EasyChair Preprint

№ 4651

Analytic Dashboard on Talent Search Examination Data Using Structure of Intellect Model

Vyankat Munde, Binod Kumar, Anagha Vaidya and
Shailaja Shirwaikar

November 26, 2020

Analytic Dashboard on Talent Search Examination Data Using Structure of Intellect Model

Vyankat Munde[1*], Binod Kumar[-2], Anagha Vaidya[3] and Shailaja Shirwaikar[4]

[1] *Research Scholar, Department of Computer Science, Savitribai Phule Pune University, Pune, (Maharashtra), India 41107*

[2] *Professor, Rajashi Shahu College of Engineering,JSPM, Pune, (Maharashtra),India*

[3] *Assistant Professor, Department of Computer Science Symbiosis Institute Of Computer studies, Pune,India*

[4] *Research Guide, Department of Computer Science, Savitribai Phule Pune University, Pune, Maharshtra*

mvv.parli@gmail.com

Abstract

The potential of Analytics and Data mining methodologies, that extract useful and actionable information from large data-sets, has transformed one field of scientific inquiry after another. Analytics has been widely applied in Business Organizations as Business Analytics and when applied to education, these methodologies are referred to as Learning Analytics and Educational Data mining. Learning Analytics proposes to collect, measure and analyze data in learning environments to improve teaching and learning process. Educational Data mining (EDM) thrives on existing data collected by learning management systems. The applicability of Learning Analytic and Educational Data mining can be extended to traditional learning processes by suitably combining data collected from technology enabled processes such as Admission and Assessment with data generated from analysis of learning interactions. The intellectual performance of the students can be analyzed using some well known Learning Frameworks. This paper demonstrates the Complete Analytics process from data collection, measurement to Analysis using Guilford's structure of intellect model. An analytic dashboard provides the necessary information in concise and visual form and in an interactive mode. The analytic process presented on talent examination data can be generalized to similar examinations in traditional educational setup.

Keywords Dashboard, Educational Data Mining, Learning Analytic, Structure of Intellect model

Abbreviations: EDM, Educational Data Mining; LA, Learning Analytic; SOI, Structure of Intellect Model

Introduction

Learning Analytic(LA) tends to focus on understanding and optimizing learning by discovering patterns in data that tells what is learnt and applying techniques for predicting what should be learnt next, to take appropriate action(Patwa et.al. 2018; Leitner, et.al. 2019) Educational Data Mining(EDM) is primarily applied to on line learning systems where the data collection, about the learner's behavior as also the presented content, can be automated (Hung, et.al 2012; Bienkowski, et.al. 2012). It is essential to expand the applicability of LA and EDM to a wider set of learning processes occurring in traditional setup. An examination is a learning interaction that helps learners demonstrate and the examiners assess what is learnt. Analysis of examination data can help improve both learning as well as the examination process.(Linan, et.al.2015 ; Khalil, M. K., & Elkhider, I. A. 2016).

Talent search examination aims at identifying students with intellectual abilities so that they can be nurtured further by providing academic and financial support. One cannot measure intelligence but can measure intellectual performance that is, how one uses his/her intelligence to adapt to the environment. The mental and scholastic abilities can be assessed using well-designed examination process. Usually such tests are objective and cover a wide range of topics followed by interview process.

About talent search exam

The existing school curriculum and the examination system are unable to identify and motivate the talented students. It is, therefore, as a national and social binding, the Centre for Talent Search and Excellence, N. Wadia College, Pune has undertaken the search of Talented Students through "Maharashtra Talent Search Examination" since 1992.

The aim of this exam is

1) To search the talented students 2) To equip the students for NTS and other competitive examination and to create ambition to succeed in each examination from early age.3) To encourage students awarding prizes

Intellectual performance can be measured as a multidimensional construct to assess different types of intellectual abilities. Guilford designed his Structure of Intellect (SOI) model (Gulford, J.P.1982), where various intellectual abilities are organised along three dimensions of content, process and product. Along each dimension there are subcategories which present different abilities required for intellectual functioning.

In this study, Talent search test is considered as a learning interaction allowing the candidate to demonstrate his/her intellectual abilities and the examiner to pose each question so that these abilities can be measured. The questionnaire content is then classified based on SOI model so that student performance can be analysed along various dimensions. An Analytics dashboard provides analysis in an interactive mode and can be effectively used by decision maker.

The paper is organized as follows. Section 2 describes the complete Analytics process for traditional teaching and learning environment including structure of Intellect model as chosen Learning framework. Section 3 provides the experimental analysis including the design of Analytics dash board followed by conclusion.

1 ANALYTIC PROCESS FOR TRADITIONAL SETUP

Learning Analytics(LA) need to be extended to the teaching and learning processes in traditional setup. In a traditional teaching and learning environment, teaching is through direct teacher-learner interaction and thus no data related to such interaction gets collected (Khalil, M. K., & Elkhider, I. A. 2016) . Analytics can be applied on data collected by technology enabled processes such as Admission and Assessment.

In an examination, learners demonstrate their intellectual abilities which reflect in their performance and the examiners design assessment tool so that each of these qualities can be identified and measured. Learning Models or taxonomies support instructional as well as assessment design. The Analysis of student performance along with that of assessment tool can be used to understand and measure the learning outcomes(Mangaroska, K., & Giannakos, M. 2018). In this study, we propose a

complete Analytic process that can be applied to the examination as a learning interaction (Talib, A. M. et.al. 2018)

. The process is divided into 5 steps as described in Table 1 each of which will be demonstrated.

A Data Selection

1. Data Selection - Choosing appropriate Admission and examination data that can support Analytics

2. Choosing Learning Frameworks - Selecting one or more Learning Frameworks/model that is well established and understanding its applicability

3. Data Preparation - Generate data by applying learning framework to the learning instrument such as Question paper

4. Design Analytics - Find different ways of analysing data that can help improve the learning process

5. Design and Implementation of an Analytics Dashboard - Make available an Analytics dashboard that can be used by the stakeholders

Learning Analytics requires data about the learners and the learning interaction. Examination is a learning interaction where the performance data indicate the learning state of the student. In an objective test , the performance data is available at lower level of granularity that is at each question level. In this study, available Talent search test data is used. Talent search examination is held to assess scholastic abilities of students so that they can be further nurtured by providing financial and training support. The tests are held for three different levels of students that is standard VIII, IX and X. The personal information about the learner such as name, class, gender as well as his locality information such as school, district etc.. is collected as part of the registration process. The performance data in each of the 200 questions by each student is available.

Sr No	Year	Number of Students	Size of csv file
1	2011	118712	40.4 MB
2	2012	107453	36.6 MB
3	2013	96100	32.8MB
4	2014	105423	36.1MB
5	2015	106795	36.5 MB

B. Choosing learning Frameworks

It is challenging to understand how the learning happens and many researchers have presented varied learning models, defined various taxonomies for instructional design and designed different frameworks that explain intellectual processing(Khalil, M. K. & Elkhider, I. A. 2016; Bakharia, et.al.2016 ; Greller, et.al. 2017). The structure of Intellect model proposed by J. P. Guilford, as multiple Intelligence theory can be used for assessing learning disabilities as also scholastic abilities (Guilford, J. P., & Hoepfner, R. 1971). Meeker's studies has demonstrated the potential of SOI in the field of education and that intellectual abilities can be both identified and improved (Meeker, M. N. 1969). Structure of intellect model has several limitations and is heavily criticized but still remains a well established tool for analysing intelligence or intellectual abilities. (Sternberg, and Grigorenko, 2001].

Once the learning model is finalised, it need to be applied to the assessment tool that is Question papers and appropriate data need to be prepared. This requires a complete understanding of the chosen mode.

B.1 Structure Of Intellect Model

Guilford's structure of intellect model (Guilford 1983)] evolved out of his efforts at developing tests for selecting pilots. Guilford isolated different factors of thinking and organized intellectual abilities along the three dimensions. of Content , Process and Product(Guilford, J. P. 1980).

This model gives 1) Reasoning and problem-solving skills (convergent and divergent operations) can be subdivided into 30 distinct abilities (6 products x 5 contents).

2) Memory operations can be subdivided into 30 different skills (6 products x 5 contents).

3) Decision-making skills (evaluation operations) can be subdivided into 30 distinct abilities (6 products x 5 contents).

4) Language-related skills (cognitive operations) can be subdivided into 30 distinct abilities (6 products x 5 contents).

B.1.1 Content

Content relates to ability to process different types of information. The information is categorized into five types but only three types will be applicable to written test while the other two may be applicable to oral assessment.

Visual/Figural - indicate the content that can be perceived through seeing . This include ability to recognize colors, different shapes such as circles, rectangles, polygons, textures such as filled unfilled regions.

Symbolic - content can be recognized by the ability to associate the defined meaning with the symbol. This include numbers from 0 to 9 , letters of the alphabet, special symbols with attached meaning such as $, π , ? etc. and designs such as arrows indicating direction.

Semantic / Word - content can be recognized by knowing the literary meaning of words and also the concepts, ideas presented using words or word phrases.

Auditory - content need to be perceived through hearing that is by understanding the variations in the sound

Behavioural - content need to be recognized by actions and expressions of people

In a subjective test, types of information (content types) of question could be different from that of the answer for example student may have to write a note describing a scene, in which case question content type is Visual while that of the answer is semantic. In a objective test, answer is provided as part of question and thus the content type the student has to deal with can be easily specified. The following figure shows how the different questions in talent search examination can be tagged to having visual, symbolic or semantic content. In Figure 1, different questions are tagged according to their content type, in most cases partly the content is of one type and partly that of other.

B.1.2 Product

The product dimension relates to kind of content processed and Operations/ processes dimension relates to different processes applied to kind of content. The product can be both an input as also the output of a mental process. Product dimension is further categorized into six types.

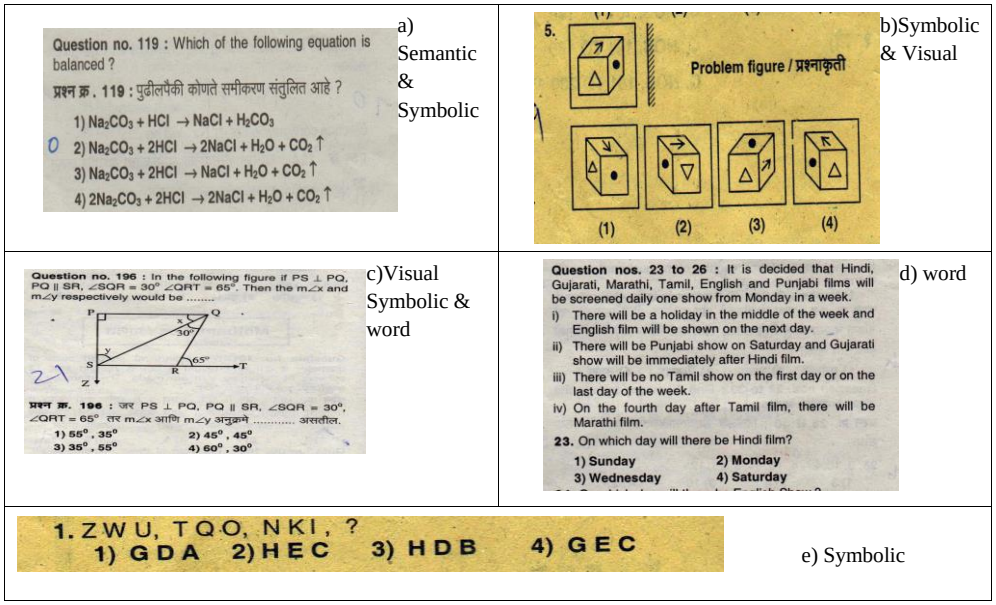


Fig. 1. Marking questions based on content type.

Units – represents single unit of information. The units are of specific content type. Visual unit could be shapes, symbolic units could be numbers, semantic units could be words, behavioral units could be facial expressions. The mental processes can be applied at unit

Classes – represent a set of items that share an attribute. The ability to organize units into groups, or select the right group

Relation – represents relationships, connection between pair of items which could be ordering between items, opposites, analogies etc

Systems – relates to relationships or interconnectedness of more than two items with interacting parts

Transformations -is the ability to understand changes in information, such as rotation of visual figures, changes in the semantics when words are used in particular context.

Implications- refers to expectation. Given a certain set of information, one might expect certain other information to be true.

B.1.3 Process

Process or operations is further categorised into six types cognition out of which only four are applicable to objective tests.

Cognition - relates to recognising or dicsovering the kind and type of information. Shapes, Symbols can be recognised. Cognition is assimilating and integrating knowledge. Cognition process uses existing knowledge to generate new knowledge. Cognition can be improved by training and repeatedly doing the activity so that you do it with ease when required. You can recognise commonly used symbols with ease without straining your memory. (Schunk, D. H. 2012 ; Fueller, et.al 2013).

Memory retention – Storing the information (content) in memory so that it can be processed in memory specifically during a oral test. This is not required in case of written test.

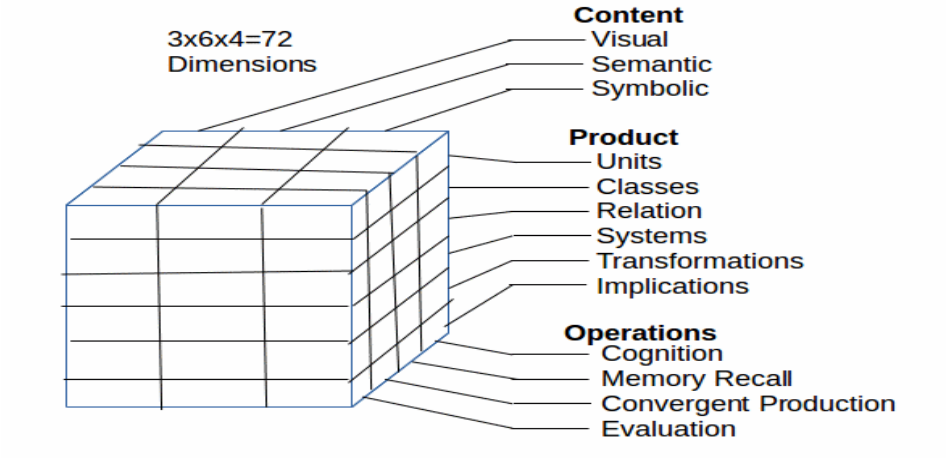
Memory Recall – Recalling higher order concepts formulas which are retained in memory over a period.

Divergent production – Divergent thinking is the ability to find as many answers to a problem which can be very well demonstrated in an open ended test but not applicable to close ended(objective) test. Fluency, Flexibility, creativity are some of the outcomes of divergent thinking.

Convergent production – Convergent thinking gives the ability to find the best answer to the given problem. The ability to use variety of facts and arrive at a correct answer. The facts act like constraints reducing number of possibilities leading to one right answer. In mathematical problems convergent production may include operations such as addition , subtraction that help in arriving at the correct answer

Evaluation - is the ability to make judgments about the various kinds of information, judgments such as which items are identical in some way, which items are better, and what qualities are shared by various items. In objective tests since options are available they can be evaluated.

Considering that all the dimensions in the structure of intellect are not mutually exclusive the three main components combine to give in all 3x4x6= 72 possible dimensions as shown in Figure 2.



After understanding the SOI model it is applied so that each question can be appropriately tagged as requiring a particular intellectual ability (Guilford, J. P., & Hoepfner, R. 1971). Each question can be marked to have one or more among the thirteen qualities as shown in Figure 2

III. EXPERIMENTAL ANALYSIS

The experimental analysis can be carried out with the help of a tool that supports both statistical analysis, data mining and with good visual capabilities. R is open source environment that is extendable with lots of packages supporting various analytical

tasks. (Crawley, M. J. 2012; Matloff, N. 2011). R shiny package can be used to quickly design an analytical dashboard. The experiment Analysis can be both Student performance analysis as also Question paper analysis. Student performance can be analyzed at individual level as also along the different demographic groups. (Hasan, R. et.al. 2020 ; Ryan, M. M. 2014).

A. Student Performance Analysis using SOI

The available datasets contains for every student the demographic information as well ticks for 200 questions. The question paper is analysed and tagged using the (Meeker, M. N. 1969) SOI dimensions. Using the Question paper key the performance score in each dimension can be computed and presented as in Figure 2.

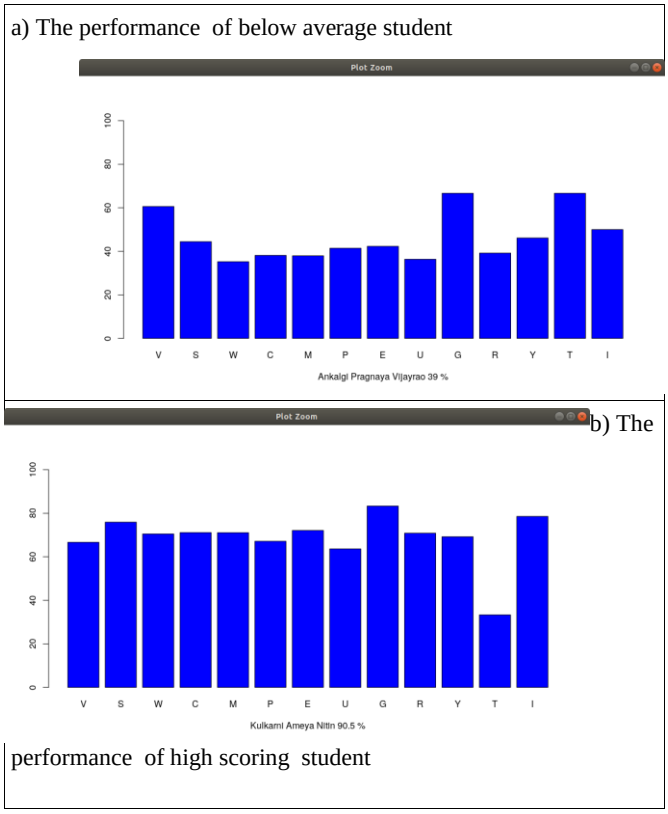


Fig 2 : Performance along 13 SOI dimensions

The ability scores of a student can be presented alongwith average performance of the school and also the district to which the student belongs as in Figure 3

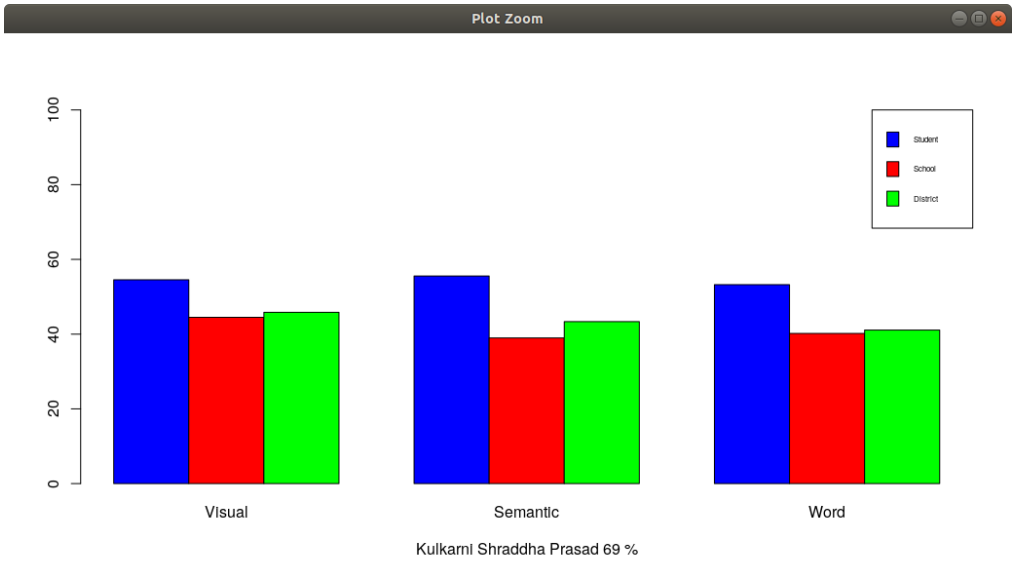
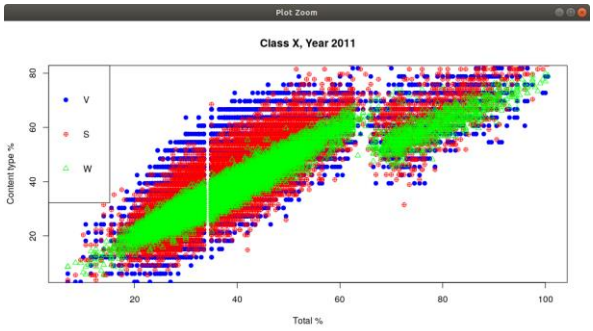


Fig: 3: Fig 3 Comparative plot for content types

B. Schoolwise, Genderwise Performance Analysis

The performance in terms of total marks obtained can be plotted against the performance scores in each content type. The semantic(word) ability has an almost linear relationship with the total.

a) Three content types against Final total for whole class



b) Three content types against Final total for a school

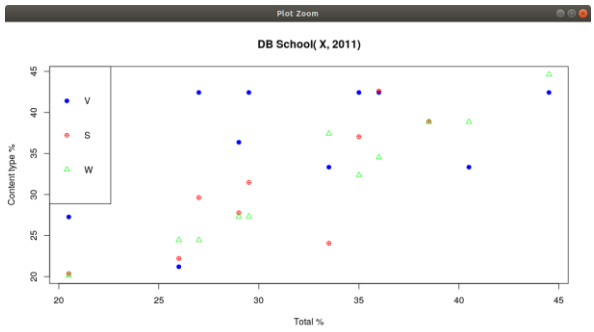


Fig 4: Relation of content types to Total score

The Genderwise performance in the year 2011 for three content types is shown in Figure 5.

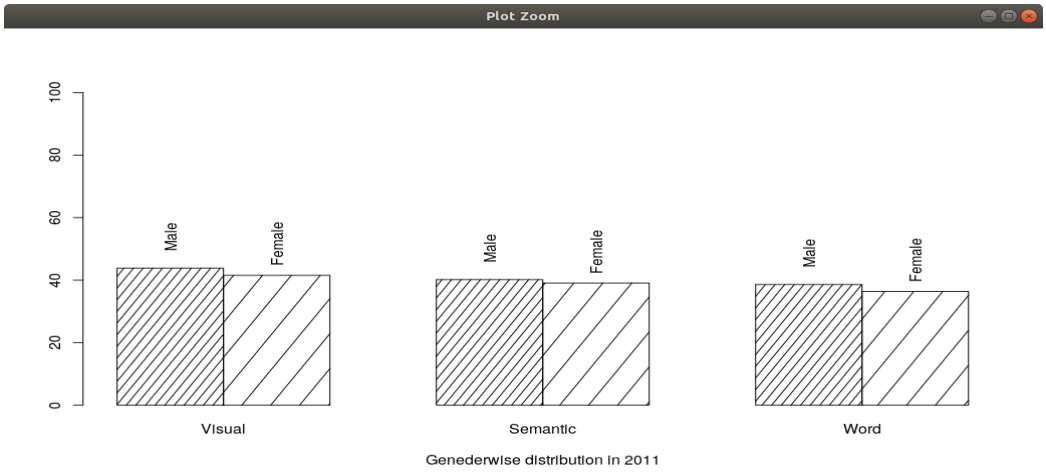


Fig 5

Fig5: Genederwise performance of different Content types

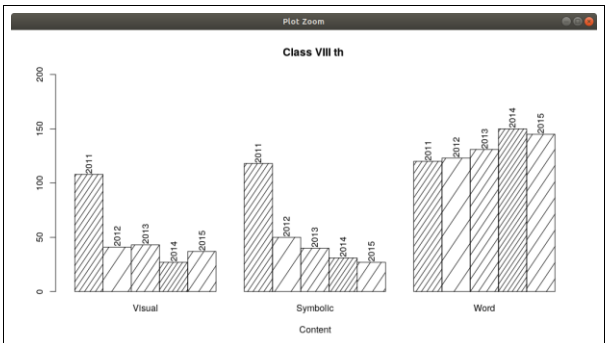
Similar analysis can be carried out for the different abilities in Process and Product dimension

.

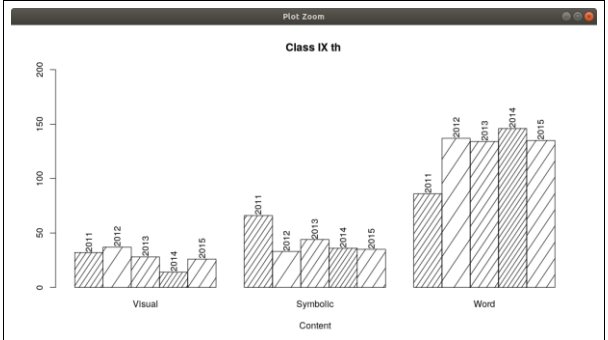
C. Question Paper Analysis

The dataset contained Question papers for three levels of students of VIII, IX and X, for five years that is 2011 to 2015. For all the 15 question papers, each of the 200 questions were tagged according to

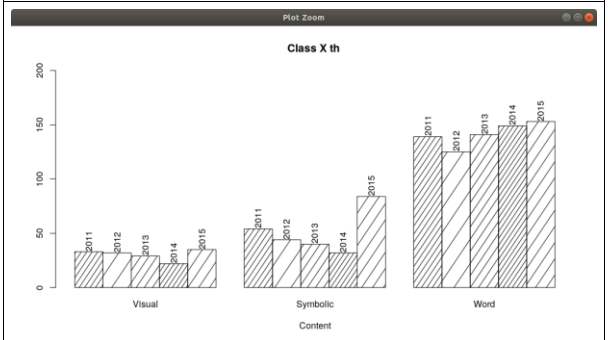
the SOI model. For the content dimension the distribution along the three sub dimensions year wise is presented for each batch in Figure 6.



a) Content distribution for class VIII



b) Content distribution for class IX



c) Content distribution for class X

Fig 6: Content distribution yearwise for each batch

D. Analytics Dashboard

A dashboard helps in reporting of analytics directly to stakeholders usually in a visual form thus supporting learners, teachers and authorities in taking right actions.

A learning Analytics dashboard presents different indicators about learners, learning instrument and learning outcomes in the form of visual reports that can help in improving learning instrument as well as the learning process depending on learners and the context(Jivet, I., et.al 2018,)..

Shiny R package helps in quickly implementing a dashboard as shown in figure 7.

A student can be selected after selecting an year and a batch, and whole lot of information about student performance is presented at a detailed level by using different learning frame works.

This dashboard uses for schools and institutes for students performance individually and school wise district

wise and taluka wise .

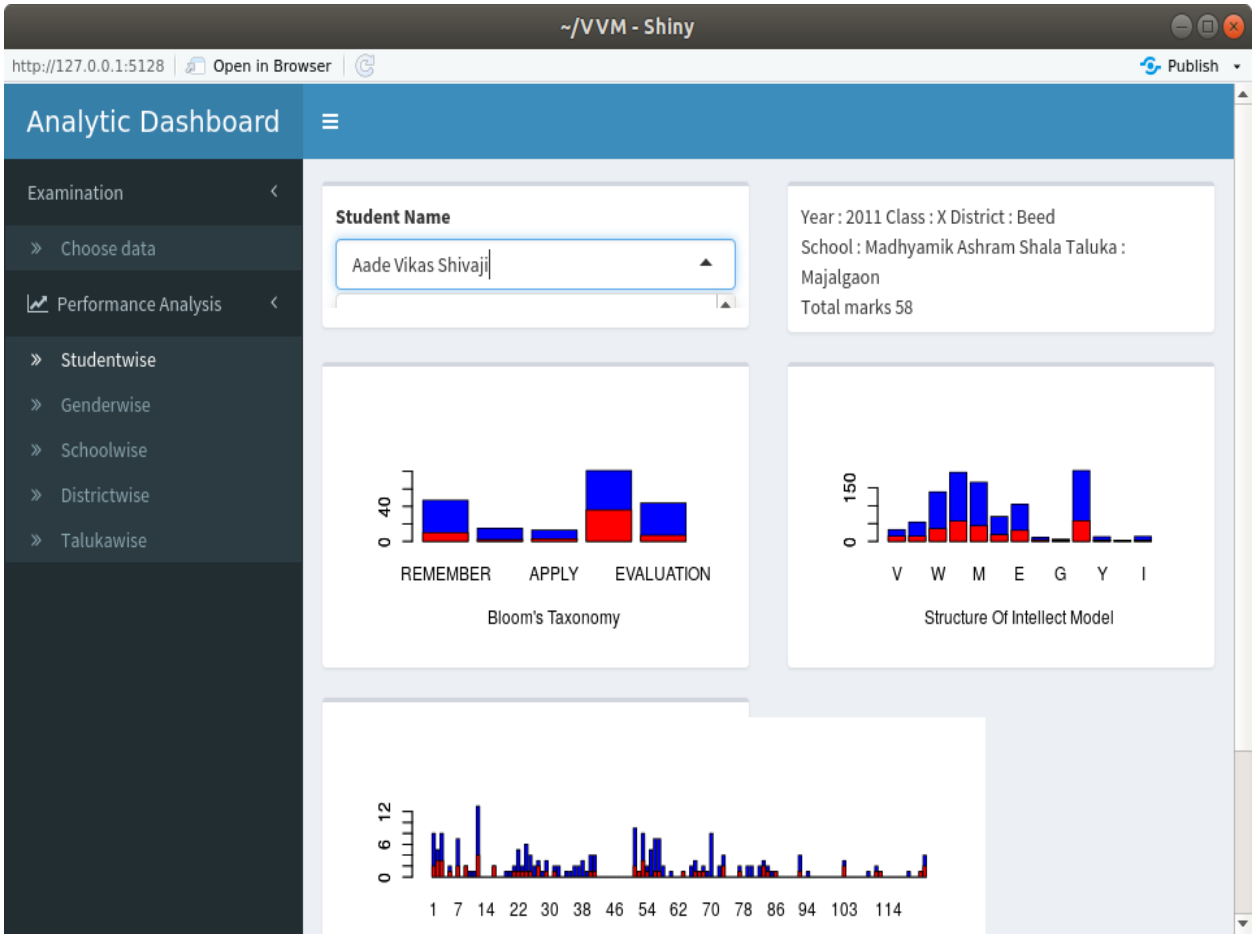


Fig 7 Learning Analytics Dashboard

IV CONCLUSION

The paper presents the complete Analytics process that can be applied to an available examination dataset. Guilford's Structure of Intellect Model is used as a Learning framework and it has its own set of critics and followers. It gives more talent search of students about their performance. This paper also

gives more about district performance and school wise performance .It fulfil the aim of talent search exam for finding the talent of students .

V. FUTURE SCOPE

Alternatively the most popular Bloom's taxonomy can be used.

REFERENCES

Bakharia, A., Corrin, L., De Barba, P., Kennedy, G., Gašević, D., Mulder, R., ... & Lockyer, L. (2016, April). A conceptual framework linking learning design with learning analytics. In *Proceedings of the Sixth International Conference on Learning Analytics & Knowledge* (pp. 329-338).

Bienkowski, M., Feng, M., & Means, B. (2012). Enhancing teaching and learning through educational data mining and learning analytics: An issue brief. US Department of Education, Office of Educational Technology, 1, 1-57.

Crawley, M. J. (2012). *The R book*. John Wiley & Sons.

Fueller, C., Loescher, J., & Indefrey, P. (2013). Writing superiority in cued recall. *Frontiers in psychology*, *4*, 764.

Greller, W., Santally, M. I., Boojhawon, R., Rajabalee, Y., & Kevin, R. (2017). Using learning analytics to investigate student performance in blended learning courses. *Journal of Higher Education Development–ZFHE*, *12*(1), 37-63.

Guilford, J. P. (1980). *Intelligence education is intelligent education*. International Society for Intelligence Education.

Guilford, J. P., & Hoepfner, R. (1971). The analysis of intelligence. *Mcgraw-hill series in psychology*.

Gulford, J.P.(1982).Cognitive psychology's ambiguities: some suggested remedies. Psychological review,89(1),48.

Hasan, R., Palaniappan, S., Mahmood, S., Abbas, A., Sarker, K. U., & Sattar, M. U. (2020). Predicting Student Performance in Higher Educational Institutions Using Video Learning Analytics and Data Mining Techniques. *Applied Sciences*, *10*(11), 3894.

Hung, J. L., Rice, K., & Saba, A. (2012). An educational data mining model for online teaching and learning. *Journal of Educational Technology Development and Exchange*.

Jivet, I., Scheffel, M., Specht, M., & Drachsler, H. (2018, March). License to evaluate: Preparing learning analytics dashboards for educational practice. In *Proceedings of the 8th International Conference on Learning Analytics and Knowledge* (pp. 31-40).

Khalil, M. K., & Elkhider, I. A. (2016). Applying learning theories and instructional design models for effective instruction. *Advances in physiology education*, *40*(2), 147-156.

Leitner, P., Ebner, M., & Ebner, M. (2019). Learning analytics challenges to overcome in higher education institutions. In *Utilizing learning analytics to support study success* (pp. 91-104). Springer, Cham.

Linan, L.C.& Parez A.A.J.(2015).Educational Data Mining and Learning Analytics:differences ,similarities and time. International Journal of Education Technology in Higher Education, *12*(3), 98-112.

Mangaroska, K., & Giannakos, M. (2018). Learning analytics for learning design: A systematic literature review of analytics-driven design to enhance learning. *IEEE Transactions on Learning Technologies*, *12*(4), 516-534.

Matloff, N. (2011). *The art of R programming: A tour of statistical software design*. No Starch Press.

Meeker, M. N. (1969). The Structure of Intellect, Its Interpretations and Uses.

Patwa, N., Seetharaman, A., Sreekumar, K., & Phani, S. (2018). Learning Analytics: Enhancing the Quality of Higher Education. Res J Econ 2: 2. *of*, *7*, 2.

Ryan, M. M. (2014). The Impact Collaborative Data Analysis has on Student Achievement and Teacher Practice in High School Mathematics Classrooms in Suburban School Districts in the Mid-West Region of New York.

Schunk, D. H. (2012). *Learning theories an educational perspective sixth edition*. Pearson.

Sternberg, R. J., & Grigorenko, E. L. (2001) Unified psychology [Editorial]. *American Psychologist*, *56*(12), 1069–1079.

Talib, A. M. et.al. (2018). Assessment of Student Performance for Course Examination Using Rasch Measurement Model: A Case Study of Information Technology