ChartMaster: A Tool for Promoting Financial Inclusion of Novice Investors

Hong Zou[1(✉)] and Sambhavi Chandrashekar[2]

[1] CIBC Investor Services Inc., Toronto, ON, Canada
`birdswimming@gmail.com`
[2] OCAD University, Toronto, ON, Canada
`schandrashekar@faculty.ocadu.ca`

Abstract. ChartMaster is a digital tool developed by Hong Zou in 2015, through co-design with visually impaired screen reader users, to improve the accessibility and usability of interactive stock market charts. The first ChartMaster usability study, conducted with screen reader users, demonstrated that the tool not only helped them access data points quicker and easier, but also proved to be "educational." The next usability study, conducted with sighted novice investors to examine ChartMaster's educational value, is described in this paper. Novice investors found it easier to discover features, learn action possibilities and locate specific data through ChartMaster than through direct interaction with stock market charts. Several of their experiences, such as finding the summary feature helpful in understanding the chart, were similar to those reported previously by visually impaired screen reader users, suggesting comparable cognitive and emotional barriers to financial literacy for both groups. Improvements to Chart-Master were also suggested.

Keywords: Interactive stock market charts · Visually impaired · Screen reader users · Accessibility · Usability · Novice investors · ChartMaster · Educational tool · Inclusive design

1 Introduction

The stock market has grown dramatically in the last few decades. Capitalization of the world stock markets has more than doubled between 2008 and 2015, and the volume of share trading increased from US$88 trillion to US$114 trillion, during the same period [1]. Along with the growth of the stock market, the number of shareholders is rapidly increasing. Globally, the number of direct shareholders was approximately 382 million in 2009, and this number is steadily increasing [2]. Within this data set, there are an increasing number of self-directed investors who rely on their own research and judgment to make financial decisions without the involvement of a financial advisor. The majority of stock market investors, however, are novice investors who lack sufficient knowledge and skills, and might not be familiar with essential research tools, such as stock market charts [3].

On the other hand, continuous evolution and innovation of investment products has made the stock market and its research tools increasingly complex [4]. Online static charts have been replaced with interactive charts that enable investors to perceive, compare and analyze data points with merely a few clicks [5]. However, there is very little research published about the accessibility of these interactive charts to individuals with visual, cognitive or dexterity constraints or to those who lack adequate technological and financial knowledge and skill. Such individuals could well be missing critical financial information needed to make informed investment decisions confidently, and, as a consequence, be excluded from full participation in financial markets [6]. Failing to improve financial literacy, especially for socioeconomically disadvantaged subgroups, will not only have negative impacts in personal financial wellbeing, but also initiate a vicious cycle of poverty and economic inequality, both in wealth and in earnings [7]. Therefore, improving the accessibility and usability of financial research tools is essential to improve the financial outcomes for all those who choose to participate in financial investments.

During 2014–15, Hong Zou conducted a preliminary expert usability evaluation study of ten major financial news and research websites such as Google Finance and Bloomberg, which revealed significant access barriers for visually impaired users. Following this, she developed a digital tool called ChartMaster using Inclusive Design[1] principles through iterative co-design with visually impaired screen reader users to facilitate their effective use interactive online stock market charts. Results of a usability study showed that this tool not only helped screen reader users access data points quicker and easier, but also assisted them in looking for information that they might have overlooked due to lack of investment knowledge, thus proving to be an educational tool [8].

To examine the scope of the educational benefits of ChartMaster, a second study was conducted, this time with sighted novice investors, to assess its usability in promoting self-learning for interacting with and making sense of stock market charts. This paper presents details about the second study—providing a description of interactive stock market charts and the ChartMaster tool, outlining the methodology adopted for the study, presenting the results, and discussing the implications of significant findings, including a comparison with findings from the earlier study involving visually impaired screen reader users. Contributions and future work are indicated at the end.

2   Interactive Stock Market Charts

Developments in information technology, such as HTML5, scripting languages and the capability of pulling live market data, have caused a major shift in investor research behaviour. Technical analysis, or charting, has gained momentum since early 2000 and has become more popular today than ever [9]. Online interactive stock market charts present statistics generated by market activity, such as past prices and volume, and

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[1] Inclusive Design is designing for the full range of human diversity with respect to ability, language, culture, gender, age and other forms of human difference (www.idrc.ocadu.ca).

enable investors to observe the historical performance of a security and predict future price movements.

Generally, a stock market chart has the following five components:

1. A line graph on the top of the chart presenting the change in share prices
2. A bar graph at the bottom presenting the changes in the volume of shares traded
3. Options to define the time frame through which the chart will be rendered
4. Identifiers for events such as dividend, split, or quarterly financial report release
5. Functions to enable a comparison with other stocks or indices.

A typical stock market chart is presented in Fig. 1.

Fig. 1. A typical stock market chart (Resource: Google Finance)

Data visualizations, such as stock market charts and graphs, are ubiquitous sources of financial and investment information. In fact, technical analysis, one of the two major methods investors use to predict the future trend of a given stock, is primarily based on the study of stock market charts. Because stock market charts are so important when making investment decisions, this research focuses on developing ChartMaster as a tool to improve the accessibility of these infographics not only for screen-reader users but also for individuals with less comfort and skill in understanding how to use and analyze stock market charts.

2.1 ChartMaster

ChartMaster is a digital tool initially developed to make online interactive stock market chats more accessible and usable to visually impaired screen reader users. It employs a series of dropdown menus to enable users to obtain key data points from a stock market chart, such as price, volume and events (dividend payout or split) for one or multiple stocks. It was developed using HTML to generate the front-end interface and JavaScript to control the back-end data retrieval and calculation. ChartMaster works with the same data set used to generate the graph by storing it in a Java ArrayList.

By default, ChartMaster is displayed as a link, grouped with other commonly used stock chart tools and placed at the top of a stock market chart (See Fig. 2). Once activated, the tool is then expanded, pushing the chart down onto the page and enabling the user to obtain information by interacting with a series of dropdown menus. The dropdown menus are grouped into three categories: (1) information type; (2) time frame; and (3) specific data set. Once the user makes the required menu choices and activates the "Ask ChartMaster" button, the answer is displayed as a textual summary at the bottom of the dropdown menus. This text is also accessible to screen reader software for reading out aloud.
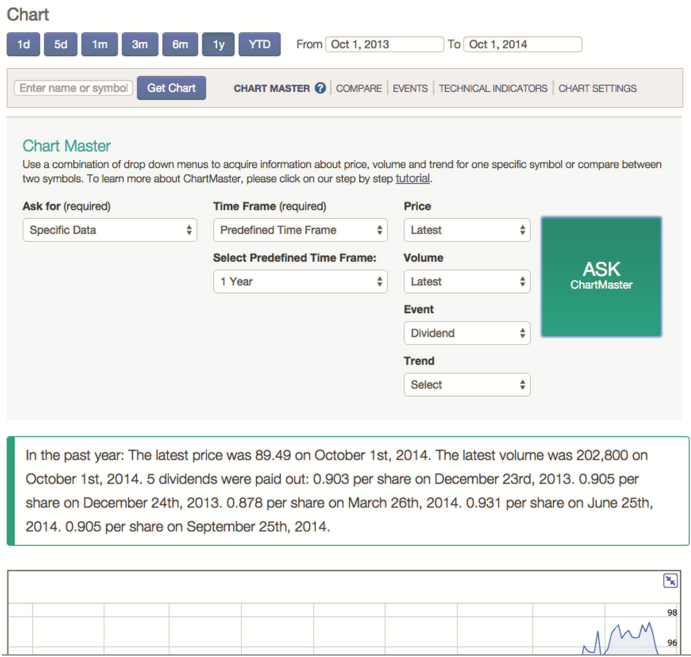

Fig. 2. A screenshot of ChartMaster

The answers are composed of three key components: (1) the data input by the user through the dropdown menus and associated text input fields, such as "6 months" and "average price," (2) the data pulled or generated by the system according to the data input by the user, and (3) a template (including the wording and punctuation marks) which arranges and presents all the data mentioned above in a meaningful and grammatically-correct way to the user.

The next section outlines the methodology adopted to test the usability of this tool for sighted novice users.

3   Methodology

Nine English-speaking adults familiar with the use of computer and the Internet, who were self-declared novice investors, not knowledgeable in the use of online financial charts, participated in the study. Within a broad framework of Human-Computer Interaction, this study involved usability testing sessions of direct interactions with stock market charts as well as interaction using the ChartMaster tool by the participants. Each session lasted one hour. Participants were paid $20 each as compensation. The sessions consisted of the following steps:

- Answering a short questionnaire about overall experience with charts, to establish a baseline.
- Interacting with three to four stock market charts from popular investment research sites—Yahoo finance, Google finance, Wall Street Journal and Bloomberg.
- Performing tasks with a stock market chart using the ChartMaster to assess discoverability, learnability and usability. The tasks involved finding answers to questions such as "what was the highest volume in the past month?" and "what is the return of the stock you bought on January 14, 2013?"
- Answering a quiz examining the connection between the investment knowledge of the participants and key metrics based on their task performance and questionnaire responses

Transcripts of session recordings and observational notes were analyzed using content analysis employing the framework of discoverability, learnability and usability, while being open to other useful insights and surprises.

4   Findings

4.1   Direct Interaction with Stock Market Charts

The study showed the participants facing significant barriers while interacting with stock market charts due to problems in discoverability, learnability, and usability. These barriers were due to design defects in the charts in the areas of *interactive design, visual design*, and *information design*. Unfamiliar terminologies and uncommon abbreviations on the charts, coupled with their lack of adequate investment knowledge, hampered discoverability, learnability and usability, leaving them overwhelmed. Overall, the experience with stock market charts was more negative than positive. The problems are described below.

Discoverability.   Key information such as legends not being incorporated in the chart, made users struggle to discover the chart's intended meaning(s), evoking remarks like, "I don't know what this whole chart is trying to tell me." Further, because relevant information was not grouped together, such as, for example "hover over" text was not physically placed near the mouse cursor, this defect made it more difficult for the participants to make a connection between the part of the chart that the mouse hovered over and the extra information about it provided elsewhere. System feedback was

inappropriate or absent. When participants hovered over an individual volume bar, the system provided no feedback to let participants know if that bar was in focus. In several other cases, the feedback was provided on the price chart instead of on the volume bar where participants' cursor was focused. Such a mismatch between the chart design and participants' mental model confused them when they were attempting to interpret the chart.

Learnability. The absence of contextual help and tutorials made it difficult for novice investors to learn more about using the charts, which discouraged them from exploring further. One participant said, "I can't figure out how this works. I don't know what they mean right away. It seems they are trying to attract people who are already in the market; someone that has experience."

Effectiveness and Efficiency. Although participants could understand that interactive stock market charts are designed to help them quickly grasp the overall trend through data visualization and acquire specific data points through interaction with the chart, they struggled to interpret it or interact with it. Tiny font size, fine chart graphics, and subtle contrast used in the charts resulted in most participants, regardless of their age, leaning close to the screen in order to be able to read the content on the page or place their mouse cursor at a particular point on the chart. Further, imprecise labels and unconventional formatting of information such as uncommon abbreviations and ambiguous date formats proved to be obstacles for novice investors to comprehend stock market charts.

Suggestions for Improvement. Participants made the following suggestions with respect to design of interactive charts:

- Add legend and axis labels
- Provide various level of help information to facilitate users' interaction and interpretation of the charts
- Use bigger graphs, which would be easy to target, and offer appropriate contextual feedback;
- Employ larger font size;
- Avoid using abbreviations.

4.2   Interaction Through ChartMaster

During their interactions with ChartMaster, participants expressed several positive feelings and remarks as well as provided suggestions for improvement. The same framework was used to examine data from these tasks.

Discoverability. It was easy for participants to locate important information and discover the key features of ChartMaster. All participants noticed and read the introduction paragraph first as it was placed on the very top of the tool. All drop down menus were also easily accessed as they were organized into columns according to their functionality. By clicking on each drop down menu, participants quickly discovered what

ChartMaster could do. "The drop down menus seem to be 'parameters' to find specific data," P5 remarked. Similarly, P3 remarked, "If I want to know the dividend, I just select Dividend." In addition, all participants discovered the call-to-action button, "Ask Chart-Master" and the textual summary generated once the button is clicked. "It looks like I can go straight and find the data instead of hovering over the chart. I don't need to even look at the chart. The information shows up right here," P1 said.

Learnability. It was apparent that the learning curve for ChartMaster was very smooth. Most of the participants immediately started to interact with it without seeking any assistance from the facilitator. To illustrate, one participant remarked, "Oh, this is… instead of having to hover, you just enter exactly what you want … the exact information you want."

Effectiveness and Efficiency. Participants found ChartMaster to be "useful" in terms of assisting them with acquiring specific data points relatively fast, such as finding the price and volume on a particular day; figuring out the return of the stock; and analyzing the chart by presenting a summary of the trend within a given time period. In addition, participants appreciated how efficient ChartMaster was in helping them complete these tasks. P6 said, "It is so much easier! Everything is accessible and detailed. Instead of looking at those tiny bars, you just select … here."

Suggestions for Improvement. Participants also gave some suggestions for improving the ChartMaster:

- Add connectivity between the textual summary and the chart; for example, high-lighting the sentence describing an uptrend in the textual summary while, at the same time, highlighting the segment of the chart that was referred to.
- Associate acceptable data format for input field directly with the labels (i.e., specific day).
- Provide error messages and/or error identification on the input boxes themselves when user fails to select required fields such as 'Ask for', or 'Time Frame'.
- "Flatten" the design by showing the two options for "Ask for" drop down menu upfront rather than burying them inside the menu.
- Provide customization and self-configuration options for the overall trend by providing only a high-level summary as a default and enabling user to see more detailed descriptions through further choices.
- Group the option "Return" under "Price" drop down menu instead of placing it under "Trend" so it aligns with novice users' mental model.
- Make labels more precise, intuitive, and easier to understand such that even novice investors might comprehend; for example, "stocks" instead of "symbols"
- Consider changing the name ChartMaster because it doesn't communicate the exact features the tool can provide to assist users to interact with stock market charts.

5   Discussion

One of the most surprising findings was that participants found the Trend Summary (the textual summary describing the trend of the chart) generated by ChartMaster to be "extremely useful". "The summary gives me an idea of how to understand the chart," P3 pointed out. This disproved wrong the researchers' initial expectation that sighted users might not be interested in the summary because they might get the information just by looking at the chart. While novice users were able to perceive the trend visually, they had difficulty interpreting it due to their low investment knowledge. As one participant pointed out, "Visually I can see that it is going up, but I don't know what that means." With the Trend Summary feature, novice users felt greater trust for ChartMaster as they did not need to analyze the chart "(because) the computer does that" for them and consequently they experienced less cognitive load. In addition, participants pointed out that even after they acquire the knowledge to interpret the trend, having a textual summary could still be beneficial as they "might be too tired to analyze it sometimes".

Participants also appreciated ChartMaster as a useful "add-on" tool to find specific data. In fact, in many cases, participants mentioned that they actually preferred to use ChartMaster to perform such tasks. Since a majority of the participants had mentioned in the pre-session questionnaire that they were "comfortable" dealing with charts in general, the researchers expected them to interact easily with stock market charts. Surprisingly, however, the study revealed that due to unfamiliarity with design conventions of stock market charts (i.e. hovering over to display additional information and press-and-drag to scroll through the chart), it became quite challenging for novice investors to complete tasks that seem very easy from the perspective of advanced online investors. This is because they do not possess sufficient knowledge to interact with the chart using various methods. In addition, some of the visual and interactive design defects, such as the use of small font and missing feedback also contribute to this preference. Furthermore, participants also realized that because "not everybody has the patience and time to go through the chart," the capability of providing specific data points through a series of drop down menu would likely reduce their stress level when interacting with the chart.

This study strengthened the hypothesis that ChartMaster is a useful "educational" resource for novice investors. Much like the visually impaired participants in the first study, the sighted participants in this study also thought that ChartMaster could be a handy tool to guide novice investors through its drop down menus in obtaining key information that investors need to acquire from charts. While both groups liked the textual summary, visually impaired users considered it merely "informative" as it communicated the data visualization using text format, while novice investors consider it an useful feature to learn how to interpret the chart. In short, novice investors recognized that visual representation is critical but the summary puts their mind in ease when they attempted to make sense of the chart.

In addition, the findings from the study point toward the likelihood that improving participants' investment knowledge by providing educational material might enhance their experience as well as improve their understanding, comfort and confidence while interacting with stock market chart. For example, the study showed that the two

participants who scored the highest in the post-session quiz (both of them got 88 % while the average is 68 %), were much less stressed when initially introduced to the stock market chart. They were able to explain the chart and find information quicker and easier than those who did poorly in the quiz. Most of the users exhibited awareness of the impact of this knowledge gap, and suggested that the next version of the ChartMaster should provide educational material to help users understand key investment terminology as well as methods of interpreting chart data. It is worth noting that both visually impaired participants as well as novice investor participants expressed this idea. Three levels of educational materials, as shown in Table 1, are planned for addition to ChartMaster's next version to provide contextual or just-in-time help to satisfy the needs of users with different knowledge levels and appetites for learning. These design enhancements echo the inclusive design implication that a variety of options need to be offered to cater to the self-knowledge and self-determination of a diversity of users [10].

Table 1. Three levels of educational materials that could be added to **ChartMaster**

	Tool tips	Glossary	Education Centre
Placement	Beside dropdown menu headers	A separate page	An section of a site
Access	Immediate access to information	Quick links or main navigation menu	Through main navigation menu
Scope	One definition	Multiple glossaries	Multiple topics
Features	Brief explanation	Short explanation	Detailed explanation
		Sorted categories	Organized categories
		Keyword search	Keyword search
Level	Novice	Intermediate	Advanced

6 Conclusion

Over the decades, worldwide interest in financial literacy and investor education has intensified. In response, this study examined whether ChartMaster, a tool originally developed for making stock market charts accessible to visually impaired screen reader users, could serve as an educational tool for novice investors.

From a human-computer interaction perspective, findings from this study expose the cognitive and emotional barriers that novice investors face while interacting with stock market charts. The study illustrates how novice investors, who lack investment knowledge and are unfamiliar with the stock market chart design conventions, are able to analyze the chart and acquire specific data with the assistance of ChartMaster. The study identified the usability gaps that can potentially be closed or reduced by offering users various educational components, both for ChartMaster and for current stock market charts. In addition, the study highlighted the importance of offering novice users preference to access information according to personal interests and needs; much the same as was discovered in the earlier study with visually impaired users. Through these findings, some components of the next inclusive design iteration of ChartMaster have

been derived to make it better fit the needs of a greater diversity of users. This will serve to expand the application of the tool to a much broader audience.

This study did not attempt to improvise on the information architecture of the earlier version of ChartMaster, such as the categorization of the different drop down menus and the data points included in each drop down menu. Further work is planned for investigating the adequacy of the current question set and modifying it if found necessary. Another area of future work would be to developing a mechanism to enable ChartMaster "pull" real-time live market data instead of just using historical data. It is also on the researchers' agenda to allow the system to automatically generate an accurate chart trend summary according to the nature of the stock.

The "curb cut" phenomenon in Inclusive Design holds that designing to address challenges faced by people in the margins spurs innovation, and Inclusive Design ultimately benefits everyone [11]. This idea will continue to inspire ChartMaster and related studies.

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