Brittle bone disease is a congenital disorder that results in fragile bones that break easily. This disease is often referred to by doctors as Osteogenesis Imperfecta (OI), which means "imperfectly formed bone." Brittle bone disease can range from mild to severe. Most cases are mild, resulting in few bone fractures. According to the National Human Genome Research Institute (NHGRI), approximately three people in 50,000 are born with brittle bone disease. It occurs equally among each sex and race.

The Brittle Bone disease is one of the rarest but most debilitating ailments affecting the human body and mind. Very often learners from this category find it difficult to elicit support from either the formal education system or from the Open and Distance mechanism. As a result, majority of them, are forced to remain outside the ambit of any kind of Education, be it School Education or Higher Education. The needs of such learners being of very special kind, demands targeted research and development of appropriate technologies under the distance learning mode to overcome the barriers imposed by their physical conditions and social constraints.

India has a very high disabled population of 2.68 crore (census 2011), of which the disability in Movement accounts up to 20.3 percent. Disability in Movement includes all kinds of persons who are incapacitated to movement due to reasons such as paralysis, leprosy etc. or due to medical conditions imposed right from birth. It is in this context that persons afflicted with brittle bone disease, constitute a very specific and rare kind of disabled group in society, incapacitated to movement right from birth itself, due to genetic causes.

The concept of bringing about inclusion of the disabled has received lot of attention in the recent times on the global arena. The Open and Distance Learning system vociferously proclaims its motto, as ‘reaching the unreached’. Recent research in the field of ODL repeatedly proves that the system has reached the reached more and left the unreached, as far as special needs are concerned. Yet the Open system with its policy towards negation of barriers, watering down of
institutional bottlenecks and red tape along with openness in access, mode and curricula, present perhaps the best options of emancipation of these teeming learners.

As per the UN Convention Article 24, “States Parties shall ensure that persons with disabilities are able to access general tertiary education, vocational training, adult education and lifelong learning without discrimination and on an equal basis with others” (www.un.org). This objective of providing access to Higher Education, especially to those severally challenged with Movement disability as is the case of persons afflicted with Brittle Bone, can be conceptualised and made possible, only by such Inclusive Education strategies that reach out to where they are, rather than bringing them to the existing conventional education system. The key lies in the Open and Distance Learning mode of imparting Higher Education.

However, remedial measures of a pedagogic nature are scant and spread far and wide. There is an utter lack of integration of pedagogy with technology at one level, and pedagogy and policy framing on the other. Needless to state, outcomes have been suboptimal and potential hardly realized. In India, though medical interventions in this issue area is common and frequently utilized for the benefit of such persons, pedagogic intervention has left much to be desired. Investments in Research on framing appropriate educational terminologies to cater to such Inclusive needs have been scant. The lack of visibility of the felt needs of such learners on the policy radar further accentuates the existing problems.

Review of Related Literature

While campus-based universities in many countries cannot handle the huge numbers of potential students, it is the distance learning programs that can address the challenge of providing access to all, including those who cannot attend regular colleges as they could be employed, may have difficulties with access due to disabilities, or other such reasons (Gaskell and Mills, 2015). However, in order to address the concern of extending the opportunities for Higher Education to even the disadvantaged and the differently abled, the challenge for the ODL system lies in developing appropriate instructional strategies and delivery mechanisms suited to their capabilities by deploying media and technology that can enhance and enrich their learning experiences (Dikshit et al 2002). Valenti et al (2002), Germann etal (2003) elaborately examined motor disabilities while Dincyurek etal (2011) investigated the problems of those who
are with orthopedically impaired disabilities. Further, Ari and Inan (2010) have focused on disability of vision, hearing, orthopaedic/ mobility and others. However, these works do not bring out pedagogic solution for the problems faced by the learners, nor do they conceive of a technology assisted intervention to solve the problems at hand.

Sepehr and Harris (1995), Wilding (1999) clearly described the special learning needs of students afflicted with disabilities.

Arslan & Inan (2010) examined the assistive technologies available for the students with disabilities. Based on the Turkish conditions, they examined the attitude of such learners towards the use of the said technologies.


Heiman (2011) study on the extent and patterns of usage of web courses focused itself on the contribution of ICT in the field of inclusive education of those with disabilities. A comparison of 964 students at higher education level with and without Learning disabilities was undertaken. Using various scales like “perceptions of Learning through online usage”, “accessibility of campus computing”; “hopes scale” and “subjective well being scale” the efficacy of various adaptive technologies clarifying the familiarity of LD students with web- based assistive technologies on the students with & without learning disabilities was researched upon. They arrived at the conclusion that the use of technologies helped the learners with disabilities to attain goals.

Research Questions

1. What are the specific nature and characteristics of persons affected by Brittle Bone disease?

2. Whether learners afflicted with Brittle Bone disease display characteristics different from normal learners.

3. What are the ideal technology based learning interventions for students afflicted with Brittle Bone disease which could optimize their learning outcome?
Methodology

The study involved the collection of data with regard to both the learning attributes and technological possibilities associated with Brittle Bone learners. To collect relevant data on the former aspect, the researchers devised a Questionnaire with 62 questions, which was divided into three sections covering the important aspects of Educational abilities, proximity to Technology/Media and use of printed study materials. The latter aspect was covered under three segments, namely, Use of computers, Use of Mobile Technology and Desirable features in a learning platform. The questionnaire was responded to by 20 prospective learners afflicted with Brittle Bone disease spread across the country. The questionnaire was administered online through Google form. Since computer facility was not available with some of the respondents, the investigators had to contact them over phone to elicit their replies. In spite of the best efforts of the researchers, a larger number could not be obtained due to the significant fact that only approximately 70 patients in the relevant category exists in the State of Kerala according to reliable information. As a result to start with itself, the universe was very small in Kerala. Certain voluntary agencies purportedly working for the Welfare of persons afflicted with Brittle Bone disease were approached by the researchers, but found their cooperation absolutely lacking for reasons best known to them. This was in spite of the fact that the questionnaire was sent to them in advance. Therefore, the researchers approached Brittle Bone afflicted persons outside Kerala as well.

Based on the data obtained under various heads, the researchers set out to formulate appropriate technological solutions to cater to the needs of Brittle Bone learners. A preliminary survey was made of the available technological solutions. It was found that platform such as A-View, WizIQ etc. are basically aimed at normal learners and do not provide a great deal of attention towards inclusive education for persons afflicted with bone diseases. Further, they also did not cater to all the technological requirements revealed by the respondents to the questionnaire. Consequently, the researchers were forced to look at the possibility of amalgamating diverse technological packages that provided learning solutions when combined together to meet the requirements of Brittle Bone learners. After a thorough survey, we found that such an amalgamation is possible through MOODLE.
Analysis of Data

The researchers obtained data on the questionnaire from 20 students afflicted with Brittle Bone disease. The data obtained in represented in a graphical mode for ease of presentation and brevity as Annexure – I. In concise, the relevant aspects of the data so analyzed are presented below:-

Demographic Features

1. Majority of the respondents was females (55%) and of the total respondents, 68% possessed educational qualification up to Standard X. Only 16% were graduates and post graduates.
2. 55% of the respondents hailed from urban areas and nearly half of the sample had a monthly family income of up to Rs.10,000.
3. A majority of the respondents were unemployed (55%) and most of them had some form of formal education (65%).
4. The Government schools were found to accommodate a good percentage of persons afflicted with Brittle Bone disease (40%).
5. Most of the respondents were unmarried (85%) due to obvious reasons.
6. A vast majority of the patients were identified with this disease, below the age of 10 years (95%).

Educational Abilities

The salient feature with respect to educational abilities may concisely be put forth as follows.

1. Most respondents displayed a high level of proficiency in mother tongue (60%) as far as reading ability is concerned as against English language (45%).
2. Most respondents displayed fair bit of flair in basic Mathematics (60%) whereas the same was found to be wanting in English writing ability in which a number of deficiencies were found including grammatical mistakes and critical mistakes in sentence structuring.
**Proximity to Technology/Media**

From the responses received, it was found that:

1. A fairly good proportion of respondents were moderate radio listeners; with the modal listening span being 1-2 hours (40%). Even within this time, a brutal majority is spent on listening to non-educational programmes (95%). However, against expectations, not many of the respondents were regular listeners of entertainment programme such as Radio Mango (25%). But among those, who listened to entertainment related radio channels, the attracting factor was basically, the style of presentation and liberal content.

2. Half the respondents watched television programmes (50%) of which hardly any time was spend on watching Educational channels such as Gyanvani, Gyandarshan, UGC Country wide Classroom and Victor’s Channel. Among the respondents, there were not many takers for POGO and other children’s channels (35%). Among these who were regular watchers of such channels, the main attracting factors were the gaming programme, animation and entertainment. However, these were many takers for general TV channels such as Asianet/Kairali etc. (75%) with soap opera and low information flow programmes such as serials being the main attracting elements. Again as expected, purely information disseminating channels such as Discovery/Safari etc. did not find too many takers (45%).

**Use of Computers**

The respondents did not exhibit a high degree of comfort with the use of Computers with most of them not using the equipment at all (55%). They indicated a preference for utilising softwares such as PowerPoint, Moviemaker, Media player, GUIs and coding languages such as HTML. Most of them had a preference for multimedia packages. It is however, noticeable that none of them had ever used any digital learning platform.

**Use of Mobile Technology**

It is interesting to note that all respondents used one or two mobile phone in their day-to-day life. 95% of them expressed their convenience in reading from a mobile screen. Most of them possessed almost phones (70%) and were attracted to features including voice call, internet, mobile games, social net working, video players and various other Apps.
Desirable Features in a Learning Platform

The researchers touched on the hearts of their Research Questions in this section. The respondents desired to have the following as essential elements of their digital learning (Computer & Mobile Based) platform. The Table 1 indicates the percentage of respondents who felt the elements as most desirable for the digital learning platform.

Table 1: Most desirable features in a Learning Platform

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Desirable Feature in a Digital Learning Platform</th>
<th>Percentage of respondents who felt it as a most desirable feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Video Player</td>
<td>80%</td>
</tr>
<tr>
<td>2</td>
<td>Audio Player</td>
<td>65%</td>
</tr>
<tr>
<td>3</td>
<td>PDF Reader</td>
<td>30%</td>
</tr>
<tr>
<td>4</td>
<td>Touch friendly digital material</td>
<td>75%</td>
</tr>
<tr>
<td>5</td>
<td>Voice recognition Software</td>
<td>70%</td>
</tr>
<tr>
<td>6</td>
<td>Bluetooth</td>
<td>20%</td>
</tr>
<tr>
<td>7</td>
<td>Upload/Download facility</td>
<td>40%</td>
</tr>
<tr>
<td>8</td>
<td>Chat board</td>
<td>60%</td>
</tr>
<tr>
<td>9</td>
<td>Digital white board</td>
<td>55%</td>
</tr>
<tr>
<td>10</td>
<td>Digital quizzes</td>
<td>60%</td>
</tr>
<tr>
<td>11</td>
<td>2D Imaging</td>
<td>40%</td>
</tr>
<tr>
<td>12</td>
<td>3D Imaging</td>
<td>50%</td>
</tr>
<tr>
<td>13</td>
<td>Wiki</td>
<td>30%</td>
</tr>
<tr>
<td></td>
<td>Use of Printed Study Material</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>------------------------------</td>
<td>---</td>
</tr>
<tr>
<td>14</td>
<td>Access to online journal</td>
<td>25%</td>
</tr>
<tr>
<td>15</td>
<td>Access to online library</td>
<td>20%</td>
</tr>
<tr>
<td>16</td>
<td>Playback</td>
<td>65%</td>
</tr>
<tr>
<td>17</td>
<td>Discussion forums</td>
<td>45%</td>
</tr>
</tbody>
</table>

**Use of Printed Study Material**

1. Most respondents (90%) were comfortable reading while lying down and therefore, any designer of educational material has to factor in, this aspect while designing the delivery mechanism. While a vast majority preferred a 12 point font in Times New Roman, some others performed in 14 point or 16 point.

2. The respondents preferred Illustrations (85%), Brief summary at margins (75%), Chapter summaries (80%), SAQs (75%), Chapter objectives (65%) and Online companion workbooks (55%). Half of the respondents preferred lying down on bed and reading the study materials before sleep.

**Designing Educational Media**

The researchers found that existing distance education printed study materials provided by Open Universities, more or less, met the expectation of brittle bone learners. Therefore, there was hardly a need to re-invent the wheel. However, which it comes to developing digital platforms, much needs to be done. The insights provided by the respondents guided the researchers in developing a digital learning platform that is simple, powerful and robust.
The digital platform was developed and activated precisely based on the responses received by administering the questionnaire and its salient features are as follows:

1. **Virtual Classroom** – A boon of integrated technologies, the Virtual Classroom lies at the heart of our MOODLE. A technology with multiple plug-ins, it enables the student to view live class sessions, be an active participant in the same, use value-added services such as White board, real time chat, record sessions, take advantage of real time interaction, upload/download presentations, interact with peers, benefit from polls and take advantage of guided didactic conversations with the virtual teacher. The virtual teacher benefits from reaching out to distant learners and in providing controlled classroom sessions. He can even conduct supervised examinations with little chance of the student resorting to malpractices. The fact that controls can be easily transferred to
the users by the administrator makes the mechanism very attractive. Our Moodle is bolstered with the incorporation of three time tested digital platforms - WizIQ, Big Blue Button and Livestreaming. In the unlikely event of the failure of any one of the platforms or learner disaffection with the same, the other virtual classrooms can be used.

Figure 2 : Virtual Classroom being set up
Activity based Applications - Though our platform has been fabricated taking into consideration all likely contingencies, it would be out of place to explain all of them. For brevity of explanation, the following plug-ins may be noted.

(i) Lessons Module - The beauty of technology when combined with the certainty of human mind can result in unexplored avenues for the learning community. The lesson module is one such instance. It brings forth multiple options for both the teacher as well as the student. These are (i) Text based applications to be uploaded and downloaded (2) Voice based applications primarily from the side of the teacher (3) Visual applications for the learner and teacher. The teacher is in a position to device teaching material in any of these modes or through a combination of these modes and deliver it through Moodle. This gives the learners a vision much better and deeper than any text book on earth.
(ii) Assignments - Assignments are an integral part of any distance learning scheme. As stated by Holmberg, good distance education resembles a guided conversation aiming at learning. The presence of traits of conversation aids and facilitates learning of a distance learner. There is constant interaction between the supporting staff and the learners. As in conventional distance education, in the digital learning environment also, the assignment module brings the learners in contact with the teacher and they engage in a guided didactic conversation. The Moodle enables the student to upload his responses using any of the format- simple text, voice recording, video recordings and any relevant combination of these. This feature enables a patient afflicted with brittle bone disease to avoid the pain, trials and tribulations of writing. The teacher also finds it research to evaluate a voice or video recording rather than the illegible writing of a learner laboring under the debilitation of Osteo Imperfecta. Just as the student achieves autonomy through digital interface, so also the teacher gets the freedom to grade assignment under objective criteria laid down. In case where, auto-response is activated, the grading takes place without human intervention and thereby autonomy and accountability are ensured. Digital quizzes are one such mechanism which in unique to such platforms.
(iii) Exam Module - Examinations are the culmination of efforts of all stakeholders in any educational system. This is equally true of Moodle where the plug-ins enable supervised examinations. In JAVA enabled systems, the only protection to be taken is to ensure that the coding does not reach the learner who may read the code and hack an examination module. If access is provided for limited time and under controlled and supervised environment, the examination module of Moodle is stable and reliable. The supervised examination module of our Moodle enables the teacher to set question paper digitally, deliver it to the student under a controlled environment and evaluate responses in the most fool proof manner. Furthermore, there are multiple evaluation mechanism as well – peer grading, external grading, auto grading, teacher grading and even self-grading as per the requirement of the course of study.
(iv) **Game based Module** - A unique feature of our Moodle is a game based module that enables creation of games to suit various subject areas. Such games provide learners real time experiences of events and scientific facts.

(v) **Online Lab submission** - Yet another unique feature of our Moodle is an online lab submission module which not only enables the learner to capture relevant information and multimedia file from the internet but also provides an interface to submit files which he himself creates in three modes, namely, audio, video and imagery. The advantage of such a mechanism is that the students are in a portion to apply their creativity to full effect. Further, the availability of modules that can be uploaded from open source sites such as Open source physics enhances the utility of this mechanism.
Figure 7: Online Lab Submission using Open Source

Figure 8: Online Lab Submission through Audio, Video & Imagery
(vii) **Virtual Chat facilities** - We have added a good number of chat modules with the Moodle, with the aim of providing real time interactivity. Apart from the normal text based chats, the Moodle created by us, also has a viable video chat. This can be an effective mechanism for peer interaction in a distance education system that hindrance by the problem of accessibility to learning centres where students can meet and interact. Undoubtedly, this is a boon for students with bone ailments.

(viii) **Survey** - Our Moodle presents a survey module that contains a number of verified survey instruments. An online teacher can gather data from their students that will improve the quality of teaching over a period of time.

![Figure 9: Student Monitoring and Tracking System](image)

(ix) **Wiki** - The Wiki module enables the participants to add and create web pages containing relevant information. It is a collaborative instrument which enables editing by learners as well as teachers. This is most useful for providing services such as group lecture notes, planning schemes, creation of online books and so on.

(x) **Glossary** - This is an activity module which enables the participants, teachers and administrators to create and maintain a list of definitions or to collect and organise resumes and information. If the auto-linking filter is enables, entries will automatically be linked where the concepts or words appear.
(xi) **Digital quizzes** - This activity enables the teacher to create quizzes of various kinds such as Multiple choice questions (MCQ), short answer type, numerical etc. Quizzes can be used as part of examinations or assignments or for immediate feedback. The instant responses received through feedback serves as a tool for effective learning especially for isolated students.
3. **Block Applications:** The researchers configured the Moodle keeping in mind the essential need to ensure retention of students. One of the major drawbacks of traditional Distance Education systems is their inability to retain learners over long periods in time. In order to avoid the recurrence of such instances, we have provided the following block applications:

(i) **Attendance module** - The attendance module provides an instant application to take attendance, to map out deficiencies in attendance of learners and to prepare a report on attendance of learners which shall be highly beneficial to teachers who monitor the retention of students. An autosign-in attendance sheet is also generated to register student presence. This is aided by the GISMO interactive student monitoring and tracking tool that extracts data from Moodle course management system. This tool generates various graphical representations which give the teachers an idea of the learning activities of students. To further aid student tracking, the Moodle has been bolstered with the plug-in, Analytics Graphs which given a clear picture of - content access, assignment submission, quiz submission, hotpot submission, hit distribution etc.
Figure 13: Attendance Module

Figure 14: Attendance Sign-in Sheet
Figure 15: Analytic Graphics of Assignment Submission of learners

Figure 16: Analytic Graphics of Hits Distribution
(ii) **Moodle text SMS service**- The text SMS service is a salient feature of our Moodle which enables the teacher to remind the students not only about urgently constituted tasks but can also be used as a motivating device to enable student retention.

![Moodle text sms service](image)

**Figure 17**: Moodle text sms service

(iii) **Ranking Module**- Even though, distance education expects students to be self-motivated, the absence of periodic ranking during the course period can often be a factor leading to student drop outs. The Moodle has a module which provides ranking in a weekly, monthly and on a general basis.
(iv) Text-to-Speech Module - Students with disability often need aid that is normally not required for general students. Students with brittle bone disease often find it difficult to scroll over texts on a normal computer. In order to alleviate this difficulty, the text-to-speech module, has been introduced which reads the text for such learners.

(v) Learning Plan - An important block incorporated by us into Moodle is the ‘Learning Plan’. This module provides a mechanism whereby the teacher can add a learning plan, add a training session, --- l-plans to users and provide real-time results.
Though our Moodle has more than 40 features, due to paucity of time and space, only a few of them have been refused to have. All these modules have been incorporated based on the results of the survey conducted by the researchers whose results has been noted above.

**Roles Assigned in the Moodle**

In a Moodle, various roles are assigned by the administrator to the users whereby a set of permissions are defined for each user. The roles assigned in our Moodle are Manager, Course creator, Teacher, Non-editing teacher, Student and guest. The roles and accompanying permissions assigned in this Moodle is summarised and presented in Table 2.
Table 2: Roles Assigned in the Moodle

<table>
<thead>
<tr>
<th>Role Assigned</th>
<th>Role Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manager</td>
<td>Managers have the right to access the course and modify it. They are not participants in any of the courses.</td>
</tr>
<tr>
<td>Course Creator</td>
<td>They can create new courses.</td>
</tr>
<tr>
<td>Teacher</td>
<td>Teachers are empowered to do anything within the course for which they are assigned to. They can change provide activities for the students, assignments, place digital quizzes and grade the students as well.</td>
</tr>
<tr>
<td>Non-editing teacher</td>
<td>In this role, non-editing teachers can only teach in the courses and grade their students but cannot modify the activities provided.</td>
</tr>
<tr>
<td>Student</td>
<td>Students are the active participants in a course. Therefore, can access virtual classrooms, lessons modules, attempt assignment submissions, digital quizzes, interact over live chat etc.</td>
</tr>
<tr>
<td>Guest</td>
<td>Guest access provides minimum or limited privileges and cannot enter text or upload any files.</td>
</tr>
</tbody>
</table>

Suggestions

1. The study reveals that mobile based applications are most favoured by brittle bone learners. Therefore, every distance learning organization should take steps to make course delivery through mobiles, an integral part of their pedagogeic process.

2. The survey of literature proves that very few ODL Institutions in India are geared up to meet the needs of inclusion of differently abled learners and especially brittle bone learners.
3. Open source software can be suitably modified and integrated onto a platform such as Moodle and relevant education can be provided to the unreached learners, especially those with special needs. It is therefore, supported that effective policy measures be incorporated in this direction.

4. The Governments at various levels allocate substantial resources for universalisation of education. Needless to state, most often the learners with special needs are left out. Learners with disability such as brittle bone, due to their relative rareness are left out of the radar. It is suggested that appropriate technological devices be provided free of cost to such learners. Infact, the current Moodle loaded Tablets can be provided to these learners as an enabling mechanism.

5. Open Universities like IGNOU should take the lead in networking inclusive technologies such as the Moodle. IGNOU can act as an incubator for development of technologies for use for differently abled students.

6. Regional centres can be mini research centres for developing relevant technologies for deployment according to the needs of learners in their region. Technology development cells are to be created at each Regional centre.

**Conclusion**

The study provided deep insights to the researchers about the magnitude of pedagogic difficulties faced by brittle bone learners. The realisation that the distance education system has left such a deserving learner group untouchened is nothing but a travesty of justice. Such miscarriage is most undesirable in a democratically Inclusive society such as India. The basic tenet of equality of opportunity and options envisaged in the grund norm of the Country, ie, the constitution is a matter of utmost concern. The current generation is not limited in its ability to reach the unreached due to the paucity of enabling technologies. The Moodle provides a free and easily accessible technology driven platform to reach out to the meekest and weakest, which is the goal and aspiration of every distance educationist. Our effort is just a small step in this direction. We would consider our research a success if at least baby steps are initiated to empower brittle bone learners without offending the ODL framework but with greater use of relevant technologies. Let our nation wake up to a new dawn.
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