

# Visualising the University Degree Journey

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## Abstract

*In UK Higher Education, examiners are placed in a privileged position, able to apply adjustments to grades and confer awards in line with institutional regulations. Most frequently, examiners utilise dense tabulations of marks that blend into one another. This paper proposes an objective visual approach and prototype system. This system can be used to chart students' journeys through their programme and visually reason about their performance. We also present the favourable evaluation when it was trialled within the School of Computer Science at Bangor University.*

## CCS Concepts

•**Human-centered computing** → Visualization systems and tools; •**Applied computing** → Education;

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## 1. Introduction

Almost all academic assessment relies on the subjective judgements of the educator; there are, however, notable exceptions such as in mathematics. Educators constantly strive to reduce the impact of this necessary evil. They employ rubrics, mark schemes, multiple-choice assessment, and other mechanisms in the pursuit of a objective individual grade for each student [CMM03]. This process, while potentially time consuming, can work on an individual assessment or module basis. As students progress further through their programmes, more and more subjectivity creeps in [Blo09]. In UK Higher Education (HE), examiners are granted broad powers to make necessary adjustments when making progression (end-of-year) and award (end-of-programme) mark confirmations [Bro04]. These adjustments are indented to provide a balance to mitigate exceptional circumstances, such as pastoral crises or missteps during delivery or assessment. Each HE institution has their own particular regulations, practices, customs, and methods when considering final grades, adjustments and award outcomes.

Administrators will diligently produce pages of spreadsheets/tables containing each students marks for that academic period for the examiners. As the number of students, programmes, modules, and combinations expand, so do these reports. Absorbing this information, combining it with any exceptional circumstances, then applying all relevant regulations [Sto04] can place a large burden on the examiners.

Visually, extensive tables of similar data do little to aid the viewer to distinguish rows and columns. This a recognised problem in the Information Visualisation field, with solutions already proposed [RC94]. Banding, division lines, colours, or more exotic methods add emphasis to assist the reader, but fundamentally

they are left to interpret the data on their own. These measures are possible but often lack these elements due to printing costs (these reports are usually printed as low resolution black and white) or lack of support for the features within the software used. Where these tools are available, the support for visualisations are limited to simple charts [BBPM\*96]. Furthermore, any commercial offering would certainly lack the customisation needed to encode all nuances of the institutional environment, regulations, etc.

Without any systemic support from tools, each examiner must follow a similar process; assimilate the data being presented, reason around it, apply (sometimes abstract) regulations, to arrive at a final grade. While disagreement, with correct intent, is healthy; this individual process will vary in focus, effort, and conviction [YBW00]. In addition, to fully consider any students' effort, examiners may need to refer to the full set of courses/modules rather than just those in the final year. The assembled quorum of examiners rely on a limited form of crowdsourcing to smooth out individual variances to arrive at a robust decision [CLT14].

This paper sets out a prototype design and method for a system to support examiners when making adjustments and/or confirming grades. The system does not merely need to show the current state of affairs, but also offer guidance and advice to the examiners. This will require building in institutional regulations, departmental policy, and local customs. While this intelligence will limit the applicability of the prototype, the method and design should be abstract enough to transfer.

## 2. Related Work

Coffrin [CCdBK14] et al. have previously suggested a process for showing engagement/performance using a hybrid Sankey/Stream band chart. This system looks at the raw data in isolation,

making the comparison among students easier. As a result, it does not compare outcomes to standards expected by the institution. Wortman and Rheingans examine trends within a programme using a more traditional node-graph structure [WR07]. Their efforts look at student movement among groups to deduce reasons for poor student retention. Mazza and Dimitrova [MD04] examine tracking data across time rather than as discrete events. This approach is closer to the goals of this work.

Implementing visualisations is not new within the Learning Analytics field. There are dashboards [VDK\*13], organisational visualisations [LPdIFV\*12], activity, and path visualisations [FBE\*13]. However these efforts focus on describing the current state, rather than assisting with the summative awarding/progression decisions. Periodic reviews of the state of learning analytics [BV17, SRTV\*17, BKA\*18] find that the questions being asked of analytics systems do not lend themselves to more advanced visualisation or interaction techniques.

There is a move toward progress tracking within Learning Analytics applications. Examples include Mastery Grids created by Loboda et al. [LGHB14], and Study Paths created by Busler and Semmler [BS17]. Most visualisation still remains basic, using bar charts to show achievement [Duv11] on an assessment-by-assessment basis. A University of Tennessee student proposed in their thesis [DeC14] a method of tying some elements of a course and student data together. DeCotes' method, however, focuses on unifying student cohorts rather than individual achievement.

Visualisations of temporal analyses is not a new concept. The literature shows a wealth of applications from medical to policing. The applications build on the same foundation knowledge, the basic techniques that can be exploited to show relationships in time and with time. The classic example is the Time line [HOB94]. This method is intuitive and follows human narrative idioms of time being a single straight line coming from the past and into the future. Dassi, Nagay, and Fauvet created a taxonomy to collect and describe various other methods exclusively dealing with temporal data [DNF05]. This builds upon Schneiderman's work, 'The eyes have it', which takes the type of data (rather than type of visualisation) as the primary construct [Shn03].

While the focus of this work is primarily graphical, presenting the outcome from an analytic process; it is important to keep sight of the ultimate goal. There are significant issues when examining education on a temporal basis [CKW18]. Designers and users alike need to have a keen understanding of how time fundamentally affects activity in the population measured. This is why in most learning analytics studies, the effect of time is obfuscated or ignored. There have been proposals to model these effects correctly [MME\*18]. As the level of analytic tools available remains quite small, the impact of these models is also small.

### 3. Design Constraints

Following a consultation with select staff within the School of Computer Science and Bangor, mixed with the authors own experiences of Boards of Examiners; the following design

constraints were defined. These are the set of initial criteria, and can be further refined where necessary.

There are two main events this visualisation/system has to support. The first is known as the 'Progression Board' meeting. This meeting is a formal meeting of all teaching staff responsible for awarding marks to students in all but the final year of their programmes. The function of this board is to confirm the marks awarded, and check that each student has met the institutional requirements to progress to the next stage of their studies. The second is the 'Final Award Board of Examiners'. In this meeting, academics involved at any stage of the programme confirm grades and confer awards. This meeting is where the majority of regulations are examined against each student case. At both of these meetings, abbreviated details of the exceptional circumstances are presented. Usually this is a severity grading and the time period the situation spanned. In addition, examiners would need to be able to recall historical performance to judge whether adjustments would be required.

In both cases there will be a significant number of students to review and pass judgement on. This necessitates a symbolic, obvious and intuitive display, enabling examiners to make quick initial judgements. However, in more difficult cases the full set of results must be easy to access to facilitate further discussion. Additionally, the manner in which student data is organised becomes more important the larger the cohort population becomes. Examiners will need to be able to select groups of students to deal with in addition to singling out individuals.

The level of detail will also need to be split; between an overview for high level consideration, and a full-detail view when required. As any discussion could be fast and free-flowing, the switch between the two would need to be as efficient as possible. As most of the detail will lose some of its meaning without the overall context, the overview should still be visible when examining sets of the detail.

## 4. Initial Design Ideas

The system was broken into three distinct pieces to aid the design process. An overview view, a detail view, and a regulation view. The regulation view is an extra aid for examiners to see and apply the relevant regulations without needing to resort to the documentation and manual calculations. All of our decisions are based on commonly held best practices, derived from case studies in Information Visualisation and Scientific Visualisation texts [Ber83, Few12, McC12, Mei13, Yau11].

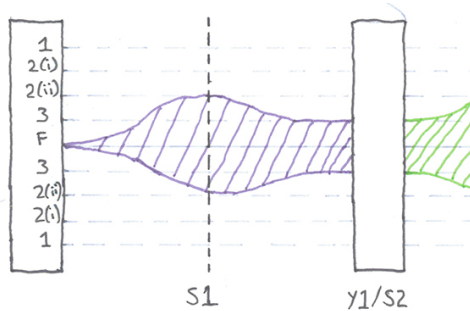
### 4.1. Overview View

This view is intended to show the student's entire programme and progression within that programme. Therefore the overriding element is time. In this view, the design choices will be restricted to chart and visualisation types appropriate for temporal data. With a temporal view, time usually occupies the categorical (horizontal) axis. The vertical or value axis would then display whichever summary statistic is chosen.

The most appropriate summary statistic would be the student's

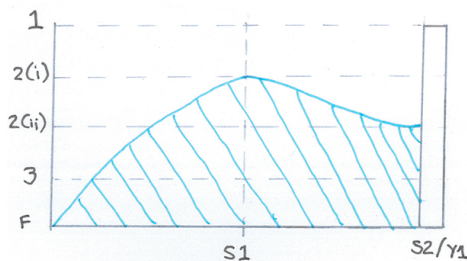
average grade during that period of time. Marks, whether using some categorical form or percentages, are discrete data points. Therefore a time-based view would be an aggregated discrete data point. This limits the choice of visualisation further; to column/bar charts, time lines, and heat maps. These choices are the more 'correct' visualisations, however the aggregation aspect allows us to infer connections between the categories. This also permits the use of stream graphs, area (and stacked area) charts, and spiral plots.

Our initial design (see Figure 1) utilises a stream graph, where the stream colouring changed width and colour based on the classification of the average grade at the end of a chosen academic year.



**Figure 1:** Initial concept art for the Overview view. This is an example of a stream graph, showing the classification of the student's average on the vertical axis (labelled with the numeric form) and semester/year marks along the horizontal axis.

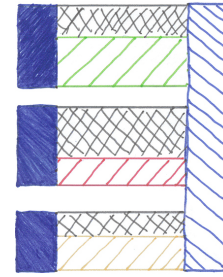
While visually more appealing, the stream graph essentially duplicates the same scale on the below centre axis, wasting the space. As a result, the view was revised to a simple area chart but keeping the interpolated curve between the data points. The revised concept is shown in Figure 2.



**Figure 2:** A revised version of the Overview view using a standard area chart. The colour of the area (in its entirety) would change based on the ending classification value.

#### 4.2. Regulation View

The Regulation View is concerned with the number of credits achieved by the student. There are three categories (under most UK HE rules); Above Pass ( $\geq 40\%$ ), Condonable (30-39%), and



**Figure 3:** Initial concept art for the Detail View. The module header (filled blue block) is scaled by module credit weighting. The width of the module block shows duration. The coloured (green, red, or amber) section is proportional to student grade. Green fill indicates the student has passed, and red indicates failure. The amber indicates the Board of Examiners may wish to discuss the case.

Fail ( $<30\%$ ). For this reason, there is no other logical choice than a simple column chart. We have chosen to use two bars, one for Above Pass (using a green colour) and the other for Fail (coloured red). We have added the threshold levels as dashed horizontal threshold lines for extra visual reference. The final design did not alter from the initial concept, as the test subjects were able to reason with the chart correctly (see Figure 6.).

#### 4.3. Detail View

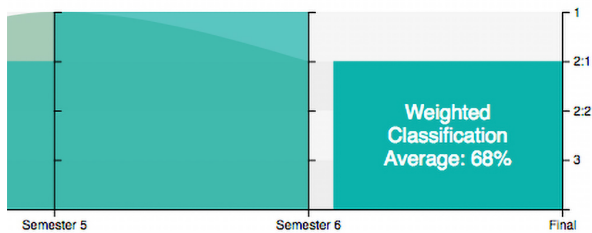
Designing the Detail View presented a challenge, due to the number of differing dimensions that needed to be presented simultaneously. Even within one academic year, there are  $n$  modules spread across two semesters. Each module has a credit weighting and a duration. It is customary that 10 credit modules usually last one semester, and 20 credits span both. However, this is not always the case. In addition, each module will have a score/grade associated for the student. In a two-dimensional medium, there are not enough spatial domains to represent each element on its own axis. We re-examined Bertin's Visual/Retinal variables [Ber83] for inspiration.

The initial idea utilises the two spatial dimensions for time and credit worth. The score is then added using colour fill, forming a gauge for each module. Figure 3 shows the original version, formed in rectangular blocks.

#### 5. Final Design

The major alterations were to the Overview and Detail views. Figure 4 shows an enlarged section of the Overview. The raw values are presented as a column chart, with a curve of best fit area superimposed on top. This gives examiners the best of both worlds, explaining where gains and losses are made in time.

The Detail View was swapped to use a Sankey diagram as the base, as the rectangle grid based version implied more connection between modules than intended and in busy programmes became cramped. Figure 5 shows the revised version. In order to more



**Figure 4:** Enlarged portion of the final Overview view. This shows the classifications for Semester 5 and 6, as well as the final degree of a fictitious student.

closely implement Bangor's institutional regulations, the final version includes five achievement colours. Green represents a clear pass, gold (as pictured for ICP-3036 and IED-3064) indicate a condonable fail, and red a clear fail. A bright yellow, and orange colour indicates a score within a 2% borderline of a pass and condonable fail respectively. These cases should be considered by the board for potential raising.

Figure 6 shows the Regulation View. This simple column chart gives examiners an at-a-glance view of the potential eligibility of each student to pass a level or enter the supplementary work phase.

An anonymous, static version of this tool can be found at <https://research.shadowraider.com/journey>.

## 6. Evaluation

A preliminary evaluation was completed using the standard System Usability Scale (SUS) [B\*96]. A total of 16 examiners, familiar with the institutions practices but not all regulations, were surveyed. This specific form of questions, using a Likert scale arrives at a score out of 40, but is commonly multiplied by 2.5 to achieve a score out of 100, but is not a percentage. Subsequent testing of the scale (using over 500 trials) has established that the average score is 68 [Sau11].

The Student Journey visualisation scored an average of 79.65 / 100 on the SUS. This score places it on the Good/Excellent boundary [BKM08]. The cut off for excellent is 80 / 100. Examining those results ranking the tool below average ( $n = 5$ ), the average score was 63 / 100. This places the tool in the marginal section of the scale.

Respondents were also given the opportunity to provide free-form comments. Most of the negative-leaning remarks were request for additional training/materials rather than suggestions or complaints. One positive comment states that this tool was able to show the situation with a student which matched, almost exactly, examiners intuitions.

## 7. Conclusion

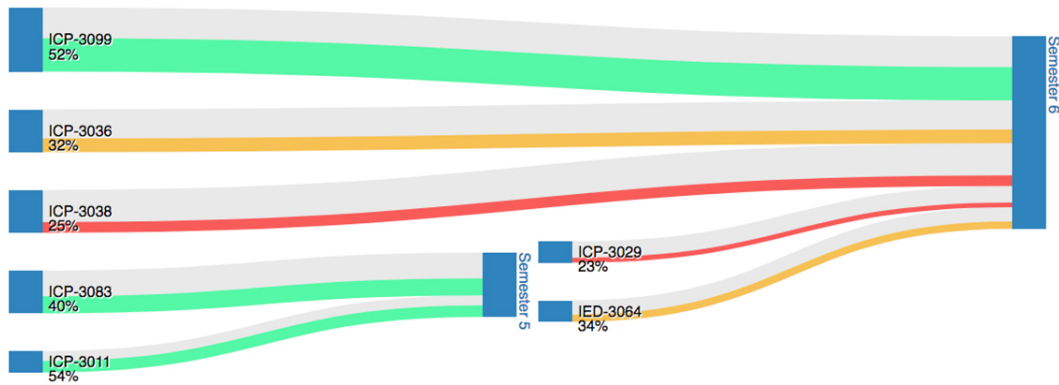
We have shown a possible objective visual aid can be produced, to assist examiners when making decisions on student performance. This prototype tool has proven usable, and popular with those evaluating it in the pilot study. A wider study will be needed

to ensure the tool meets or can meet the needs of a wider audience. The visuals produce appear to correlate well with intuitive impression of students held by the examiners. This work provides a sound foundation to produce further enhancements and associated work.

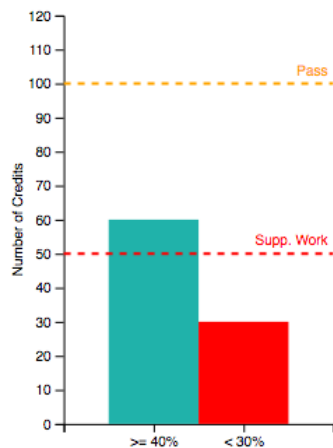
## References

- [B\*96] BROOKE J., ET AL.: Sus-a quick and dirty usability scale. *Usability evaluation in industry* 189, 194 (1996), 4–7. 4
- [BBPM\*96] BERGIN J., BRODIE K., PATIÑO-MARTÍNEZ M., McNALLY M., NAPS T., RODGER S., WILSON J., GOLDWEBER M., KHURI S., JIMÉNEZ-PERIS R.: An overview of visualization: its use and design: report of the working group in visualization. In *ACM SIGCSE Bulletin* (1996), vol. 28, ACM, pp. 192–200. 1
- [Ber83] BERTIN J.: *Semiology of graphics: diagrams, networks, maps*. University of Wisconsin press, 1983. 2, 3
- [BKA\*18] BODILY R., KAY J., ALEVEN V., JIVET I., DAVIS D., XHAKAJ F., VERBERT K.: Open learner models and learning analytics dashboards: a systematic review. In *Proceedings of the 8th International Conference on Learning Analytics and Knowledge* (2018), ACM, pp. 41–50. 2
- [BKM08] BANGOR A., KORTUM P. T., MILLER J. T.: An empirical evaluation of the system usability scale. *Intl. Journal of Human-Computer Interaction* 24, 6 (2008), 574–594. 4
- [Blo09] BLOXHAM S.: Marking and moderation in the uk: False assumptions and wasted resources. *Assessment & Evaluation in Higher Education* 34, 2 (2009), 209–220. 1
- [Bro04] BROWN R.: *Quality assurance in higher education: The UK experience since 1992*. Psychology Press, 2004. 1
- [BS17] BUSER P., SEMMLER K.-D.: Study paths, riemann surfaces and strebel differentials. *Journal of Learning Analytics* 4, 2 (2017), 62–75. 2
- [BV17] BODILY R., VERBERT K.: Review of research on student-facing learning analytics dashboards and educational recommender systems. *IEEE Transactions on Learning Technologies* 10, 4 (2017), 405–418. 2
- [CCdBK14] COFFRIN C., CORRIN L., DE BARBA P., KENNEDY G.: Visualizing patterns of student engagement and performance in moocs. In *Proceedings of the fourth international conference on learning analytics and knowledge* (2014), ACM, pp. 83–92. 1
- [CKW18] CHEN B., KNIGHT S., WISE A.: Critical issues in designing and implementing temporal analytics. *Journal of Learning Analytics* 5, 1 (2018), 1–9. 2
- [CLT14] CHIU C.-M., LIANG T.-P., TURBAN E.: What can crowdsourcing do for decision support? *Decision Support Systems* 65 (2014), 40–49. 1
- [CMM03] CHOINSKI E., MARK A. E., MURPHEY M.: Assessment with rubrics: An efficient and objective means of assessing student outcomes in an information resources class. *portal: Libraries and the Academy* 3, 4 (2003), 563–575. 1
- [DeC14] DECOTES M. B.: *Data Analytics of University Student Records*. Master's thesis, University of Tennessee, 2014. 2
- [DNF05] DAASSI C., NIGAY L., FAUVET M.-C.: A taxonomy of temporal data visualization techniques. *Information-Interaction-Intelligence* 5, 2 (2005), 41–63. 2
- [Duv11] DUVAL E.: Attention please!: learning analytics for visualization and recommendation. In *Proceedings of the 1st international conference on learning analytics and knowledge* (2011), ACM, pp. 9–17. 2
- [FBE\*13] FORTENBACHER A., BEUSTER L., ELKINA M., KAPPE L., MERCERON A., PURSIAN A., SCHWARZROCK S., WENZLAFF B.: Lemo: A learning analytics application focussing on user path analysis and interactive visualization. In *Intelligent data acquisition*





**Figure 5:** The revised Detail view using a Sankey diagram as the base visualisation. The colours represent pass, condoned fail, and failure. The exact scores are added as text for clarity. The source (left) blue blocks are scaled by the credit weighting of the module. The grey bars are to show the boundary of the achievement gauges.



**Figure 6:** The Regulation View, comprising two column charts. The green column (left) shows the number of credits achieved above the pass mark. The red column (right) shows the number achieved at a fail level. The two marker lines show the pass and supplementary work eligibility points.

and advanced computing systems (idaacs), 2013 ieee 7th international conference on (2013), vol. 2, IEEE, pp. 748–753. [2](#)

- [Few12] FEW S.: *Show me the numbers: Designing tables and graphs to enlighten*. Analytics Press, 2012. [2](#)
- [HOB94] HARRISON B. L., OWEN R., BAECKER R. M.: Timelines: an interactive system for the collection and visualization of temporal data. In *Graphics Interface* (1994), pp. 141–141. [2](#)
- [LGHB14] LOBODA T. D., GUERRA J., HOSSEINI R., BRUSILOVSKY P.: Mastery grids: An open source social educational progress visualization. In *European Conference on Technology Enhanced Learning* (2014), Springer, pp. 235–248. [2](#)
- [LPdlFV\*12] LEONY D., PARDO A., DE LA FUENTE VALENTÍN L., DE CASTRO D. S., KLOOS C. D.: Glass: a learning analytics visualization tool. In *Proceedings of the 2nd international conference on learning analytics and knowledge* (2012), ACM, pp. 162–163. [2](#)

- [McC12] MCCANDLESS D.: *Information is beautiful*. Collins London, 2012. [2](#)
- [MD04] MAZZA R., DIMITROVA V.: Visualising student tracking data to support instructors in web-based distance education. In *Proceedings of the 13th international World Wide Web conference on Alternate track papers & posters* (2004), ACM, pp. 154–161. [2](#)
- [Mei13] MEIRELLES I.: *Design for information: an introduction to the histories, theories, and best practices behind effective information visualizations*. Rockport publishers, 2013. [2](#)
- [MME\*18] MAHZOON M. J., MAHER M. L., ELTAYEBY O., DOU W., GRACE K.: A sequence data model for analyzing temporal patterns of student data. *Journal of Learning Analytics* 5, 1 (2018), 55–74. [2](#)
- [RC94] RAO R., CARD S. K.: The table lens: merging graphical and symbolic representations in an interactive focus+ context visualization for tabular information. In *Proceedings of the SIGCHI conference on Human factors in computing systems* (1994), ACM, pp. 318–322. [1](#)
- [Sau11] SAURO J.: *A practical guide to the system usability scale: Background, benchmarks & best practices*. Measuring Usability LLC Denver, CO, 2011. [4](#)
- [Shn03] SHNEIDERMAN B.: The eyes have it: A task by data type taxonomy for information visualizations. In *The Craft of Information Visualization*. Elsevier, 2003, pp. 364–371. [2](#)
- [SRTV\*17] SCHWENDIMANN B. A., RODRIGUEZ-TRIANA M. J., VOZNIUK A., PRIETO L. P., BOROUJENI M. S., HOLZER A., GILLET D., DILLENBOURG P.: Perceiving learning at a glance: A systematic literature review of learning dashboard research. *IEEE Transactions on Learning Technologies* 10, 1 (2017), 30–41. [2](#)
- [Sto04] STOWELL M.: Equity, justice and standards: assessment decision making in higher education. *Assessment & Evaluation in Higher Education* 29, 4 (2004), 495–510. [1](#)
- [VDK\*13] VERBERT K., DUVAL E., KLERKX J., GOVAERTS S., SANTOS J. L.: Learning analytics dashboard applications. *American Behavioral Scientist* 57, 10 (2013), 1500–1509. [2](#)
- [WR07] WORTMAN D., RHEINGANS P.: Visualizing trends in student performance across computer science courses. *ACM SIGCSE Bulletin* 39, 1 (2007), 430–434. [2](#)
- [Yau11] YAU N.: *Visualize this: the FlowingData guide to design, visualization, and statistics*. John Wiley & Sons, 2011. [2](#)
- [YBW00] YORKE M., BRIDGES P., WOOLF H.: Mark distributions and marking practices in uk higher education: some challenging issues. *Active learning in higher education* 1, 1 (2000), 7–27. [1](#)