2022

A specialist engineering project

Investigate an engineering project in a relevant specialist area

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Report brief

The following report focuses evaluating a problem that that is currently being seen throughout a given community, said problem would be studied by looking at the problem itself and the collateral issues that it is causing. From there, research on potential solution needs is going to be conducted which would include existing solution that might be made in order counteract the issue, requirements for the final solution to the problem, and some of the tools that the solution might require. From there, an analysis of three possible appropriate and realistic solutions would be done, each of which being thoroughly investigated through certain criteria used to study the potential feasibility of each of the said solutions.

Table of contents

Problem evaluation **1**

What is the problem? **1**

Effects of the problem **1**

Research and design **2**

Solution requirements **2**

Existing solutions **2**

Potential tools to be utilized **2**

Possible solutions and feasibility studies **3**

Website dashboard **3**

OCR application **5**

Manual input application **6**

Conclusion and justification **7**

References **8**

Problem evaluation

What is the problem?

A major problem currently being seen throughout schools all over the world is the lack of an appropriate method that can be utilized in sorting through and analyzing student data. Nowadays, if data has to be collected on a particular group of students, the process of doing so generally involves sorting through their grades either by going through past papers or utilizing the school's personal grading application, after which manually organizing said data onto an excel sheet, and then adding graphs for each student. Overall, said process is rather inefficient when taking into account the time it takes to do it and the fact that it is not very sustainable or expandable as the overall system would get more and more unorganized and complicated to sort through as the number of students increase, and when considering the fact that schools in Oman average around 418 according to a publication made by (Oman Observer, 2019) in 2019, utilizing the stated process would be extremely inefficient.

Overall, analyzing student data is especially important when considering the various advantages that school executives, teachers, and students themselves could benefit from a school that is able to provide such a feature, with said benefits – or rather the drawbacks of not implementing student grade analysis – being discussed in the following section.

It should also be noted that the school in which the solution is going to be implemented in is the Royal Guard of Oman's Technical College, and therefore some references to the school are going might be included within the following sections as well as using school-equipment during solution justification.

Effects of the problem

Weak students could go unnoticed

One of the main drawbacks of not analyzing student grades is that it leads to an increased chance of not noticing weak students or even strong students that are experiencing a gradual decline in their grades. That is the case since although a teacher or the student themselves might be able to keep track of their school grades, it might not be very evident the direction in which the overall performance of said student is heading towards unless it is presented in an appropriate and clear manner that allows both students and teachers to see any fluctuations in performance over time.

Teachers can evaluate their teaching methods

As stated earlier, analyzing data would not only be beneficial for the student but also for teachers, and one way in which teachers could utilize this feature is by being able to experiment with different teaching methods and they would be able to accurately and technically evaluate their teaching methods for each class of students they teach, which in consequence would ease the teaching process for teachers as they would know what works best and in addition it would also benefits the students as they are going to be taught in a method proven by statistical results. It should be noted that of course student performance is not entirely based on the teacher, however, it nonetheless would be a useful tool to have, especially for younger students as a teacher's teaching method would be more prominent with them as most younger students depend entirely on what they learn in class.

Parents could track their child's progress efficiently

Another major benefit of applying student statistics is that parents can track their child's progress and be able to assist them in aspects that their child might be struggling on since students would generally want to hide most information about their grades from their parents, however, this is never the right approach as a child's parents would be unable to assist their child where needed. Additionally, such statistics would be very beneficial for a tutor if the parents were to hire one, since said tutor would be able to plan ahead easily and have a good grasp on the method and approach they should using when working with the student as they would know exactly which aspects they have to work on.

School executives could track specific students

Students that have a weak overall grade are often dismissed from any extracurricular activities that the school board might be hosting or thinking about joining, such as competitions and artistic or technical showcase events, however, using statistical analysis, school board executives are able to filter out certain students and focus on ones that might be particularly talented in a certain subject, and for a student to be weak overall but is performing well in a certain subject generally indicates that they have a given talent for said subject. The same feature could also be utilized in tracking students weak in certain subjects and suggest programs that they could enroll into in order to improve their performance.

Students can easily deduce what they need to improve upon

The most important benefit of implementing student grade analysis is the fact that students would be able to analyze their grades and plan their study schedule according to their data, as they would be able to see exactly what they should be working on in an organized and clear manner, and therefore are able to prioritize certain areas and work more on them relative to other aspects that influence their grade. Said aspects could include a student's lab work, homework, project, tests, and their exams. Overall, this would improve student productivity and consequently student grades, leading to both higher success rates and average GPA across the whole school.

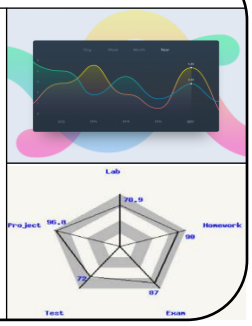
Research and Design

Solutions requirements

Data visualization

One of the more important requirements – if not the most important – is for the final solutions to be able to provide the data in a visualized way using a combination of graphs, charts, and tables, as this would result in data that is clear and easy to read, since displaying data solely in a numerical format would consequently mean that it is hard to read and analyze by students and teachers, therefore leading to many simply ignoring the feature as extracting information and benefiting from it would be rather inconvenient for the end-user. This is especially important when then number of information being displayed at once is rather vast, and although displaying student data is not as massive as some other application of data visualization, it nonetheless would seem daunting if displayed in a numerical format.

As such, the main advantage of data visualization is that no matter whether the number of data is large of small, having it plotted on a graph or chart would not overwhelm students or teachers as it would in a numerically displayed format, moreover, having data in a visualized format could provide insight into any patterns that should be taken into account such as the decrease of performance in a particular time of the year.



Easily expandable

The data analysis system that is going to be utilized for the solution needs to be sustainable in that addition to the school's student body and any expansion of the overall system would not interfere with its base function nor lead to the process becoming inconvenient or tedious.

Convenient and user-friendly

The process needs to be as convenient as possible which includes decreasing the overall manual work that the user would have to do as well as ensuring that using the product is relatively easy as a parent or a kid that might be tech illiterate might have to use the solution/product.

Existing solutions

MasteryConnect

MasteryConnect is an existing solution that most resembled the idea in mind to be implemented. It is a website that provides students, teachers, and admins the ability to track student grades and display them onto a table that teachers can inspect and gain insight onto which student requires additional support, furthermore, teachers are able to interact with students and send worksheets via an integrated feature within the website. Moreover, students can sign into the website to view their own progress. However, MasteryConnect is more about providing assessments and acts more as an examination platform rather than focusing on data tracking and analysis, additionally, it uses a numerical format for displaying much of their data, which – as stated earlier – is a major drawback.

Tableau

Tableau is a software website and application that specializes in data visualization for various industries and can potentially be a valid solution for the problem, however, the problem with it is that the way its data is displayed is rather complicated and could be classified as "overkill" for the purposes of our solution since Tableau is mainly utilized by large business which require a data structure that shows exactly everything, which can lead to it being rather daunting for both students and teachers. Additionally, Tableau is rather expensive as it costs $840 USD annually, although said price should not be a major issue considering it is relatively cheap in comparison to normal annual school payments, it nonetheless is a factor that has to be taken into account.

Potential tools to be utilized

Database

By definition, a database is a structured and organize collection of data that stores said data for it be used by an algorithm or program. Databases can be stored in file systems, however, databases that are meant to be utilized for storing a large number of data are stored in designated databases server or computer cluster that consists of a large number of hard disks in which data for the databases is stored in, for the purposes of this particular problem, utilizing a small server for the database would be a necessity for having a sufficient amount of storage for the student data that is going to be stored. With that being said, communicating with databases required the use of a specialized language known as SQL. SQL, or Structured Query Language, is the standard language for database communication and management as stated by (ANSI (American National Standards Institute), 2018)*, and as such, it is a necessary tool that would have to be included in the final product. It should also be noted that there are multiple SQL providers, each of which with its own features, with the most popular of which being MySQL, PostgreSQL, and MSSQL, as mentioned by* (Romanowski, 2020)*. A more in-depth analysis on the differences and which SQL provider is going to be preferable for the final solution will be done during the technical specifications section of solution.*

Programming language

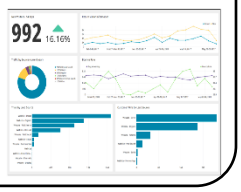
In addition to databases, the use of a programming language is going to necessary in order to work with SQL properly while also being able to use any other functions that the final product might require. The answer to which programming language would pair the best with SQL is rather vague as most programming languages would suffice, and as such it mostly up to personal preference and if the product is going to require the use a specific language. However, according to (McKeown, 2020)*, some of the most utilized languages with SQL include Python, C#, and Java, although, the biggest contender for the language to be utilized is C# as it is the language that the team working on the product has the most experienced with.*

Possible solutions

Website dashboard

Solution idea

A potential solution to the analyzed problem is the creation of a website dashboard that can be accessed using a login system by students, teachers, and school board executives. From there, teachers could easily input data to the website, from there, the website would handle the data by adding it to the database and then plotting it onto a graph for the teacher as well students to analyze, although students would only be able to see own analytics via a profile page, while teachers would be able to see each one of their students' analytics as well as the average performance for every class they teach.



Website dashboard's feasibility study

Ease of use

The overall ease of use of the website depends entirely on the execution, as having an unorganized website would make navigating the website a frustrating process, however, if done right, users would be able to navigate and use the website without any issues, as a great GUI (Graphical User Interface) should be able to lead the user on the right direction by making the GUI design clean and making sure that buttons contrast the background of the web page and are placed in predictable location, consequently leading to a website that is easy to navigate by the user. All things considered, traversing a GUI is a straightforward and familiar process, and therefore the overall usability of the dashboard should be easy for the end-user.

3/3

Net improvement and impact

Utilizing a website as the solution would net a major positive impact to the school, as the website can be accessed by any student, teacher, or parent from anywhere, making the tracking process easy for any user. Additionally, having a website in general comes with a lot of benefits, as the school would have an online platform in which they could add any additional services that they might want to have for the user while also. Additionally, for the school to have an online presence means that it can establish an image that would project great educational quality which would in turn assist in publicizing the school in a great manner for anyone that might have never heard about it.

3/3

Expenditures

There are two main areas of expenditure that the website dashboard would necessitate, the first of which is the purchase of a database server, which – as stated earlier – would be needed in order to store any data that is going to be utilized. In addition to that, the purchase a domain via a domain hosting provider would be necessary as it provides to major components in hosting a website, it provides the domain name, which allows users to search for the website using the domain name, and it also provides a web server which is used to actually upload the website's files onto the internet the World Wide Web (www). In terms of the actual costs for both of those, a hosting service such as GoDaddy, BlueHost, or HostGator, generally cost around 40 to 80 OMR per year. While no capital costs would have to spent for the database as RGOTC already owns one, the electrical expenditures of maintain said server would have to be taken into account. The overall electrical cost may vary depending on the database server that RGOTC specifically uses, however, as mentioned by (Maddox, 2013)*, the average electrical consumption for a database is approximately 20.4 kWh per day or 7446 kWh per year, which translate to around 423.5 OMR a year due to the price of 1 kWh being 0.0007 OMR in Oman according to* (Global Petrol Prices, 2021)*. As such, this totals the overall expenditures to approximately 500 OMR a year, which – relatively speaking – is a price that is not extremely significant in comparison to the school's overall expenditures, especially when considering that the school has other uses for the database, meaning the website would simply be a small addition to an already existing expenditure.*

2/3

Time consumption

Building a website in general is quite a lengthy process, which is the case since website development not only requires a lot of dedication to make sure that website not only looks good and easily navigable but also functions well and has no major connectivity issues to either the web server or the database, and as such working quickly would not be feasible if the final product is to be good. Additionally, the team working on the website does not have much experience in web development, and there would be some instances where the team would have to learn some new concepts, adding onto the time consumption factor.

0/3

Sustainability and expandability

One of the major advantages of utilizing the website dashboard is how sustainable and expandable it is. That is the case since with a website, sustainability simply stems from maintaining the servers and the domain, which – as detailed earlier – is not a significant expenditure. Moreover, any addition in the student body would not hurt functionality of the website as if storage space were to run out, which already is very unlikely, adding storage to the server is not a major problem. In addition, due to website being custom made, any additional features or services could be easily added further into the life cycle of the website, making it a very expandable solution.

3/3

Size and complexity

In general, creating a website that is fully customizable to the client's (RGOTC) needs, has an easy to navigate GUI, and works exactly as intended, is a process that involves a lot of work and requires a great amount of knowledge of the software and programming languages that are going to be utilized in the process of creating the website. Overall, the size of the project is big relative to size of the team working on it as it would involve the use of a large number of data and displaying them in a visualized manner. In addition – as stated earlier – the team working on the project does not have a lot of experience in web development, and as such, there are going to be several new programming concepts that would have to be learnt, which would increase the overall complexity of building the website. Additionally, data visualization on its own is already a somewhat complex process, and to pair that with an interact GUI that looks good would be an even bigger challenge.

1/3

The need for a specialist's expertise

As mentioned, the team working on the website does not have a lot of experience in terms working with web development related applications, and therefore specialist expertise would be necessary. Said specialist expertise would most likely be in the form of online tutorials and courses that explain web development using various frameworks and programming languages as well as the help of the team's supervisor, however, the development and building process of the website would be done by the team alone. (1/3)

1/3

Potential risk

There are three areas in which risk is involved if the website dashboard is to be utilized as the solution. The first of which is the chance of not finishing the website in the required amount of time since – as mentioned earlier – the overall project is big relative to the size of the team.

Another risk involved with the website is the potential of it being hacked, which would be a very major issue that has to be dealt with since if the website were to be hacked student data could potentially be leaked, and although student grade data being leaked is not something that could be used against the students to hurt them in the form of ransomware, it nonetheless is a risk that would absolutely need to be taken into account, not only to ensure the student's identity and information is being kept safe but to also oblige with article (4) which mention the requirement of any website to employ safety methods that prevent the leak of user-base's confidentiality. (2/3)

2/3

Legal constraints

There are a number of legal constraints that have to be taken into account when building a website that would be accessible in Oman. The following legal clauses are the ones that have been deemed relevant to the purposes of the website dashboard, all of which have been taken from a draft made by Oman's Telecommunication Regulatory Authority in 2012 → (Telecommunications Regulatory Authority, 2012)

Article (4): *The Websites Hosts and Owners shall maintain effective methods to protect the integrity and confidentiality of the End-users transactions and other personal identifiable information. Security/Privacy mechanisms shall be consistent with current industry standards and appropriate to the type of information collected, maintained and transferred to third parties.*

Article (5): *The web site owner must adopt a policy of privacy and security of the website and must abide by them. The website should contain a link in all its pages that leads to the page of the policy adopted by it.*

Article (8): *the website owner and website host shall not utilize or make available any program that may destroy or damage data on end-users devices.*

Article (12): *Website owner shall not collect, use or disclose personally identifiable information of children without the permission of their parents or guardians. When seeking parental permission, owner shall clearly specify the nature of the proposed communications, the personal information being collected and all potential uses of the information.*

Article (19): *The Owner should ensure that End-users understand their liability arising out of accessing the website.*

Article (20): *Website owner shall list contact details such as email address and/or local telephone that may be utilized by end-users for any enquiry or complaints.*

Article (21): *The website should not host any links to external website that violate this regulation.*

OCR application

Solution idea

OCR, or Optical Character Recognition, is a software tool that is used for the recognition of characters and symbols in either physical or digital format. The way the process will work is that an OCR application would be developed that would be able to read the student certificate, said OCR application would be programmed to know what to exactly look for in the certificate and would extract the necessary data. From there, the program will take said data and organize it into a document which contains visualized data that can then be sent to the user.

OCR program's feasibility study

Ease of use

Using the application should be a relatively easy process, as it simply involves uploading images of the students' certificates, from there, the program would generate the required images and they could simply be downloaded by the user. However, an issue that could hurt the overall simplicity of the program would be sending said data to student, as each student would have to receive their own results, said process would either involve the use of email or an organization management software such as MS Teams, with said process likely ending up being time consuming. (1/3).

1/3

Net improvement and impact

As a whole, the improvements that utilizing this solution would net are somewhat minimal as the OCR program would require an image of the student's certificate, meaning that statistics would be provided at the end of the semester alone, which limits a lot of the advantages that student grade analysis should be able to provide, as one of the main benefits of student grade analysis is adaptive learning and to be able to change learning methods, which this process prevents as students would have to wait till the ender of the semester to see their statistics. (1/3)

1/3

Expenditures

Overall, said program would require no expenditures whatsoever, which is the case since the sorting of data would be done entirely through application and it would not have to retrieve or upload any data since said data would be uploaded by the user at the start of the application. (3/3)

3/3

Time consumption

Coding an OCR program involves a lot of troubleshooting to make sure that the program works exactly as intended in a more or less "trial and error" process, which would generally take a lot of time, as a faulty OCR program could potentially extract unwanted data and utilize it when creating the visualized data as that would hurt the overall accuracy of the data being made. Nevertheless, said troubleshooting would not be a very significant hinderance the overall process is relatively simple. (2/3)

2/3

Sustainability and expandability

The sustainability of the application is one of the major issues with this particular solution, which is the case since an OCR application working with regex (the application used for extracting data) is programmed to check contents of a specific document, and if any changes were to be made with the document, then potential inaccuracies could as the program is extracting information. Additionally, due to the simplicity of the program, there is nothing that can be done about expanding it or improving on it. (0/3)

0/3

Size and complexity

Overall, OCR applications are not very difficult to program, and – as stated in the time consumption section – simply involve a process of trial and error to troubleshoot them and make sure that they work exactly as intended. The main complex part of the process would be to transform said data into a graphical format, a process that would be complicated for any of the given solutions. (2/3)

2/3

Potential risk

The program has very little risks, which is the case since it would simply follow the same exact set of commands every time, meaning that as long as it has been tested enough, there are no risks for it to output inaccurate data. However, working with a large number of data could likely slow down the user's computer, which is something that would have to be taken into account. Other than that, there is no other issue that could affect the program. (3/3)

2/3

The need for a specialist's expertise

As mentioned, programming an OCR algorithm is not a very difficult task, and as such, very little assistance for an expert would be required, as the main tool utilized for extracting data – regex, or Regular Expression – is very straightforward to use and well documented, meaning any issues that might be ran into during the development process could simply be looked up online through various documentations, especially the ones uploaded by W3School on their website. (3/3)

3/3

Legal constraints

There are no legal constraints that must be considered when working on the OCR program as all the data being utilized if property of the RGOTC and would be directly sent to the student they belong to without any possible interferences in which data could be leaked and used for other purposes such as ransomware.

Manual input application

Solution idea

This solution involve the development of an application that students and teachers alike could utilize in order to manually input their data and view the final results, this process could either be through either reading data from a CSV or .xl file and then automatically get updates whenever changes are made to that file, which would be done through the "Panda" libraries available with the python programming language, or by manually inputting the data into an organize and user-friendly GUI.

Manual input application's feasibility study

Ease of use

This particular solution could potentially be considered to be relatively difficult especially when considering that users without an already organized file would either have to create one from scratch or input the data manually one at a time, a process that would be very time consuming, time that might not be easily expendable for a lot of students especially older ones with a lot of school work on their hands. In addition to that, due to the process' difficulty, many younger kids and tech-illiterate parents would find it very difficult to actually use the product.

0/3

Expenditures

Overall, the application would not necessitate any expenditures whatsoever, as all the data being utilized would be taken either from a file already found within the computer (the CSV or .xl file) or it would be inputted by the user themselves within the application, meaning data would not have to be taken from an external source and as such there would no need for something such as a database. Other than the database, there are no other areas of expenditures that could have needed, as such, the solution would not require any expenditures in order to make.

3/3

Net improvement and impact

Due to using this solution bring relatively difficult, a lot of people might not bother with using it, teachers would also face the same issues, and it would much difficult for them to track each student's grades and the grade of the overall class, therefore nullifying the potential advantage of teachers using the solution to track their teaching methods, with the same being said to both students and executives, additionally, the solution would not have any other purposes, and therefore the overall impact it would have on the students and teachers would be somewhat low.

0/3

Time consumption

As stated in the size and complexity section, the overall required programming is relatively and straightforward even on an elementary level, as such, most concept that are required do not need a lot of thinking nor a lot of code to actually be written, considering that, the overall time consumption for this solution would be very little. (3/3)

2/3

Potential risks

There would not be any major risks that either the team or the user would have to deal with considering the application is going to be fully local and within the computer, meaning IoT or web exploitations would not be an issue that anyone would have to deal with. With that being said, having a very significant amount of data being calculated and plotted into a graph while also running other applications simultaneously could potentially slow down the computer, although the overall memory and processors management processor of newer operating systems and programming languages has become automated and more advanced, this is a point that should be taken into account when considering potential risks of using the application by the user. (2/3)

1/3

Size and complexity

In comparison to the other two products, this one might be easiest and least complex due to the programming required for it being the most straightforward, with it simply being a process of reading inputted data from a file or a read command, both of which being elementary programming concepts that would not be of any difficulty to implement, with that being said plotting the data onto a visualized graph would still be a challenge, although the team would be able to focus on that much more considering the initial input code can be done with relative ease.

2/3

Sustainability and expandability

Just like the OCR application, this solution's main problem is the fact that it cannot be expandable, which is the case due to its purpose being for a single purpose only, unlike that of the website, meaning after the application has been developed and launched, there would not be any other way for it to be developed further and enhanced in a manner that would be significant and meaningful. (0/3)

0/3

The need for a specialist's expertise

As mentioned, the product is relatively simple and is not even a very big project, with most of the required concepts being on the elementary level, a level that every member of the team working on the solution would be more than capable working at, as such, no specialist expertise would be required. (3/3)

3/3

Legal constraints

The application would not potentially have an effect on anyone nor could security or confidential data from it potentially leak. As such, there are no legal constraints that might prevent the team from moving along with the development of the solution.

Conclusion and justification

Solutions	*Website dashboard*	*OCR application*	*Manual input application*
Ease of use	**3**	**1**	**0**
Expenditures	**2**	**3**	**3**
Time consumption	**0**	**2**	**2**
Size & Complexity	**1**	**2**	**3**
Net impact	**3**	**0**	**0**
Need for a specialist	**1**	**3**	**3**
Potential risk	**2**	**2**	**2**
Sustainability	**3**	**0**	**0**
Total	**15**	**13**	**13**

Justification for the chosen solution

As can be seen from the table above, has the most combined points overall from the feasibility study's criteria in comparison to the other two proposed solution. In terms of ease of use, a website is a more straightforward and familiar process in comparison to using the OCR program or the manual input application as students would have to initially request their data rather than be able to access it immediately whenever they want when it comes to the OCR program, while they would have to manually input all their data onto the input application which would be time consuming and difficult for tech-illiterate students and parents. In terms of expenditures, although utilizing either of the applications might be cheaper, the cost of maintaining the server and the annual domain charges that would come if the website path were to be chosen are rather insignificant compared to the school's overall expenditures. Additionally, the website would be able to provide a much more sustainable and expandable solution that can easily act as a platform for the school to integrate other services that they might deem useful for either staff or the student-board later on in addition to it also providing an online presence for the school. As a whole, it is quite evident that the website would be providing benefits further than simply solving the problem it was initially designed for, something that cannot be said about the OCR or manual input applications, as both of which are simply is an internal application that have been created for a single purpose with little to no potential areas of expansion.

Be that as it may, the website dashboard still has major downsides that need to be considered, all of which relating to the complexity and overall difficulty of the project rather than the solution's quality. Which is understandable considering getting into and working well with web development is already a decently complex topic on its own, and when combined with the fact that the team working on the project does not have a lot of prior knowledge in that specific field, it increases the overall complexity and difficulty of actually developing a solution with a great outcome, which consequently increases the overall time consumption of the product which would mean that the expertise of a specialist would likely be required, either in the form of courses and online tutorials or the assistance of the team's supervisor. All of this can be neglected if either of the stated application solutions were to be chosen, with them being easy to develop as the concepts and tools required in order to make them are basic and on an elementary level, meaning on the team working on the solution would not have a hard time, therefore decreasing the overall time required to make the project as well the potential risk of having an incomplete or sub-bar final product. Moreover, there is an inherent risk when it comes to utilizing a website for any given reason due to hacking and exploitation possibilities that could lead to data leaks, potentially leading to the loss of confidentiality as well as blackmail, all of which are problems that would not need to be worried about for either application. Although there are certain security measures that can be taken in order to prevent such issues, there simply is nothing on the internet that is fully impossible to breach.

Despite the stated disadvantages of going with the website dashboard route, if the solution were to be executed and launched successfully, the impact would be extremely tremendous, and overall, the advantages of the website dashboard outweigh the effort and complexity of learning how to carry out the process efficiently and properly, and as such, the website dashboard is the solution that would be implemented as the final product in order to solve the analyzed problem.

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“*The greatest value of a picture is when it forces us to notice what we never expected to see.*”

- John Tukey

Pioneer in data analysis and visualization