Good practices learned from designing a more interactive project based visual analytics course

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Abstract

In the hyperconnected world that we live in, attention spans are constantly shrinking, and young students can't keep their engagement for more than 144 characters at a time. This distractful world presents a major challenge for university teaching, even more if the classes include complex topics such as computer programming. Computer enhanced classrooms that were created to better support students, can be actually detrimental for remembering when instructors are poorly trained (Klemm, 2007). However, even with highly trained professors, traditional methods seem insufficient for teaching dynamic topics like visual analytics that rely heavily on the production of interactive and web-based visualizations. This paper presents four good practices (GP) for teaching complex technological concepts such as Visual Analytics: GP1 Mixed (theory+application) classes, GP2 Web-based and modifiable slides that allow self pacing, GP3 Public visibility and open standards and GP4 Iterative problem-based feedback through different rythms. These best practices were acquired as a result of a three years collaboration the University of Los Andes (Colombia) and the University of Kaiserslautern (Germany) and although they aren't novel on their own (e.g. Albinson, 2016), used together they generated positive results when applied to a Visual Analytics course, as suggested by a post class survey.

Keywords: Project based learning in computing, Visual Analytics Course, Interactive web-based slides

Type of contribution: best practice paper.

1 Introduction

The challenges to design and execute advanced classes such as visual analytics are diverse and complex. Among others, the need for interactive analysis of data, the dynamic evolution of tools, and the high dynamic environment of this young discipline, creates an interesting playground for putting together international collaborations to tackle these challenges. In this paper we present four good practices produced as a result of an international collaboration aimed to explore better ways of teaching complex topics such as Visual Analytics. After three years of iterating different courses in the topics of Visual Computing and Visual Analytics, we present four good practices that applied together in our last course generated positive effects on our students as evidenced by our post-class survey. We believe that these good practices (GP) could be of use to the community, and therefore we report them extensively on this paper. Namely the good practices are:

- GP1 Mixed Sessions design that includes: one block of theory concepts presented as mini blocks of theory and practice, and one block of lab practice
- GP2 Web-based and interactive Class materials that allow for self-pacing during class.
- GP3 Web visibility, using open source philosophies, projects exposure and complete online availability of the resources.
- GP4 Iterative feedback loops, with different timings

These good practices were produced as one of the results of an international collaboration between two teams (one in Colombia, one in Germany) who worked together for three years putting competences and experiences. One of the objectives of this collaboration was to consolidate a common visual analytics course that incorporated the best practices of both teams, and which could be replicated on each institution. Moreover, this course was designed to enhance the added value of live sessions, and to integrate new hands-on techniques to increase the engagement and consequently foster the learning environment. The result of this process is a project based course (Bell 2010) with interactive sessions based on interactive web-tools applied to session subject, and web visibility for results of student team's process and results. This paper presents four good practices characterized from this consolidated course as a proposal for the community to reuse and build upon them.

A timeline of this collaboration outlining the courses imparted and the partial incorporation of each one of the good practices can be found on **Error! Reference source not found.**.

Figure 1 Timeline of classes and activities

The Course website can be viewed in http://johnguerra.co/classes/isis_4822_fall_2016/, where the contents and tools can be visited. The projects can be visited too in http://johnguerra.co/classes/isis_4822_fall_2016/projects.html.

The rest of this paper is organized as follows. First we describe the related work and some of the characteristics of the international collaboration that gave birth to this project. Then the set of four best practices is presented, with details of their implications. Right after that, the results of a students' survey are presented and analysed. Finally we present the conclusions and acknowledgements

2   Related Work and Collaboration Process

The international collaboration supported by the German Exchange Academic Service (DAAD) aims to define a common Visual Computing curriculum for Master of Science level.

The course *"Introduction to Visual Analytics"* was selected as a use case for this collaborative building process. Our own previous experience was built on Colin Ware course and textbook (Ware 2010), Chris North contributions (Endert et Al. 2014), and Robert Spence book (Spence 2006).

Many efforts have been done in order to deliver more quality learning spaces in computing (Albinson, 2016) (Anslow 2015). The specific experiences in visual analytics referenced in the bibliography (Elmquivst 2012, Endert 2014, Keim 2010) provide general guidelines to build a common framework for the development of our proposal. Likewise, other international collaboration experiences show us some guidelines in order to get value of our experience (Chidanandan 2010)

The main concerns after a review of existent courses, including our courses, were:

- Low students' participation in-person sessions, and low level of engagement in the projects.
- Low ability to efficiently transition between the understanding of visual analytics challenges to hands-on and applied results.Low visibility of students' work.

To enhance the quality of our learning spaces in the graduate programs, we defined a road map to advance towards this goal:

1- First, the design and implementation of a course in the framework of International Summer School in Colombia (3 weeks - 45 hours) based on German experience.
2- From this experience as well as contributions based on previous Colombian experience, a second version of the course was defined and held in parallel in both Universities.One year later, a second iteration of the summer course was held with the active participation of two teams. The project-based structure was adopted and two training workshop projects and a team mini-project inspired on the IEEE VAST challenges (IEEEVIS 2017), were defined as part of the course activities.
3- We applied the new structure to a new course on scientific computing and visualization with very encouraging results (from the students' point of view).
The current version of the Visual Analytics course (15 weeks, 45 hours), held in Fall 2016 in Colombia, includes web-live tools in the course sessions in order to have a more dynamical live sessions. The course evolves towards project-based learning and active learning sessions (briefing about the theory and hands-on activities based on web interactive visualizations with programming code manipulation challenges on the examples). We decided to introduce as textbook Tamara Munzner's book (Munzner 2014) to follow her proposed structure for the design of interactive visualizations "Why-What-How", which we find very close to our working method.

In the next section we present the four good practices that we learned from designing and executing the Visual Analytics course, which we think could be of benefit for the community.

3   Good practices for teaching an advanced computing course.

To improve on students' class immersion and provide better learning tools for our Visual Analytics course, we applied and crafted a series of four good practices for teaching an advanced computing course. These practices came as a result of a three years long international cooperation between "University of Los Andes (Colombia) and the University of Kaiserslautern (Germany). Each of these practices is probably not novel on its own, however considering the positive feedback that we obtained from our students we believe that there is value on applying them as a combined strategy. In this section we present those four practices in detail, and explain some of their implications in the class.

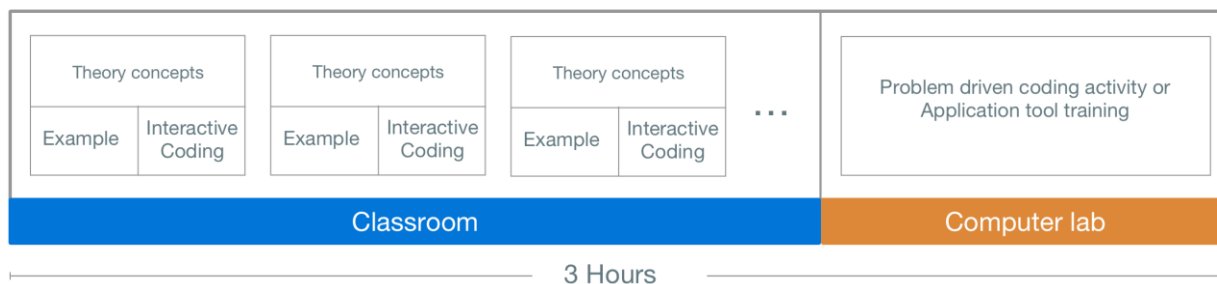## 3.1   GP1: Mixed (theory + application) classes

Figure 2 GP1 Mixed class design structure

The first good practice extracted from our experience was the design of our class sessions. We used a mixed approach that split the three hours session into two blocks, one main one in the classroom and the second one in the computer lab. This allowed students to first learn the concepts during the first part and then to reinforce their learnings during the laboratory session solving problem-based code activities, and learning real world tools usage. Moreover, during the first session in the classroom, students were faced with small blocks of a theory concept immediately followed by an example that could be code or non-code based. During these small blocks students were encouraged to discuss their implications (i.e. weaknesses and strengths) for the non-code based, and they were stimulated to modify the code and create new modified and publicly available examples for the other ones. This type of interaction generated a fruitful class environment, were students constantly presented new examples that were shared using a Slack backchannel during class. Figure 2 illustrates an example of how the class sessions were divided in a mixed structure.

Visual Analytics, as many others advanced computing concepts, is a concept that is learned better by practicing. However, a typical Visual Analytics or Information Visualization course can easily end up being a constant display of endless examples of visualization techniques, without time for interiorizing their strengths and weaknesses, left alone to learn how to code them. Based on our experience with this collaboration, we designed the course sessions to use a mixed (classroom + lab activity) approach that encouraged the constant interaction with coding examples. Moreover, given that the class slides were accessible during class on an interactive web page that allowed interaction and modification of the code examples, students were encouraged to modify the code and create their own adjusted examples. We describe the structure of the interactive and modifiable slides in Section 3.2.

It is important to note that the class duration (three hours) and weekly schedule (Tuesdays at 18:00) presented a limitation that was beyond our control. Given this restriction, we believe that the mixed class design helped students staying engaged and motivated. Moreover, by using the small theory + example blocks during the classroom sessions, we presented students with a more hands on approach that in our opinion encouraged them to ponder on the strengths and weaknesses of each concept for the non-coding examples, or to better understand how to build them on the coding examples.

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We don't claim that this mixed approach is novel, or that it was created by us. However, it was a useful technique to keep students engaged, to increase interaction, and a good solution for our long three hours sessions. Furthermore, the short concepts given during the classroom sessions that included theory + examples (code or non-code based), seems to be a good addition to the mixed approach that could be beneficial to the teaching community.

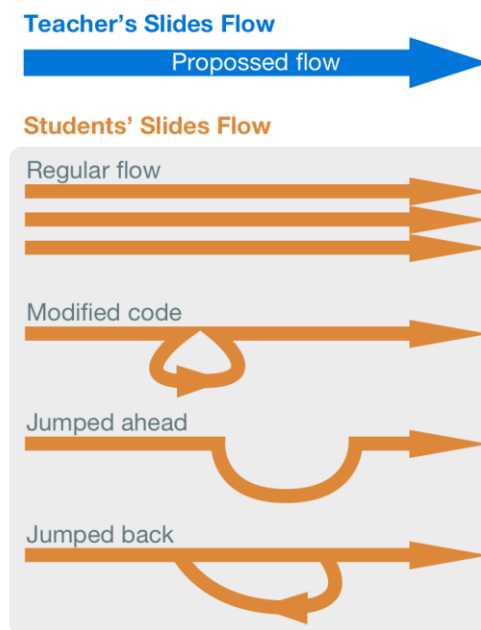### 3.2   GP2 Web-based and modifiable slides that allow self pacing

Figure 3 Students' slides flow

The second good practice identified learned from this project was to use web-based slides, which students could follow along or at their own pace, and which included interactive and modifiable code examples. A more basic version of this type of web-based slides has been proved beneficial in the past (Albinson, 2016), we improved upon this work by including interactive and easily modifiable code examples using Blockbuilder (Johnson, 2016).

D³ (Bostock, 2011) is one of the most used libraries for creating interactive information visualizations for web. It is a standard the facto not only for creating visual analytics, but also for teaching it. One of its success could be attributed to the creation of bl.ocks.org (Bostock, 2010), a repository of visualization examples created from wrapping Gists (i.e. code examples published on the Github platform). bl.ocks.org contains thousands of examples that can be easily used as a boilerplate for creating new visualizations. Despite this, creating new bl.ocks (i.e. new examples in the platform) was a complicated procedure. To address this, Ian Johnson started a crowdfunding campaign to create a new platform called blockbuilder (Johnson, 2015) that allows developers to create a modify blocks directly in the browser. During our class we leveraged these two tools and displayed most of our examples embedding them on the web slides using blockbuilder. By doing this, we allowed students not only to see a running, interactive example on their computers and mobile examples, but also to modify these examples and fork them, creating new bl.ocks with their modifications that were stored in their individual bl.ocks pages, and were therefore available to the general public as well.

Students could reference the slides later to find examples to use in their own projects. Further examples were proposed by students and the professor whenever a class discussion leaned towards a topic not discussed in the slides. For example, when discussing treemaps as a visualization technique, students asked for other real world applications of the technique and the instructor shared the example of the map of the market (FinViz, 2007) that uses treemaps to compare stock prices changes. Slack was used as backchannel to distribute these examples during class. Given the history and storage capabilities of the messaging tool, students could search back when they needed to find them.

The slides were created using Reveal.js (El Hattab, 2011) and were shared publicly both in the class homepage, and as source code on Github. Being on Github anyone can reuse these materials and build upon them. For the theory concepts, the slides built heavily on the materials published by Tamara Munzner (the author of the guide book) on her website. These materials are made available on PDF format, and because of that they had to be transformed as images to be used on the web slides. Moreover, the static examples on the slides were replaced with the aforementioned interactive and modifiable ones. Furthermore, new examples and topics were included on the slides too to demonstrate new techniques, illustrate more current examples or simply to enrich the materials provided by Tamara. Figure 4 and Figure 5 show examples of the slides used during class, the first one for the theory concept and the second one for the interactive and modifiable example.
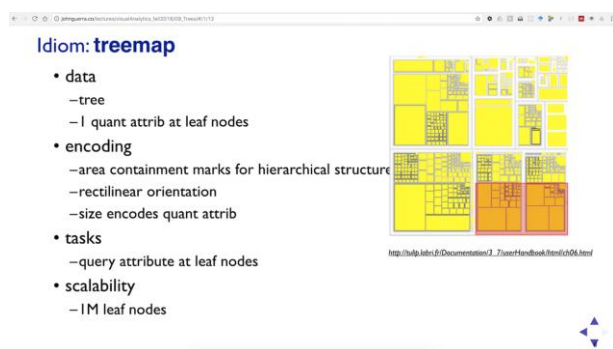

Figure 4 Slides theory example, based on Tamara slides. Available at

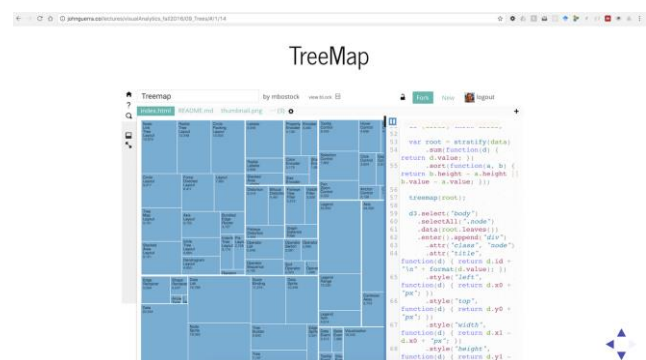http://johnguerra.co/lectures/visualAnalytics_fall2016/09_Trees/#/1/12

Figure 5 Slides interactive and modifiable demo example. Available at

http://johnguerra.co/lectures/visualAnalytics_fall2016/09_Trees/#/1/14

The concept of using web-based slides is not novel per se; however, we consider that the combination of the web slides with the blockbuilder examples can be new. More importantly, the class materials proved to be useful for engaging students during class. Furthermore, they seem to have helped students understand how the examples where built and could have facilitated the development of their own projects. Although, further research is required to demonstrate those effects, we believe that this good practice could be of use to other educators teaching similar coding topics.

3.3   GP3 Public visibility and open standards

Our third good practice was public visibility of all the activities generated during the class both by the students and the instructors. Open standards and open source licenses were used to publish the materials. We believe that this helped motivating students to increase the quality of their work, while at the same time getting more visibility of it. Students could also reflect on how to better critique the work of other professionals, by knowing that their work could also be criticized by the public.

For the final presentations students developed a video demonstration, created a live demo and did a presentation that was streamed and advertised publicly. Furthermore, a dynamic subsection of the class homepage was created to showcase their projects. This page was built dynamically from a Google sheets that students built collaboratively. An interesting anecdote that suggested the effects of public exposure was that when students were asked initially to complete the sheet, they didn't complete it all in time, and the ones that did it, provided incorrect answers to questions like an URL that showed a thumbnail of their projects. However, when the page was made live and they could see the direct results of their changes and mistakes on a public facing page, and could see the better examples of their peers, they all completed the assignment or updated their responses to collectively build a better project page.

The project page can be accessed on http://johnguerra.co/classes/isis_4822_fall_2016/projects.html. The code that generates this page can be found on github https://github.com/john-guerra/homepageJohnGuerra/blob/master/classes/isis_4822_fall_2016/projects.html and is available for the community to use it.

For the smaller projects, and some of the class activities students created bl.ocks. These are small code snippets commonly used in the visualization community, specifically for those who work using D^3, the most commonly used visualization library for the web. For building these bl.ocks, students could use blockbuilder, a web-based tool that allows online editing and live previews. They commonly used class examples (which were also presented with blockbuilder) as a starting point for their projects, but they could also start from scratch or use any other public bl.ocks. Blockbuilder was a widely used among students that preferred it for building their projects over desktop based tools, at least initially. Finally all of these projects were made public on each student account. Slack was used again as the communication channel even when it was not during sessions. Students commonly shared their bl.ocks and other interesting results using it.

We believe that using open standards, public exposure and modern tools such as slack and blockbuilder enriched significantly the class. Most of the tools used aren't novel by their own, but we believe that the community could benefit for using them in their own lectures.

3.4   GP4 Iterative problem-based feedback through different rhythms.

Last but not the least, our fourth identified good practice was the constant application of feedback loops with three different rhythms:

- Immediate feedback for the activities during class,
- One week feedback for the short projects and homeworks,
- And longer feedback for the final and more extensive project that was developed during a two month period.

We believe that these three rhythms allowed students to constantly receive retro alimentation of their work, allowing for rapid prototyping, iteration and pivoting if necessary

For the immediate feedback, students will criticize and comment class examples as well as on the fly selected cases. Class discussion was highly encouraged and students were constantly inquired to explore different points of views and to use the learned concepts to produce less biased critiques.

In the case of the short projects, students were usually given one week to create visualizations using public data with real tasks. Students were then encouraged to give peer reviews of their work and to discuss it on class. Given that all of these materials were made public, it was an easy task to interchange opinions. Finally, it was a common practice to give the students datasets of visualizations that were created and published by other professionals, but without showing the students the existent visualization. Afterwards, students were asked to compare their results with the ones produced by professionals having to use the concepts learned in class to support their claims. This technique was used during the midterm exam, were students were first asked to visualize a dataset for specific tasks that they could define on their own. Then, they were presented two visualizations, one that was a professionally made piece, but that got a mixed reaction from the community. The second one, was a proposed fixed of the first one, created during a global initiative called #MakeOverMonday, that every morning invites professionals to "fix" a visualization that might have issues. Finally students were asked to compare the three visualizations (the one created by each student, the original one made by a professional and the final one created during the #MakeOverMonday) and argue which one was better for the defined tasks. We believe that these type of activities and constant feedback showed the students the community aspect of the visual analytics world.

Finally, for the long term project, students were task to find a real user, with real data and a real problem. The instructors made a call for projects among their contacts and collected a list of about 20 possible projects from which student's selected their final project. This real user played a fundamental role as an expert in the project, giving students a taste of what it is to work with a real person with a problem, and that commonly doesn't have skills of the theoretical concepts given in the classroom. This idea was inspired in part by the information visualization classes of Dr. Ben Shneiderman at the University of Maryland, were one of the instructors pursued his PhD. The project was divided in four deliverables, which gave students significant feedback and allowed them to pivot if necessary. As mentioned in the previous sections all the materials were made available, and the experts were asked to help grading the students' projects on their capacity to generate insights. The final projects were showcased in a section of the class home page, and are since then, been public with a video demonstration, a short paper and a full deployed demo with real data (even if it is anonymized).

We are convinced that the constant feedback on the three different rhythms encouraged students to keep up with the pace of the class, while also learning the valuable lesson that visual analytics is a concept that needs to be learned in the context of the global community. Moreover the requirement of using real world problems with real users that care about them, seems like a perfect way of measuring the acquired skills while given students valuable field experience. We believe that this good practice could also be of great benefit to the community.

4   Effect of the good practices on the students

As a post course activity, we conducted a survey to explore the students' perception on the effect of the good practices described in this section to their learning process. The survey included ten questions, targeting the concepts used on each of the good practices. The questions asked were:

Q1. Each class sessions was divided in two 1.5 hours sections, one in the classroom and the second one in the lab. How useful do you think this division was for your learning process compared to your experience?

Q2. Each class session included an introduction reviewing and one take home message. How useful do you think these two were for your learning process compared to your experience?

Q3. During class concepts were presented in modules that included a theory description and an applied example (that could be code based or not). How useful do you think they were for your learning process compared to your experience?

Q4. During class Slack was used as a backchannel for sharing examples and for allowing students conversations. How useful do you think it was for your learning process compared to your experience?

Q5. Class materials were presented using web-based slides with interactive and modifiable demonstrations. How useful do you think it was for your learning process compared to your experience?

Q6. Class projects were conducted using a real world client as an advisor and co-evaluator. How useful do you think it was for your learning process compared to your experience?

Q7. The class was conducted with three learning rhythms: short term class concepts, two medium term short projects, and one longer term final project. How useful do you think it was for your learning process compared to your experience?

Q8. Slack (off class) was used as the main communication channel for questions and comments. How useful do you think it was for your learning process compared to your experience?

Q9. The class enforced the use of public web demos, videos and Github code sharing (open source). How useful do you think it was for your learning process compared to your experience?

Q10. The class page featured a public facing projects page showcasing students work. How useful do you think it was for your learning process compared to your experience?
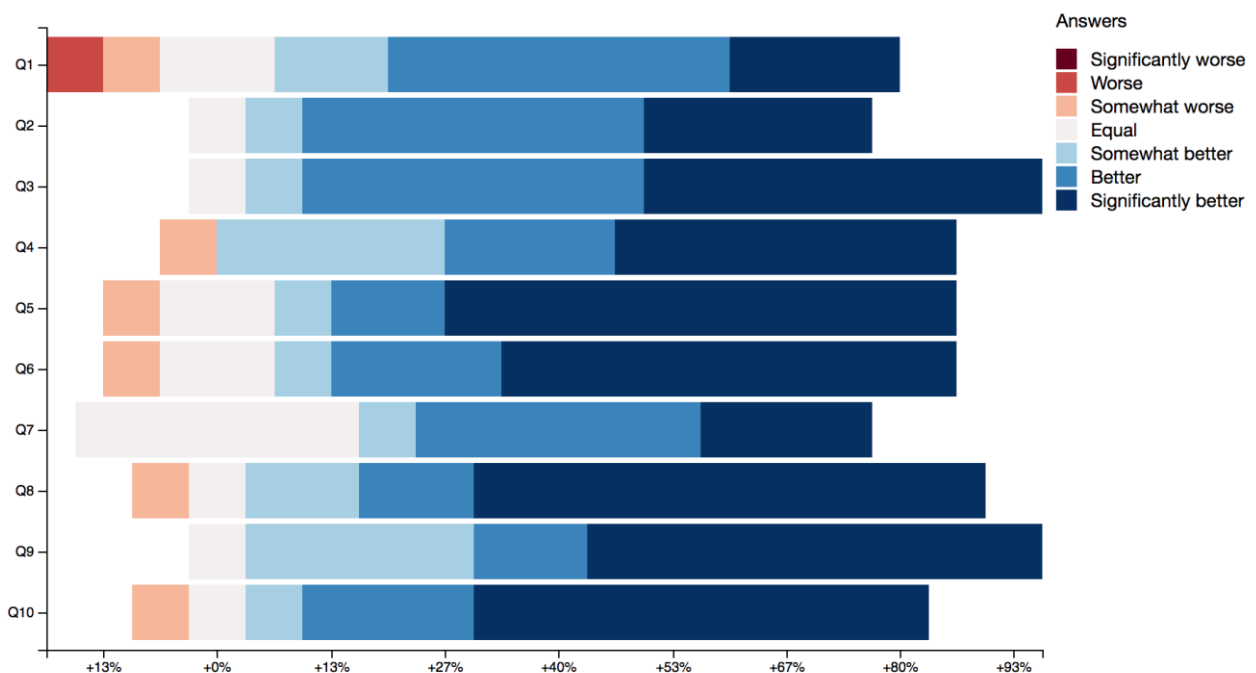

Figure 6 Students' survey results

This survey was answered by 15 students (10 Graduate students and 5 senior undergraduates). As observed in Figure 6 the most positive student perceptions were towards GP2 (Web-based and interactive Class materials) (Q2,Q3,Q5), and GP3 (Web visibility, project exposure) (Q6,Q9,Q10).

We found interesting that GP1 and GP4, related with the sections of one session and different timings in the course activities (Q1, Q7), and received a more distributed answers nevertheless positives. We found that these two good practices were less evident for students in the quotidian activity. In other hand, the use of asyncronic, informal communication channel (Slack) in and out of classroom (Q4, Q8) was positively perceived by students.

Overall, the survey's results corroborated our belief that the good practices identified during the class were perceived as beneficial for the learning process of students by themselves. Moreover, it showed us some points to enhance our course in next fall term.

5 Conclusions

We have presented a set of four good practices extracted as the result of an international collaboration to design a visual analytics. Although these practices alone weren't completely novel on their own, they showed to be beneficial during our class when used as a whole, as suggested by our survey results and personal experience. We believe that these practices could be replicated by the community on similar scenarios, and therefore shared them on this paper.

Based on our experience during this collaboration, we will be continuing on improving our course design to iterate and enhanced the good practices identified. We found of special interest the added value of interactive web-tools during the sessions, and the different project-based activities in the course. In the same note, we believe that the client-driven projects and the visibility of course activities were key success factors.

6 Acknowledges

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