the session and is used to unlock the session data. The examination then commences.

Each session packet contains the question papers required for the particular city/center/date/ session, but the papers are not associated with any particular student. When a student logs in to the system, one question paper is randomly selected from the available papers for the student's course and delivered to the student. Students can only appear for the examination according to their date sheet. A student who does not belong to the session is unable to log into the system. A student who successfully logs in only sees the question paper for the course that was planned on their date sheet.

At the end of a session, the data is immediately packed into a "student attempts" session packet and at the end of each day, all packets for the day are sent back to the university.

This daily process is repeated for the duration of the examinations at each center. All of the conduct mechanism is programmed into the system and the superintendent needs only rudimentary IT skills to manage it.

7.6 Grading and Result Declaration

The grading of student attempts is a massive exercise. All MCQs are graded by the system. For essay questions, student attempts for the same question are grouped and presented for grading. Thus, when the staff accesses the grading interface, they are presented with multiple attempts for the same question, with the grading rubric displayed alongside. The staff member then grades all student attempts consecutively. This results in a very high level of uniformity and consistency in the grading process. At no time is the student's identity available to the staff, and the entire grading process is conducted anonymously.

When all questions have been graded, the Controller declares the result, which then becomes visible in the student's gradebook in their LMS accounts.

7.7 A Note on Encryption and Security

The sanctity of the assessment process is considered paramount. All questions in the question bank are encrypted and are not human-readable. During the entire process, the questions stay encrypted and only become readable when they are displayed on the screen. This is true even for the grading process. When the question papers are dispatched to the exam centers, they are wrapped into session bundles that are encrypted and password protected. All bundles for a day are further grouped and password protected again. Similarly, the data returned to the university are also encrypted by the system.

The examination system developed by the Virtual University has been in use since 2008 and has withstood the test of time. One top-tier conventional university has adopted the system for its admissions process, and another public-sector university is in the process of inducting it. For the Virtual University, the greatest benefit is derived by its students who now control the scheduling of their exams. The transparency and efficiency afforded by the system has been widely appreciated.

8. OPENCOURSEWARE

In the very early days, the question of intellectual property rights came up. Since the university intended to broadcast its courses over free-to-air television, would it allow viewers to record the same? It did not take long to realize that it would be virtually impossible to prevent recording of the courses, and this realization actually led to the university making its courses available on videotape for only the cost of duplication. The practice continues today, except that the medium has changed from videotapes to CDs, and finally to DVDs. All Virtual University course are available from the online bookshop at nominal cost.

It was then decided that Virtual University courses would be published for free and open access to all knowledge seekers, and in 2005, the university established its own YouTube channel (<http://www.youtube.com/vu>) and all lectures were uploaded. Students quickly started creating playlists and according to the site, more than 20 million views have been recorded to date.

However, without the playlists, the lectures appeared at random on YouTube. Inspired by MIT OpenCourseWare, the Virtual University became a member of the OpenCourseWare Consortium (now the Open Education Consortium) and established its very own opencourseware website (<http://ocw.vu.edu.pk>). The site was awarded the Best Site Award for 2012 by the Consortium.

All courses published on the site are published under a Creative Commons CC-BY-NC-SA license. The license requires material on the site to be used by attribution and not for commercial use. It also requires any derivative works to be published under the same license. More than 30 national universities have established mirror copies of the Virtual University OCW site for use by their faculty and students.

9. LIFE SCIENCES

The year 2014 saw the introduction of life sciences at the Virtual University through its Bioinformatics program, which was soon to be joined by several other life sciences programs in subsequent years. Until this time, all Virtual University programs had been theoretical in nature, except for Computer Science and Information Technology. The laboratories required for the latter two programs were part of the university's operating structure, and therefore posed no challenge. Life sciences, on the other hand, was a completely different matter.

The introduction of life sciences required the establishment of wet labs, and the university has proceeded to do so in four different cities of the country. Students study all their courses using the established Virtual University pedagogy but must spend intensive sessions at the labs. This sometimes involves traveling and staying in other cities, which is a serious impediment. To overcome this, the concept of a mobile wet lab is in development that would allow taking these labs to students located in smaller and even remote cities. When implemented, this innovation would further strengthen the Virtual University promise of taking education to the doorsteps of knowledge aspirants.

10. CONCLUSION

The Virtual University is Pakistan's first university based completely on modern Information and Communication Technologies (ICT). The university was established by the government as a public-sector, not-for-profit institution with a clear mission: leverage ICT

to provide extremely affordable world-class education all over the country and thereby alleviate two of the major problems faced by the higher education sector, a lack of capacity in conventional universities and an acute shortage of qualified professors.

The university opened its virtual doors in 2002 and, in a short span of time, has expanded its outreach to over 100 cities of the country with over 150 Virtual Campuses (Virtual University of Pakistan, 2017) established by the university itself or in association with the private sector. With an enrollment exceeding 100,000 students and more than 45,000 graduates to date, the Virtual University has become one of Pakistan's largest universities and established a world-class reputation in a relatively short span of time. The flexibility in its operational methodology has motivated a large number of working professionals to benefit from the university's various programs.

According to the "Virtual Information System" (Virtual Information System, 2017) of the university, 55% students for the Spring 2017 semester belong to the 25 years or lower age bracket, while fully 45% of the student body is age 26 or older.

Historically, females have accounted for only 26% of the student body. However, the trend is improving, and for Fall 2016, nearly 40% of admitted students were females.

The methodology of the university promotes independent thinking and problem solving, while the IT literacy of all graduates is a given. A recent survey of over 7000 graduates indicated that fully 80% of them were gainfully employed.

The programs offered by the university span the fields of computer science, information technology, management science, applied psychology, mass communication, education, sociology, mathematics, bioinformatics, biotechnology, molecular biology, genetics, and zoology. Several other disciplines are in the pipeline.

The flexible nature of its methodology has made it the university of choice for working professionals and lifelong learners, while its low cost and extensive outreach has contributed significantly toward providing affordable, equitable access to tertiary education for younger full-time students throughout the country. The various systems developed by the university are already being deployed by one other public sector university in Pakistan, while the examination system is being used at another top-tier university. The experience gained and internalized by the university is relevant for other countries facing similar challenges, and the Virtual University of Pakistan would be very willing to collaborate on such endeavors.

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