The CITY University

Vision Screener for Schools

Discussion document for HSD3b prepared by:
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What is the City Vision Screener for Schools?

The CITY Vision Screener for School (CVSS) is a radical new computer program for performing and managing vision screening in schools. The program and its accompanying components constitute a self-contained vision screening system capable of generating questionnaires, presenting test stimuli on a standard computer screen, performing an expert analysis of results, managing a database of each child's visual history, generating reports for parents, optometrists, doctors and teachers and providing summary statistics relating to the overall screening program.

The program is the product of over five years' research and development by a team of optometrists at the Department of Optometry and Visual Science at City University. The system has been tested on over 1500 children and has been shown to be sensitive (97%), specific (97%) and highly efficient (3 minutes / screening).

This document summarises the current status of vision screening in schools in the UK, describes the rational behind the CVSS and explores ways in which it could be implemented in the UK.

Problems With Current Methods

It is generally accepted that the current provision for vision screening in UK schools is unsatisfactory in a number of respects:

- The sensitivity and specificity of current screening methods is poor.
- There are considerable regional variations in the battery of tests employed and the referral criteria applied.
- Parents and teachers receive minimal feedback on the results of the vision screening.
- In most areas, there is no systematic follow up for the children who fail a vision screening.
- There is no central collation of data. This makes it difficult to assess the effectiveness of screening programmes or monitor regional/longitudinal trends in the prevalence of eye problems among children.
- The facilities available for vision screening in schools are often less than ideal. Light levels are often difficult to control and the viewing distance for test charts is often constrained by the dimensions of the room allocated for the purpose, making it difficult to score the tests reliably.
- The personnel responsible for administering vision tests often have very limited knowledge of visual assessment and yet are required to interpret test results and exercise some discretion about the need to refer.
- The time taken to perform a vision screening is dependent on the protocol employed. In most cases the process is entirely manual requiring a school nurse to administer the tests and prepare referral reports. This can be tedious, time-consuming and prone to errors.

Is Vision Screening in Schools Justified?

The purpose of vision screening in schools is to" identify children with unsuspected remediable conditions, so that treatment can be offered before educational and social progress is affected".

The target conditions for vision screening in schools are as follows: 1) “significant“ refractive errors (myopia, hypermetropia, astigmatism, anisometropia), 2) strabismus, 3) amblyopia, 4) colour vision defects. It is at least arguable that conditions such as binocular and accommodative anomalies should also be included as target conditions within the definition given above.

The value of vision screening in schools has been the subject of considerable debate over the past few years. In general terms, a screening programme should comply with the following criteria:

(a) The condition being screened for is common;
(b) It is a significant health problem;
(c) It is amenable to treatment;
(d) The cost of case-finding (including diagnosis and treatment) should be economically balanced in relation to medical expenditure as a whole; and
(e) A cheap and reliable screening test exits.

In order to justify vision screening in schools, it is necessary to consider each of these criteria in more detail.

(a) The Condition Being Screened for is Common

In a recent survey of over 1500 children in inner-London schools (carried out as part of the evaluation of the CVSS), the overall prevalence of these target conditions (excluding colour vision defects) was found to be 19% (range 9-28% between schools). There can be little doubt that vision screening in schools complies with the first criterion.

(b) The Condition is a Significant Health Problem

None of the target conditions can be considered "significant health problems". However, within the context of vision screening in schools it is more appropriate to ask if any of the target conditions are likely to affect a child's social and educational development.

It is beyond doubt that significant uncorrected refractive errors will handicap a child in the learning environment. The effects of moderate refractive errors, binocular / accommodative anomalies, amblyopia and strabismus are more difficult to assess. Intuition and anecdotal evidence would suggest that these conditions could, and do affect various aspects of a child's development. However, it is difficult to prove a link between visual disorders and educational development because so many other factors contribute to this complex process. It is also impossible to perform a controlled study to investigate the possible link because it is of course unethical to withhold treatment from children who are found to have visual disorders.

Until firm evidence is available to suggest that these conditions do not affect a child’s progress in the educational environment, there is a strong case for continuing some form of vision screening in schools.

(c) The Condition is Amenable to Treatment

With the exception of colour vision deficiencies, all of the target conditions are treatable, although the efficacy / value of amblyopia therapy for school age children is contentious.

(d) The Cost of Case-Finding (including Diagnosis and Treatment) Should be Economically Balanced in Relation to Medical Expenditure as a Whole

Concurrence with this criterion is dependent on the perceived benefits of vision screening in schools and the relative cost of providing the service. While the debate as to the benefits of school vision screening awaits firm evidence, progress could be made in improving the cost/ benefit ratio if the cost of vision screening could be reduced and the sensitivity / specificity increased.

(e) A Cheap and Reliable Screening Test Exists

Screening methods vary significantly from one area to another. In a survey of 165 districts in 1984, Stewart-Brown and Haslum (1988) found that all districts screened for reduction in distance visual acuity, 96% screened for colour vision defects, 73% for strabismus and 67% for reduction in near visual acuity.

While the tests used for vision screening are cheap and inherently reliable, the tests are often administered under conditions outside their intended design specifications. Light levels may vary and viewing distances may be constrained by the dimensions of the room allocated for testing. Furthermore, the personnel responsible for vision screening often have little formal training in the assessment of vision. These factors tend to reduce the reliability of the screening tests.

The principal cost of screening is the cost of employing suitable personnel to perform the tests. In most cases the process is entirely manual requiring the nurse to administer the tests and prepare referral reports. This can be tedious and time consuming.

The City Vision Screener for Schools

Figure 1

The City Vision Screener for Schools (CVSS) has been developed in a bid to improve the sensitivity, specificity and efficiency of vision screening in school and to overcome many of the shortcomings of existing methods.

The CVSS is based on a computer program that will run on any PC running Microsoft Windows. Such computers are readily available in most schools.

Screening using the program involves three phases: (a) questionnaire phase; (b) vision testing; and (c) analysis and report generation.

(a) Questionnaire Phase

A printed questionnaire/consent form is sent home with each child to be completed by the child's parents. The questionnaire includes a series of questions relating to symptoms, signs, history and family history (appendix A). This data is entered into the program’s database prior to the vision screening via a simple graphical interface (Fig 2). This take 30 seconds per child on average.

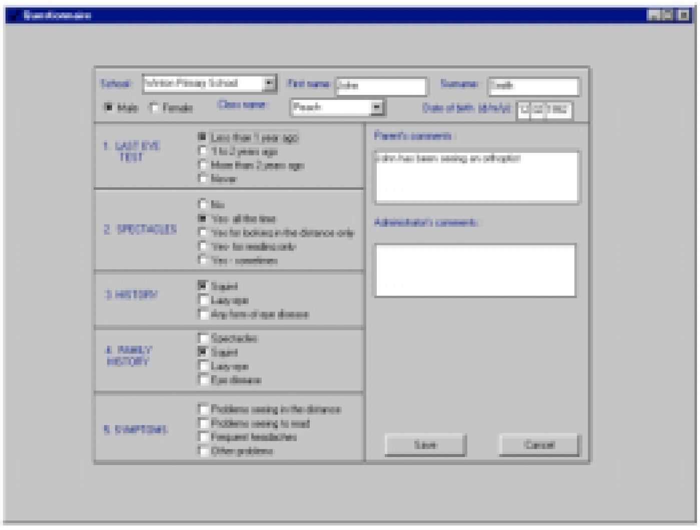


Figure 2

(b) Vision Testing

When the program is first run on a "new" computer, a simple calibration procedure is carried out. This requires the user to measure the width and height of a square displayed in the centre of the screen and to enter the screen viewing distance for the visual acuity tests (3 to 6m). This calibration data is used to scale the test stimuli and calculate test results in terms of angular subtense (e.g. visual acuity).

At the time of the screening, the child's name is selected from the database and a series of vision tests are conducted. Throughout the screening, the examiner is given instructions in a small help window at the bottom of the screen (fig 3). Results for each test are recorded by simply "clicking" on the appropriate option and data is automatically added to the database.

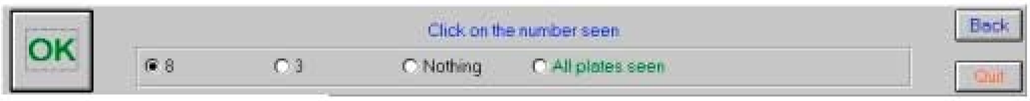


Figure 3

For computers fitted with a sound card and loudspeakers, the computer can generate spoken instructions throughout the screening, ensuring consistency and eliminating the need for the administrator to give the same instructions over and over again. Instructions are currently available in six different languages.

The screener performs tests of colour vision, stereopsis, associated phoria, monocular distance visual acuity and a +2.50D blur test for hypermetropia.

Colour Vision Test

Due to the problems of generating precise colours on a VDU screen, colour vision is assessed using selected plates from the Ishihara test. The result for each plate is entered into the program so that the diagnosis can be included in the analysis and reports.

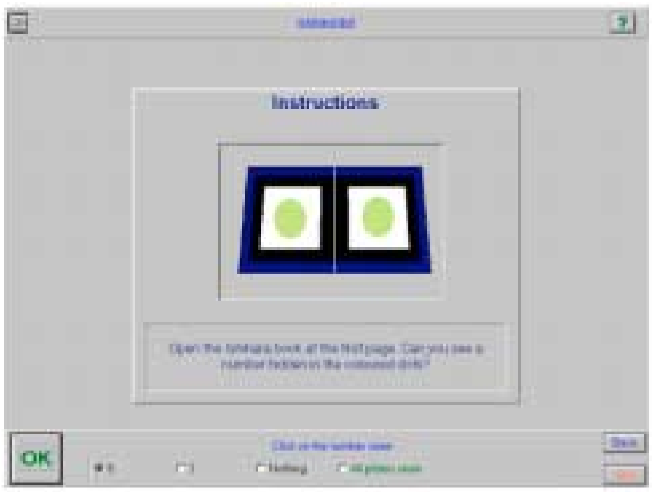


Figure 4

Stereopsis

Stereopsis is assessed using a series of red / green random dot stereograms displayed on the computer screen. The child views the screen through red / green goggles from a distance of 50cm. If the child has stereopsis, a shape is seen standing out from each box on the screen.

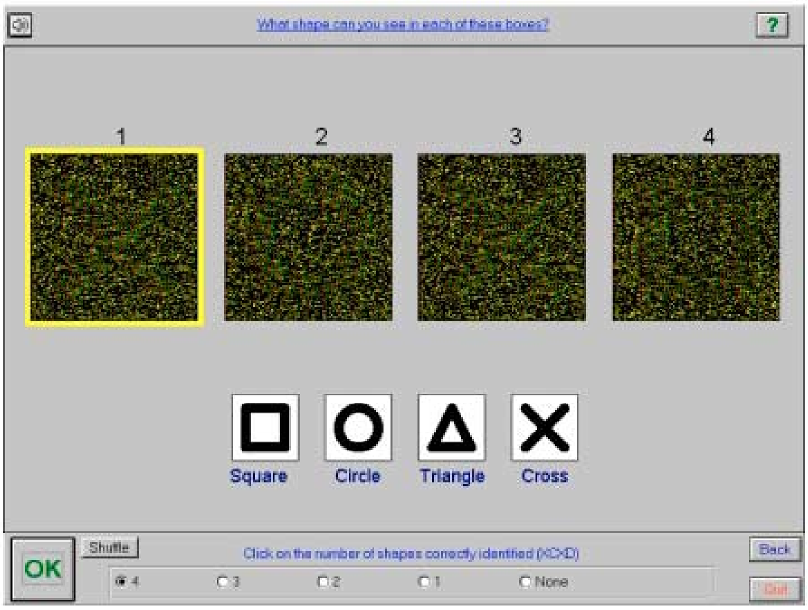


Figure 5

This test has been shown to be a very sensitive test for strabismus.

Associated Phoria

Associated phoria (fixation disparity) is assessed using a stimulus configuration modelled on the Mallett test (fig 6). The child views the computer screen through red/green glasses and sees "☐ + ☐" binocularly, while the markers above and below the "+" are seen monocularly.

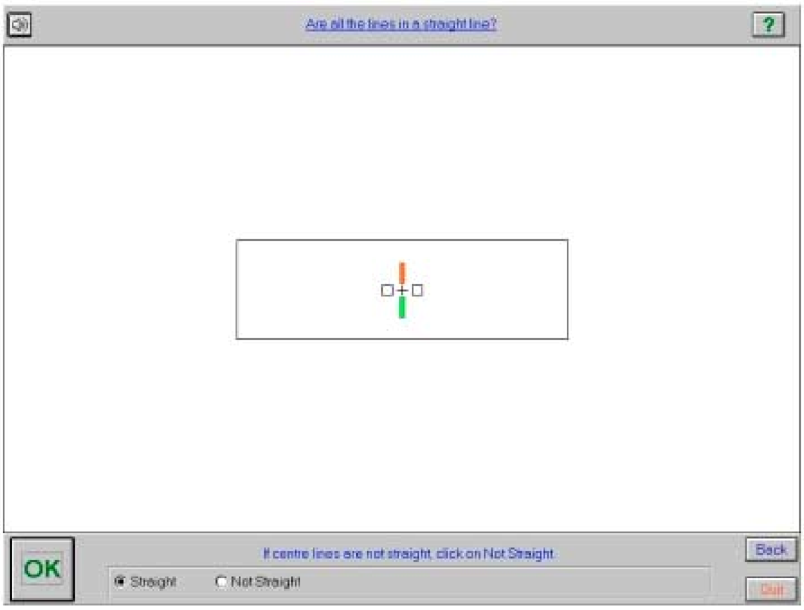


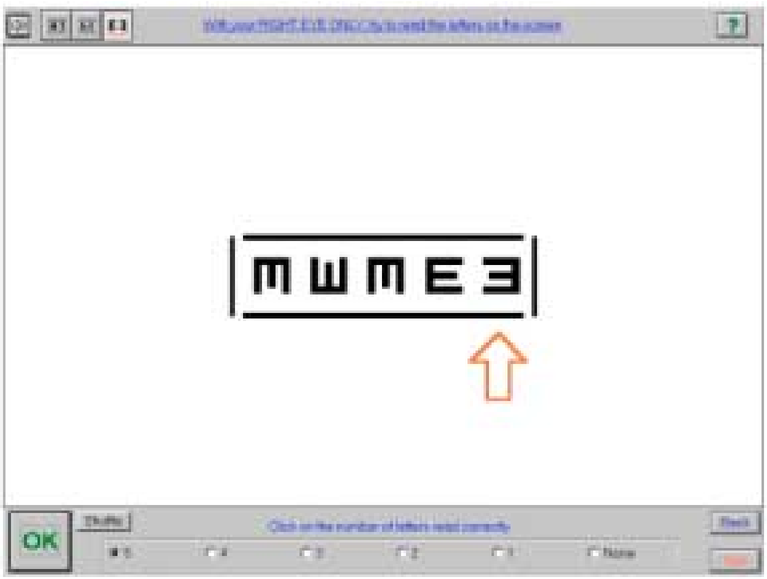
Figure 6

The child has to report firstly, how many lines they can see (check for suppression) and secondly, if the lines appear to be in a straight line (check for fixation disparity).

Results obtained using this test have been shown to correlate well with results obtained with the Mallett fixation disparity test, which in turn has been shown to relate well to the presence of symptoms.

<u>Vision Acuity</u>

Visual acuity is measured by presenting a single line of letters on the computer screen (fig 7). The letters are surrounded by crowding bars and the size of the letters is scaled according to the viewing distance (3m to 6m) and the size of the screen (available from the calibration routine). The initial letter size is set at LogMAR = 0.1 (6/7.5). If all five letters are read correctly, the program moves on to the next test. If the child fails to identify one or more of the letters, letter size is increased by 0.1 LogMAR units. This is repeated until all letters are read correctly (or a predetermined ceiling is reached). The letter order is randomised to avoid learning effects.



Figures 7 and 8

LogMAR charts have many advantages over conventional Snellen letter charts and are used almost exclusively in all areas of vision research.

A matching chart is available for children who cannot name the letters. Alternatively, a range of other optotypes, including illiterate Es, Landolt Cs and lower case letters, are available.

Laboratory studies have shown that visual acuities measured using the system correlate very well with those obtained using a standard LogMAR chart. Furthermore, results do not change significantly over a typical range of screen luminances (50 to 120 cdm^{-2}).

<u>+2.50D Blur Test for Hypermetropia</u>

To test for hypermetropia, five letters (size LogMAR 0.2) are viewed through +2.50DS spectacles. Unless the child is more than +2.50 dioptres hypermetropic, the letters will appear blurred and will not be read.

If one or more letters are read correctly, the size of the letters is decreased until no letters are read or a predetermined ceiling is reached (LogMAR 0).

Figure 9

<u>Data Analysis</u>

On completion of the screening, the data is analysed by a series of algorithms. Two forms of analysis are undertaken. The first is based on a simple set of criteria for each set of vision test results. The pass/ fail criterion for each of the tests can be set to comply with the policy of the school or health authority. This basic analysis is similar to that performed in most screening programs.

The second analysis attempts to model the decision processes carried out by a clinician by taking account of symptoms, family history and test results to determine a provisional diagnosis (poor VA in both eyes, poor VA in one eye, hypermetropia, alternating strabismus, binocular vision anomaly and/or colour vision defect). This analysis uses a combination of logic trees and a weighted risk index method. Details of this analysis have been accepted for publication (Thomson and Evans, 1999).

Having established a preliminary diagnosis, the program is able to generate customised reports for parents and the school and if necessary, a referral letter for an optometrist or doctor. Sample referral letters are included in appendix xx.

These reports can be viewed, analysed and printed from the administration screen (fig 10). The exact wording and layout of reports can be customised to reflect the policy of each school or screening authority.

The program also provides a breakdown of global statistics, e.g. prevalence of symptoms, distribution of acuity, overall pass rate etc. Such statistics should be of value to those responsible for administering screening programs.

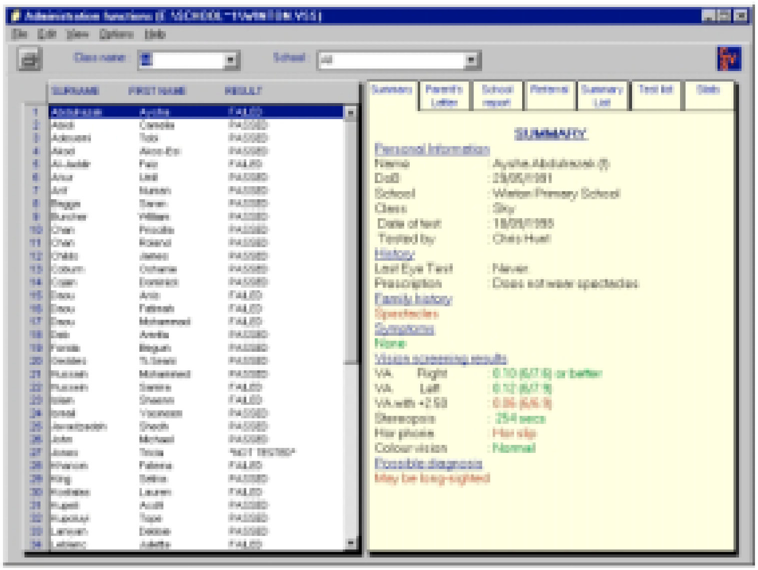


Figure 10

A tear-off slip can be added to the referral letter to enable the screening administrator to obtain feedback relating to the results of this referral. This information can be entered into the program to allow a child's visual history to be monitored.

Evaluation of the City Vision Screener for Schools

Methods

The CVSS has been subjected to a large-scale evaluation on children aged between 5 and 8 years attending schools in Camden and Islington.

Of the 1762 questionnaires / consent forms issued, 1554 (88%) were completed and returned with consent given. Of these, 1528 children in 21 schools were screened using the CVSS.

Following the vision screening, each child was assessed by an optometrist. The optometrists performed a cover test, retinoscopy and ophthalmoscopy and where indicated, a variety of other tests including subjective refraction, fixation disparity, stereopsis and near point of convergence. On the basis of this assessment, the optometrists were asked to classify each child as a pass or fail using the following criteria.

- Myopia > 1.00D in either eye
- Hypermetropia > +2.50D in either eye
- Astigmatism > 1.50 DC
- Strabismus
- Amblyopia (VA> LogMAR 0.2)
- Binocular vision anomaly causing suppression or fixation disparity
- Any significant eye pathology

The optometrists were <u>not</u> given access to the results of the vision screening.

Results

Of the 1528 children screened, 332 (21.7%) were deemed to have failed the vision screening (excluding colour vision defects). The failure rate ranged from 28% to 9% in different schools. Of the children that failed the screening, 64 failed because of poor VA in both eyes, 103 for poor VA in one eye, 108 for suspected hypermetropia and 57 for binocular vision problems (excluding strabismus). A further 58 children failed the Ishihara test.

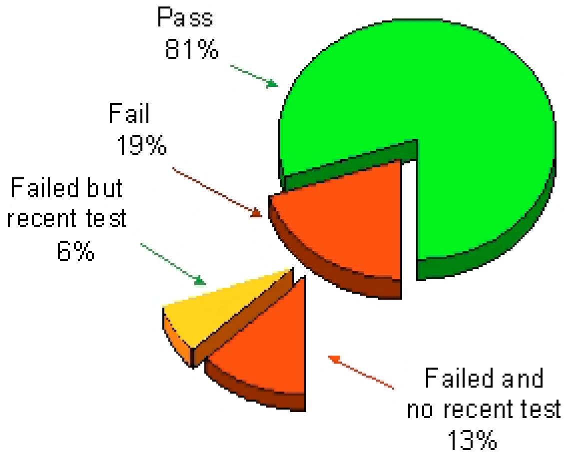


Figure 11

A comparison of the results of the vision screening with the optometric assessment gave the following results:

True +ve **284**	False +ve **48**
True -ve **1187**	False -ve **9**

Table 1

Five of the false negative results related to binocular vision anomalies (3 decompensated phorias, 2 convergence insufficiencies) that the optometrist considered were significant enough to warrant referral. Three of the false negatives related to astigmatism above the 1.50D criterion and one, to a -1.25DS myope who just achieved the visual acuity threshold.

The false positive results mainly related to the binocular vision test and the stereopsis test. These tests required more explanation than the others and many of the children did not speak English as their first language. The addition of computer-generated instructions in other languages should reduce this problem.

Of the 293 children who failed the optometric assessment, 199 (68% of failures, 13% of those tested) had not had an eye examination within the past two years. This demonstrates the importance of vision screening in schools.

Based on the figures given in table 1, the CVSS had an overall sensitivity of 97%, a specificity of 96%, a positive predictive value of 86% and a negative predictive value of 99%.

These figures are very impressive for any screening test and a considerable improvement over current screening methods.

The screening took 3 minutes per child on average and the tests were very well received by the children. Informal feedback indicated that parents and teachers greatly valued the detailed reports and a number of letters were received from optometrists and doctors praising the clarity and the detail of the referral letters.

The CVSS is currently undergoing an independent evaluation.

Advantages of the City Vision Screener for Schools

- Requires low specification PC (available in nearly all UK schools).
- Easy to install and set up.
- Quick and very simple to use.
- Use of computer screen ensures consistent viewing conditions and allows letter charts to be scaled for different viewing distances.
- Comprehensive battery of tests which reliably detect all of the target conditions.
- Computer-generated spoken instructions in six languages.
- Fun for the children!
- Built in "expert" system to analyse results allowing the system to be used by those with limited knowledge of vision.
- Automatically generates customised reports for parents, teachers and optometrists/ doctors.
- Ensures the use of consistent referral criteria.
- Excellent sensitivity and specificity.
- Tracks the visual history of each child including feedback from referrals.
- Potential for national collation of screening results by transfer of data by EMAIL to a central database.

A Vision for Vision Screener in Schools

It is our view that the CVSS represents a major breakthrough for vision screening in schools.

We would like to see the program installed in every school in the UK. One representative from each school (school nurse, teacher or similar) would attend a training course set up in the area. The course would ensure that all those responsible for vision screening in schools met certain minimum standards relating to their knowledge of vision and visual disorders. They would also receive hands-on training using the CVSS. This initial course would be backed up by a helpline and further training courses as required.

Results from each school could be sent by EMAIL to a central database. This would allow statistics relating to regional and longitudinal trends in the prevalence of eye problems to be monitored and would enable resources to be targeted more effectively.

Initial funding for such a project (including training) would be of the order of 1.5 million pounds. Subsequent funding for maintenance of the program, training and backup would be obtained by charging each school an annual licence fee (circa £100 / school).

We believe that this would enable the UK to provide the best school vision screening service in the world and would ensure that children with varying visual capabilities would enjoy equal opportunities throughout their school careers.

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Appendix A – Parental Questionnaire

Appendix B – Sample Reports