PART I. SYNTHESIS AND CHARACTERIZATION OF DONOR-π-ACCEPTOR COMPOUNDS WITH PENTADIENYL-BRIDGED INDOLINE AND TETRAHYDROQUINOLINE DONORS AND ALDEHYDE AND THIOBARBITURIC ACID ACCEPTORS

PART II. LONGITUDINAL STUDY COMPARING ONLINE VERSUS FACE-TO-FACE COURSE DELIVERY IN INTRODUCTORY CHEMISTRY

by

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Patrick F. Greco

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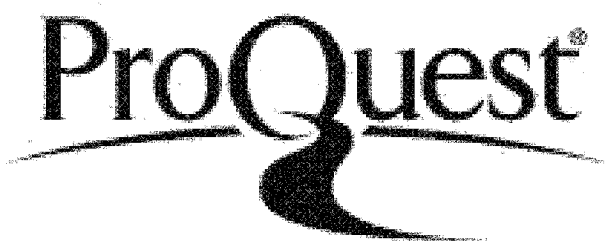

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ABSTRACT

PART I. SYNTHESIS AND CHARACTERIZATION OF DONOR-π-ACCEPTOR COMPOUNDS WITH PENTADIENYL-BRIDGED INDOLINE AND TETRAHYDROQUINOLINE DONORS AND ALDEHYDE AND THIOBARBITURIC ACID ACCEPTORS

PART II. LONGITUDINAL STUDY COMPARING ONLINE VERSUS FACE-TO-FACE COURSE DELIVERY IN INTRODUCTORY CHEMISTRY

Patrick F. Greco

Part I. The design and development of organic second-order nonlinear optical (NLO) materials have attracted much interest due to their applications in optoelectronic devices and modern communications technology. Donor-π-acceptor compounds, D-(CH=CH)$_n$-A, often exhibit hyperpolarizability that results in laser frequency doubling (second harmonic generation) and spectroscopic solvatochromism. To study the effect of donor amine geometry upon properties associated with second-order NLO behavior in simple donor-π-acceptor compounds, equilibrium geometries and hyperpolarizabilities (β) for donor-acceptor polyenes with amine donors were calculated at several levels of computational theory. Two new molecules with donors that only differ by one methylene group were chosen for comparison. Thus, 5-(N-methylindolin-5-yl)-2, 4-pentadienal (**1a**) and 5-(N-methyl-2, 3, 4-trihyrdroquinolin-6-yl)-2, 4-pentadienal

(**2a**) were synthesized in two steps from starting materials described in the literature. These aldehydes were converted into stronger acceptors in one step to give diethylthiobarbituric acid derivatives **1c** and **2c**, as well as tricyanofuran derivatives **1d** and **2d**. Positive UV solvatochromism was observed in all three derivatives. NMR solvatochromism was most pronounced in **1c** and **2c** vs. **1a** and **2a** as measured by changes in chemical shifts. Additionally, coupling constants showed more conjugation in **1c** and **2c**, where **1a** and **2a** showed less conjugation. Finally, differential scanning calorimetry and thermal gravimetric analysis were used to compare decomposition and melting temperatures of these compounds to determine their stability. Aldehydes, **1a** and **2a** had distinct melting points, while the **1c**, **2c**, **1d**, and **2d** derivatives decomposed at temperatures above 150 °C.

Part II. This longitudinal study focused on an introductory chemistry course taught using two different modes of delivery: online and face-to-face (FtF). The sections of the course using the different delivery modes covered the same material at the same level, used the same textbook, and were taught by the same instructor. Student success was tracked over a period of nine consecutive years along with other important dependent variables including the number of developmental courses taken, student age, math and reading placement scores, overall GPA and full time status. Surprisingly, student success correlated negatively to their placement scores.

The students who chose the online course had higher overall GPA's and better placement test scores than the FtF students. Despite these advantages, online students were less successful than their FtF counterparts. This result suggests that FtF instruction was more effective, even with better students. These findings have important implications for institutions evaluating the role online instruction will play at their institutions.

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PART I. SYNTHESIS AND CHARACTERIZATION OF DONOR-π-ACCEPTOR COMPOUNDS WITH PENTADIENYL-BRIDGED INDOLINE AND TETRAHYDROQUINOLINE DONORS AND ALDEHYDE AND THIOBARBITURIC ACID ACCEPTORS

CHAPTER 1

INTRODUCTION

For the last several decades, non-linear optical (NLO) materials have generated considerable interest and study due to their applications in telecommunications, electronic switching and laser frequency doubling (Prasad, 1991). Materials that exhibit NLO properties are based on experimental molecules designed to change according to the intensity of the light passing through the material. These materials have great potential for overcoming problems with current fiber optic networks, mostly through eliminating current electric networks and enabling networks which are solely fiber optic (Ma, 2003). Different orders of nonlinear optical properties refer to the amount light can affect a response from the material. Due to their chemical flexibility organic materials have emerged with increasing interest. In addition, organic NLO materials possess a high degree of optical non-linearity in comparison to their inorganic counterparts. Organic donor-acceptor polyenes with amine donors and acceptors coupled through conjugated systems are of special interest in the study of second-order structure-property relationships and nonlinear optical behavior (Kwon, 2005). Moreover, these compounds are of interest for dye sensitized solar cells (Chen, 2007).

Hyperpolarizability can be measured in solution using e-FISH calculations based on the Taylor series, $\mu = \mu^\circ + \alpha E + \beta E^2 + \gamma E^3 + ...$,where μ° is the static dipole, E is the applied electric field, α is the linear polarization, and β is the second order polarization or hyperpolarization. Large β values indicate strong NLO behavior in molecules.

Classic molecules with large β are composed of π electron donors and π electron acceptors separated by a conjugated π system (D-π-A), usually a polyene. Effective interaction between the donor and acceptor regions results in a number of measurable properties. One such property is bond length alternation (BLA), or the average difference between single and double bond lengths in the molecule. The maximum value of BLA (0.11 Å) is obtained for fully alternating single (1.45 Å) and double (1.34 Å) bonds. BLA values can be determined from x-ray crystallographic data (Marder, 1994), or estimated from the difference in NMR coupling constants (ΔJ) for protons interacting on double and single bonds (Blanchard-Desce, 1997).

Other measurements of electronic interactions in D-π-A compounds include solvatochromism of the intermolecular charge transfer (ICT) band. A bathochromic shift (positive solvatochromism) of the intramolecular charge transfer (ICT) transition is observed and correlates with a large hyperpolarizability β (Blanchard-Desce, 1997). In general, longer π systems have larger values of β (Marder, 1994). In this study we limit the polyene length to a diene (n=2). The advantages of this bond length are ease of synthesis, and the absence of molecular twisting due to steric interactions between the donor and acceptor that decreases conjugation in shorter polyenes.

CHAPTER II

MATERIALS AND METHODS

To study the effect of the donor group on the stability and conjugation in donor-acceptor polyene dyes, two new molecules have been synthesized: 5-(N-methylindolin-5-yl)-2, 4-pentadienal (**1a**), and 5-(N-methyl-2, 3, 4-trihyrdroquinolin-6-yl)-2, 4-pentadienal (**2a**). Due to their similar structure and properties, **3a** and **4a** were used for comparison with the synthesized compounds.

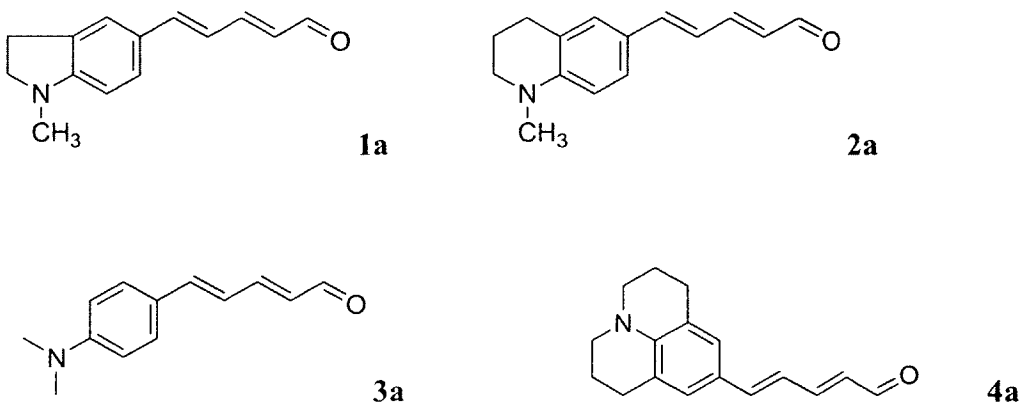


Figure 1. Structures of synthesized compounds **1a**, **2a**, and known compounds **3a** and **4a.**

The same three-step procedure was used to make both compounds, based on a modification of literature procedures for individual steps (Figure 2). Following the method of (Mohri, 1995), indoline (**11a**) and tetrahydroquinoline (**12a**) were first methylated using potassium hydride and iodomethane to form **11b** and **12b.** Next, a selective electrophilic aromatic bromination method using N-bromosuccinimide

(Katayama, 1984) was performed to give primarily para-brominated products **13** and **14**, which were purified by column chromatography using silica gel and 10% ethyl acetate in hexanes as eluent. Finally, lithium-halogen exchange was performed on **13** and **14**, followed by nucleophilic addition to N, N-diethylaminopentadienal (**17**), resulting in dark red solids **1a** and **2a**, respectively. The final products were purified with column chromatography using 20% ethyl acetate in hexanes to give 54% of **1a** and 52% of **2a**. The final products were purified by recrystallization and characterized by NMR, IR, HRMS, and melting point.

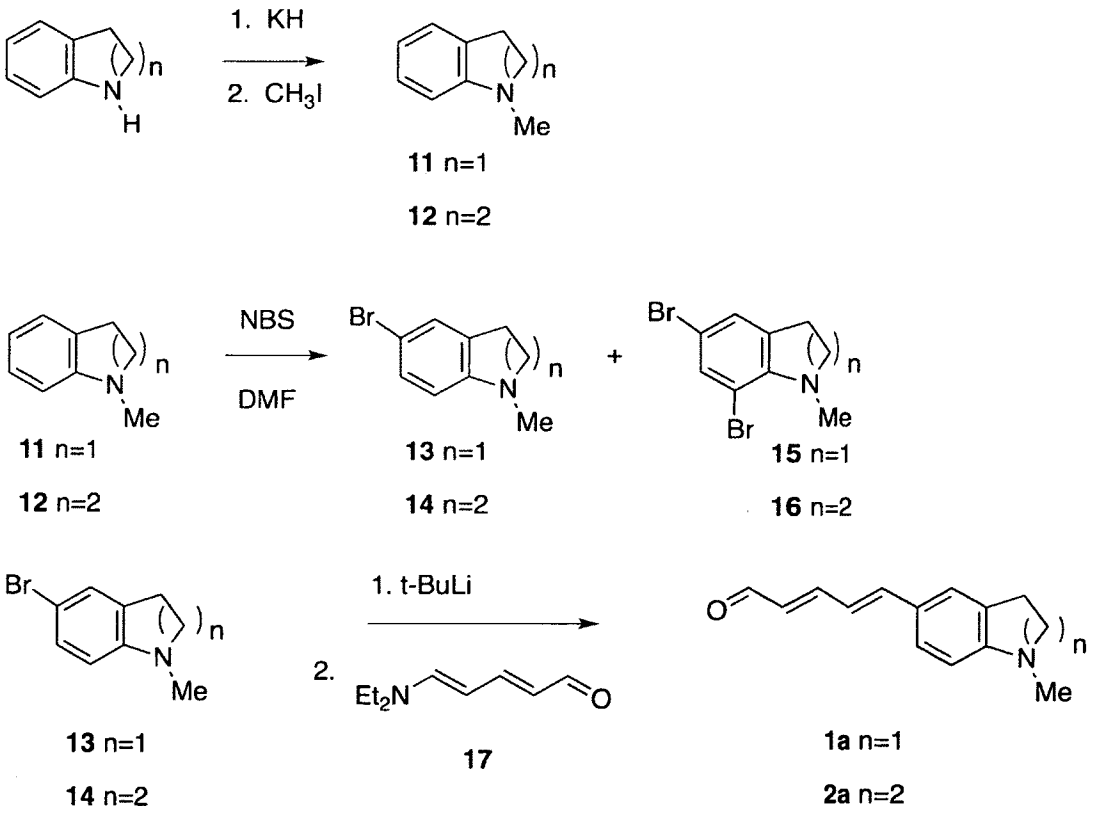


Figure 2. Three step synthesis of indoline and tetrahydroquinoline donors.

In order to compare the electronic structures of tetrahydroquinolinyl and indolinyl polyenes, **1a**, **2a**, and **3a** (available commercially) were converted into donor-acceptor polyenes using two strong acceptors, 2-dicyanomethylene-3-cyano-4,5,5-trimethyl-2,5-dihydrofuran (TCF) and N, N-diethyl thiobarbituric acid (TB) via Knoevenagel condensations (Figure 3). The condensations with TB were particularly convenient. Donors **1a** – **3a**, as well as TB, were readily soluble in warm ethanol, yet products **1c-3c** were barely soluble. Catalytic piperidine was used to obtain a nearly quantitative yield of **1c** – **3c** after heating for 15 min, but the reaction also worked without added catalyst. Derivatives of **1a** – **3a** with TCF formed more slowly, were less soluble in ethanol than TB derivatives, and piperdine catalyst was required. Precipitates **1c, 2c, 3c, 1d, 2d,** and **3d** were easily isolated by filtration and air drying.

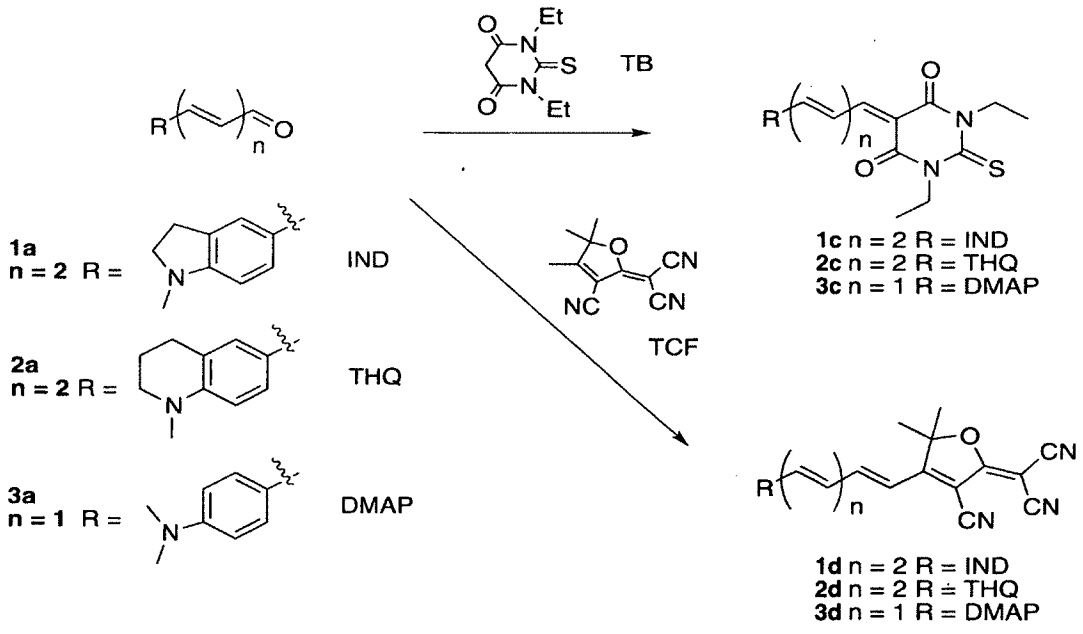


Figure 3. Synthesis of TB and TCF derivatives, **1c-3c**, and **1d-3d.**

Instruments, Materials and Reagents

Potassium hydride, methyl iodide, N-bromosuccinimide (NBS), dimethylsulfoxide (DMF), *t*-butyl lithium, tetrahydrofuran (THF), and N, N-diethylthiobarbituric acid were purchased from Sigma-Aldrich Chemical (Milwaukee, WI) and used as received. Additional solvents anhydrous diethyl ether, anhydrous ethanol, ethyl acetate, chloroform, and hexanes were purchased from Fisher Scientific, (Pittsburg, PA).

2-Dicyanomethylene-3-cyano-4, 5,5-trimethyl-2,5-dihydrofuran (TCF) (Gopalan, 2004) and N, N-dimethylaminopentadienal (Becher, 1980) were synthesized according to literature procedures. Solvents used for solvatochromic studies were anhydrous HPLC grade and purchased from Sigma-Aldrich or Fischer.

Thermal Analysis

Melting and decomposition temperatures were obtained using differential scanning calorimetry (DSC) Differential scanning calorimetry was run on a TA Instruments DSC 2920 ramping between 25 °C and 250 °C at a rate of 10°C per minute. DSC temperatures were chosen based on melting point observation using a Mel-Temp capillary melting point apparatus purchased through Cole Palmer (Dubuque, IA)..

UV Spectroscopy

Ultraviolet-visible spectra were run on an Agilent Technologies Diode Array Spectrophotometer from 400 nm to 800 nm at absorbance of 0.4 - 0.8 using acetone, acetonitrile, cyclohexane, carbon tetrachloride, diethyl ether, 1,4-dioxane, DMF, DMSO, ethyl acetate, ethanol, methylene chloride (CH_2Cl_2), nitromethane, pyridine, toluene, and

trifluoroethanol. Beer's Law plots to obtain ε for new compounds were made using solutions in $CHCl_3$ at three concentrations in the absorbance range of 0.30-0.70.

NMR Spectroscopy

Nuclear magnetic resonance spectra were either run on a JEOL EMX 500 MHz or JEOL EM 300 MHz NMR in DMSO-d_6, acetone-d_6, chloroform-d, and acetonitrile- d_3. Deuterated solvents were 99.9% pure and purchased from Cambridge Isotopes (Andover, MD) or Sigma-Aldrich (Milwaukee, WI).

Calculations

All semi-empirical calculations using the AM1 method and quantum-mechanical calculations using Hartree Fock 6-31G(d) and B3LYP/6-31G(d,p) methods were carried out within the Spartan 4.1 program (Wavefunction, Inc, Irvine, CA). Geometry optimizations were undertaken using extended convergence limits using keyword OPTICYCLE=300 and MAXCYCLE=300. Equilibrium geometries were calculated using B3LYP/6-31G(d,p) and solvent-dependent values for λ_{max} and hyperpolarizability β were calculated using ZINDO in the Cerius 2 (Version 3.5) program (Molecular Sciences, Inc., City of Industry, CA). Default conditions were used except that the refractive indices and dielectric constants were entered for each solvent.

Synthetic Methods

General Procedure for N-Methylation. According to the method of Mohri (Mohri, 1995), a dispersion of potassium hydride (35% in mineral oil, 1.1 eq) was suspended in dimethyl ether (40 mL/mmol indoline) and cooled to 0 °C. the heterocyclic amine (1.0 eq) and triethylamine (10.0 eq) were added dropwise via addition funnel over 15 min and stirred for 30 min. Iodomethane (1.1 eq) was then added dropwise, the

reaction mixture was warmed to room temperature, and stirring was continued overnight. Saturated NH_4Cl was added and the mixture was made basic using a 5% NaOH solution. The product was extracted with CH_2Cl_2 and dried over $MgSO_4$. Solvents were removed under reduced pressure, and vacuum distillation afforded pure N-methyl amine.

N-Methyl indoline (11). Yield: 95%, bp 55 °C, 0.25 torr; ^{1}H NMR δ 2.73 (s, 3H), 2.91 (t, J=8.1 Hz, 2H), 3.26 (t, J=8.1 Hz, 2H), 6.51 (d, J= 8.3 Hz, 1H), 6.66 (t, J=7.3 Hz, 1H), 7.05-7.11 (m, center at 7.07, 2H); ^{13}C NMR δ 28.7, 36.1, 56.0, 107.1, 117.7, 124.2, 127.2, 130.2, 153.3; MS *m/z* 133 (M, 77), 132 (M-1, 100), 117 (8), 91 (16), 77 (10).

N-Methyl tetrahydroquinoline (12). Yield: 79%, bp 86 °C (0.25 torr). ^{1}H NMR δ 1.95-2.00 (m, center at 1.98, 2H), 2.76 (t, J=6.6 Hz, 2H), 2.88 (s, 3H), 3.21 (t, J=5.7 Hz, 2H), 6.59 (d, J= 8.0 Hz, 1H), 6.60 (td, J= 7.7, 1.1 Hz, 1H), 6.95 (dd, J=7.4, 1.2 Hz, 1H), 7.07 (td, J=7.8, 1.8 Hz, 1H); ^{13}C NMR δ 22.4, 27.7, 39.0, 51.2, 110.9, 116.1, 122.8, 126.9, 128.7, 146.6; IR cm^{-1} 2935, 1602, 1503, 740; MS *m/z* 147 (M, 76), 146 (M-1, 100), 131 (30), 130, (25), 118 (22), 117 (20), 91 (18), 77 (18).

General Bromination Method for N-Methylated Aromatic Amines Using N-Bromosuccinimide (NBS) (Katayama, 1984). The heterocyclic amine (1.0 molar eq) was dissolved in dry DMF (1.0 mL / mmol) and NBS (1.1 eq in 1.0 mL / mmol) was added over 1 h via an addition funnel. The reaction was allowed to stir for 2 h at 0 °C or until TLC showed that the starting material was absent. The reaction mixture was poured into four volumes of water and made basic with Na_2CO_3. The organic layer was extracted with ether three times, washed with water, then washed with brine. The ether layer was dried over Na_2SO_4, then the solvent was removed using vacuum to give a brown oil. The

oil was purified by filtration down a short silica plug using 20% ethyl acetate in hexanes to give a clear oil.

5-Bromo-1-methylindoline (13). N-Methylindoline (**11**, 1.20 g, 9.0 mmol) was dissolved in DMF (10 mL) in a 50 mL round bottom flask under argon. NBS (1.70 g, 9.5 mmol) in DMF (10 mL) was added dropwise over 2 h via a pressure-equalizing addition funnel. The reaction was stirred for 2 h at 0 °C, worked up following the procedure in the general method above, then the solvent was removed under vacuum to give a brownish oil (with $R_f = 0.70$ and 0.75). After purification through a silica plug using 20% ethyl acetate in hexanes eluent, a clear oil (1.01 g) was obtained. Yield: 53%. The primary component had: ^{1}H NMR δ 2.75 (s, 3H), 2.94 (t, J=8.6 Hz, 2H), 3.28 (t, J=8.6 Hz, 2H), 6.42 (d, J= 8.5 Hz, 1H), 6.67 (s, 1H), 7.08-7.06 (m, max at 7.08, 1H); ^{13}C NMR δ 27.6, 39.0, 51.0, 107.6, 112.3, 124.8, 129.5, 131.0,145.6; MS *m/z* 213 (M+2, 42), 211 (M, 48), 131 (100), 130 (25), 117 (8), 89 (10), 77 (10).

6-Bromo-1-methyl-1,2,3,4-tetrahydroquinoline (14). A solution of NBS (1.54 g, 8.65 mmol) in DMF (10 mL) was added to a solution of N-methyltetrahydroquinoline (1.08 g, 7.35 mmol) in DMF (13 mL) over 2 h via a pressure-equalizing addition funnel attached to a 50 mL flask. The reaction was stirred for 2 h at 0 °C, worked up following the procedure in the general method above, then the solvent was removed under vacuum to give a brownish oil (1.94 g, 86%). The oil was purified by filtration down a short silica plug using 20% ethyl acetate in hexanes ($R_f = 0.57$) to give a clear oil (1.09 g). Yield: 48.4%; ^{1}H NMR δ 1.92-1.96 (m, max at 1.94, 2H), 2.72 (t, J=6.6 Hz, 2H), 2.85 (s, 3H), 3.20 (t, J=5.8 Hz, 2H), 6.41 (d, J=8.6 Hz, 1H), 7.08 (d J=2.3 Hz, 1H), 7.12 (dd, J=8.9, 2.6

Hz, 1H); ^{13}C NMR δ 22.1, 27.6, 39.0, 51.0, 107.6, 112.3, 124.8, 129.5, 131.0, 145.6; IR cm^{-1} 2942, 1593, 1501, 1323, 1207, 797; MS *m/z* 227(M+2 96), 226(M+1, 87), 225(M, 100), 224(M-1, 83), 146(10), 145(26), 144(65), 131(32), 130(33), 117(7), 103(9), 89(9), 77(11).

6,8-Dibromo-1-methyl-1,2,3,4-tetrahydroquinoline (16). ^{1}H NMR δ 1.92-1.96 (m, max at 1.94, 2H), 2.77 (t, J=6.6 Hz, 2H), 2.84 (s, 3H), 3.18 (t, J=5.5 Hz, 2H), 7.34 (d, J=2.3 Hz, 1H) 7.50 (d, J=2.3 Hz, 1H); MS *m/z* 307 (M+4), 306 (M+3), 305 (M+2, 100), 304 (M+1), 303 (M), 302 (M-1), 211 (M-Br-Me), 209 (M-Br-Me), 144 (M-2Br), 144(M-Br-1), 130, 117, 89.

General Procedure for Synthesis of Aromatic Pentadienals (Friedli, 1997). The aromatic bromide (1.1 eq) was dissolved in dry THF and cooled to -78 °C. *t*-Butyllithium (2.2 mol eq, 1.7 M in hexanes) was added dropwise under argon and the solution was allowed to warm to room temperature for 1 h, then recooled to -78 °C. N,N-Diethyl penta-2,4-dienal (**17**, 1 mol eq) was dissolved in THF and added dropwise. The mixture was stirred for 1 h and was allowed to warm to room temperature for 30 min or until TLC with 20% ethyl acetate in hexanes showed the reaction was complete. The solution was poured into 1M HCl, shaken, and the resulting red solution was brought to à pH of 10 with 10% NaOH. The product was extracted with ethyl ether and dried over sodium sulfate. The product was purified using flash chromatography TLC with 20% ethyl acetate in hexanes.

5-(4-N-Methyl indolinyl)-penta-2,4-dienal (1a). Compound **13** (400 mg, 1.9 mmol) was dissolved in *t*-butyl methyl ether (15 mL) under argon and cooled to -78 °C. *t*-

Butyllithium (2.5 mL, 4.18 mmol, 1.7 M in hexanes) was added dropwise under argon and the solution was allowed to warm to room temperature for 1 h, then recooled to -78 °C. N,N-Diethyl penta-2,4-dienal (262 mg, 1.7 mmol) was dissolved in *t*-butyl methyl ether (10 mL) and added dropwise. The mixture was stirred for 1 h and allowed to warm to room temperature for 30 min. The reaction was worked up as described in the general procedure above. After a flash column using 20% ethyl acetate in hexanes, 128 mg of a red crystalline product ($R_f = 0.3$) was obtained. Yield: 56%; mp. 91.53 °C (with dec.).; ^{1}H NMR δ $CDCl_3$ 2.88 (t, J=6.6 Hz, 2H), 3.07 (s, 3H), 3.44 (t, J=5.8 Hz, 2H), 6.14 (dd, J=14.9, 8.0 Hz), 6.51 (d, J= 8.6 Hz, 1H), 6.77 (dd, J=15.5, 10.9 Hz, 1H), 6.88 (d, J=15.4 Hz, 1H), 7.29 (s, 1H), 7.38 (d, 2.3 Hz, 1H), 7.39 (dd, J=14.7, 11.2 Hz, 1H), 9.52 (d, J=8.6 Hz, 1H); ^{13}C NMR $CDCl_3$ δ 28.6, 35.2, 56.0, 106.9, 122.1, 123.9, 126.1, 129.6, 130.5, 132.2, 144.8, 154.9, 156.0, 194.3; IR 1661 (C=O), 1589 (C=C) cm^{-1}; λ_{max}= 418 nm (log ε = 4.41); HRMS Calculated for $C_{15}H_{17}NO$: 213.1154

N-Methyl tetrahydroquinolinyl 6-penta-2,4-dienal (2a). Compound **14** (226 mg, 1.00 mmol,) was dissolved in *t*-butyl methyl ether (10 mL) under argon and cooled to -78 °C. *t*-Butyllithium (1.3 mL, 2.2 mol eq, 1.7 M in hexanes) was added dropwise under argon and the solution was allowed to warm to room temperature for 1 h, then recooled to -78 °C. N,N-Diethyl penta-2,4-dienal (154 g, 1.0 mol) was dissolved in *t*-butyl methyl ether (10 mL) and added dropwise. The solution worked up as described in the general procedure. After a flash column using 20% ethyl acetate in hexanes, a red crystalline product (101 mg) with $R_f = 0.38$ was obtained. Yield: 53%; mp. 78.05 °C (with dec.); ^{1}H NMR δ $CDCl_3$ 1.94-1.99 (m, max at 1.96, 2H), 2.82 (s, 3H), 2.99 (t, J=8.3 Hz, 2H), 3.44

(t, J=8.4 Hz, 2H), 6.16 (dd, J=15.0, 8.1 Hz), 6.38 (d, J= 7.9 Hz, 1H), 6.79 (dd, J=15.4, 10.9 Hz, 1H); 6.93 (d, J= 15.1 Hz, 1H), 7.22 (dd, J=14.7, 11.2 Hz, 1H), 7.20 (d, J=2.3 Hz, 1H), 9.52 (d, J=8.6 Hz, 1H); ^{13}C NMR $CDCl_3$ δ 21.9, 27.7, 38.8, 56.0, 110.3, 121.0, 122.7, 123.4, 128.0, 128.5, 143.9, 147.9, 154.1, 193.6; IR cm^{-1} 2931, 2837, 1665 (C=O), 1583, 1519, 1321, 1148, 1122, 983; λ_{max}= 430 nm (log ε = 4.55); HRMS Calculated for $C_{15}H_{17}NO$: 227.1310; Observed: 227.1363.

General Procedure for Knoevenagel Condensation of Aldehydes with N,N-Diethyl thiobarbituric acid (Friedli, 1997). The aldehyde (1.0 mol eq), and N,N-diethylthiobarbituric acid (**18**, 1.0 mol eq) were dissolved separately in anhydrous ethanol (total of 3 mL) and heated to a gentle boil in an Erlenmeyer flask. The mixture was stirred for 30 min until no aldehyde remained by TLC (20% ethyl acetate in hexanes). The solution was cooled to room temperature, vacuum filtered using a Hirsch funnel, and air-dried.

(2*E*, 4*E*)-(5-(4-N-Methyl indolinyl)-penta-2,4,6-trienyl)-thiobarbituric acid (1c). Yield: 62 %; ^{1}H NMR δ 1.29, 1.30 (t, J=7.3 Hz, 3H), 1.99, 1.97 (q, J= 5.7 Hz, 2H), 2.76 (t, J=6.3 Hz, 2H), 2.87 (s, 3H), 3.53 (t, J=8.3 Hz, 2H), 3.03 (t, J=8.3 Hz, 2H), 4.54, 4.55 (q, J=6.9 Hz, 4H), 6.37 (d, J=8.6 Hz, 1H), 6.94 (dd, J=11.5, 14.9 Hz, 1H), 7.05 (d, J=8.6 Hz, 1H), 7.23 (d, J=11.4 Hz, 1H), 7.28 (s, 1H), 8.02 (app t, J=13.2 Hz, 1H), 8.11 (d, J=12.6 Hz, 1H); ^{13}CNMR δ 12.4, 12.5, 27.7, 34.3, 43.1, 43.6, 54.9, 105.8, 155.7, 147.9, 131.8, 131.2, 127.1, 125.2, 123.7, 123.5, 111.1, 158.4, 159.0, 160.1,161.1, 178.8; λ_{max} ($CHCl_3$) 630 nm; HRMS calculated for: $C_{22}H_{26}N_3O_2S$, 396.1740; Observed: 396.1755.

(2*E*, 4*E*)-5-(1-Methyl-1,2,3,4-tetrahydroquinolin-6-yl)penta-2,4-dienyl thiobarbituric acid (2c) Yield: 55%; ^{1}H NMR ($CDCl_3$) δ 1.28, 1.30 (t, 7.4, 3H), 1.99, 1.97 (q, J= 5.7 Hz, 2H), 2.76 (t, J=6.3 Hz, 2H), 3.00 (s, 3H), 3.37 (t, J=5.7 Hz, 2H), 4.56 (q, J=6.9 Hz, 2H), 6.53 (d, J=8.6 Hz, 1H), 6.94 (dd, J=14.9, 11.5 Hz, 1H), 7.03 (d, J=14.9 Hz, 1H), 7.16 (s, 1H), 7.27 (dd, J= 8.6, 2.3 Hz, 1H), 7.33 (dd, J=13.7, 10.9 Hz, 1 H), 8.02 (app t, J=13.2, 1H), 8.11 (d, J=12.6 Hz, 1H); ^{13}C NMR ($CDCl_3$) δ 12.4, 12.5, 21.7, 27.7, 38.8, 43.0, 43.5, 51.3, 110.5, 111.0, 122.9, 123.5, 127.1, 129.1, 129.6, 147.8, 149.0, 158.3, 159.0, 160.0, 178.8; λ_{max} ($CHCl_3$) 654 nm; HRMS Calculated for: $C_{23}H_{27}N_3O_2S$, 409.1824; Observed: 409.2023.

General Procedure for Knoevenagel Condensation of Aldehydes with 2-dicyanomethylene-3-cyano-4,5,5-trimethyl-2,5-dihydrofuran (Gopalan, 2004). The aldehyde (1.0 mol eq), 2-cyano-3-dicyanomethylene-5,5-dimethyl-furan (**19**, 1.0 mol eq) and 4-methylpiperidine in ethanol (13 μL of a 1M solution) were combined in 10 mL of boiling ethanol. The solution was heated at reflux overnight, or until TLC demonstrated the disappearance of the aldehyde. The solution was allowed to cool, filtered under vacuum with a Hirsch funnel, and air-dried. The solution was then cooled to room temperature, vacuum filtered using a Hirsch funnel, and air-dried.

(1-(4-N-Methyl indolinyl)-hexa-2,4,6-trienyl)-2-cyano-3-dicyanomethylene-5,5-dimethyl-furan (1d). Yield: 66.5%; ^{1}H NMR (DMSO-d_6) δ 1.70 (s, 6H), 2.81 (s, 3H), 2.95 (t, J=8.3 Hz, 2H), 3.44 (t, J=8.6 Hz, 2H), 6.46 (d, J=8.1 Hz, 1H), 6.51 (d, J=14.9 Hz, 1H), 6.64 (dd, J=14.3, 11.5 Hz, 1 H), 7.00-6.94 (m, 2H), 7.30-7.25 (m, 2H), 7.36 (s, 1H), 7.70 (dd, J=15.2, 11.8 Hz, 1H); IR cm^{-1} 2223; λ_{max} ($CHCl_3$) 570 nm; HRMS Calculated for: $C_{22}H_{21}N_4O$, 357.1715; Observed: 357.1717.

(2*E*, 4*E*)-5-(1-Methyl-1,2,3,4-tetrahydroquinolin-6-yl)penta-2,4-dienyl (2d). Yield: 72%; ^{1}H NMR ($CDCl_3$) δ 1.67 (s, 6H), 1.98 (t, J=6.0 Hz, 2H), 2.76 (t, J=6.3 Hz, 2H), 3.02 (s, 3H), 3.36 (t, J=5.8 Hz, 2H), 6.31 (d, J=14.9 Hz, 1H), 6.45 (dd, J=14.1, 11.8 Hz, 1H), 6.53 (d, J=8.6 Hz, 1H), 6.78 (dd, J=14.9, 10.9 Hz, 1H), 6.86 (d, J= 8.7 Hz, 1H), 7.03 (dd, J=13.8, 10.9 Hz, 1 H), 7.14 (s, 1H), 7.23-7.28 (m, max at 7.23, 2H), 7.51 (dd, J=15.5, 11.5 Hz, 1H); λ_{max} ($CHCl_3$) 680 nm; HRMS Calculated for: $C_{26}H_{25}N_4O$, 409.2023. Observed: 409.2041.

1-(4-N,N-Dimethylaminophenylpenta-2,4-dienyl)-2-dicyanomethylene-2-cyano-5,5-dimethyldihydrofuran (3d). 4-(N, N-dimethylaminophenyl) cinnamaldehyde (175 mg, 1.0 mmol), and 4-methylpiperidine in ethanol (50 μL of a 1 M solution) were combined in 100 mL of boiling ethanol. Small ethanol rinses were used to rinse the flasks, and the solutions were boiled and stirred for ~15 min. The solution was allowed to cool, filtered under vacuum with a Hirsch funnel, and air-dried. Yield: 66.5%; ^{1}H NMR (DMSO-d_6) δ 6.55 (d, J=14.9 Hz, 1H), 6.75 (d, J=8.6 Hz, 2H), 7.19 (dd, J=14.9, 11.5 Hz, 1H), 7.40 (d, J=15.5 Hz, 1H), 7.52 (d, J=9.1 Hz, 2H), 7.77 (dd, J=14.9, 10.9 Hz, 1H); IR cm^{-1} 2224 (CN); λ_{max} ($CHCl_3$) 606 nm; HRMS Calculated for: $C_{25}H_{23}N_4O$, 395.1872; Observed: 395.1874.

CHAPTER 3

RESULTS AND DISCUSSION

Equilibrium geometry calculations were performed for the pentadienals (**1a-10a**) and their dicyanovinyl derivatives **(1b-10b)** shown in Figure 4 using the AM1 basis set in PC Spartan. Comparisons of different computational levels have been studied and it was found that the DFT/B3LYP method was more reliable than others and had a high predictive power for the spectroscopic data (Isborn, 2007). Furthermore these methods have been used in previous studies of aromatic aminal and nitriles using DFT/B3LYP (Bredas, 2007). Serponitsky found that HF6-31G* was a good lower level predictor of spectroscopic data (Serponitsky, 2009). Previous studies found that AM1 is still a very good predictor of equilibrium geometries for planar molecules.(Bredas, 2007).

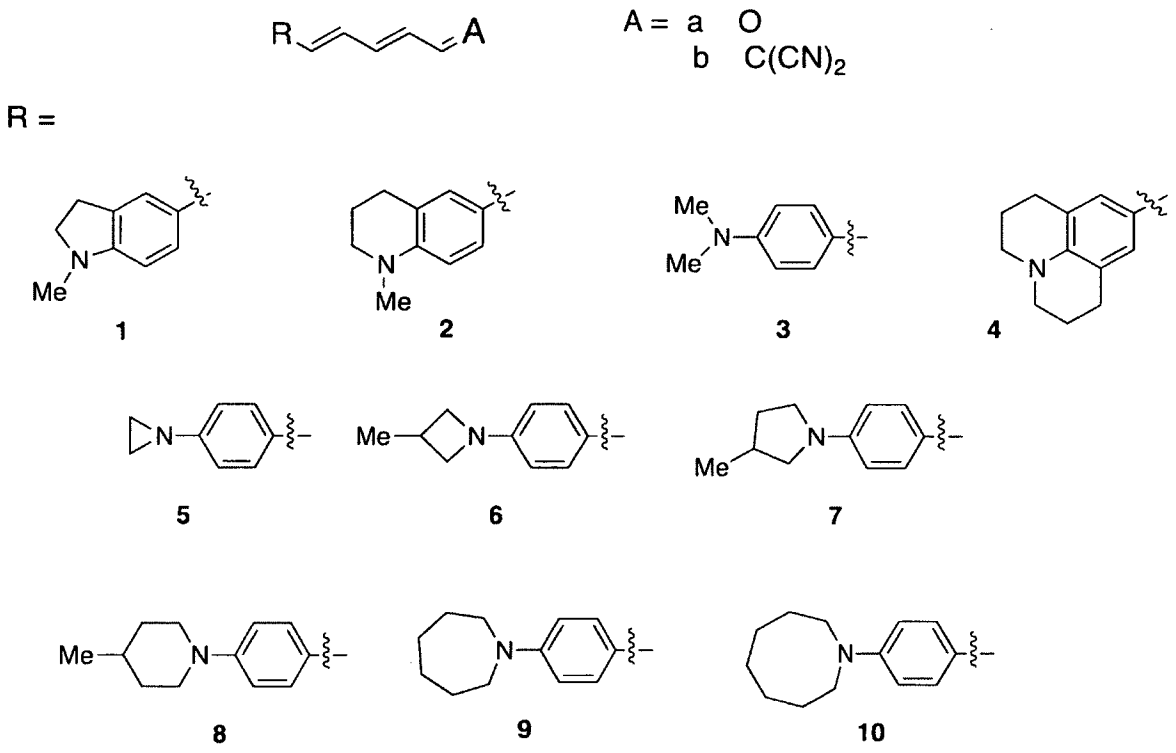
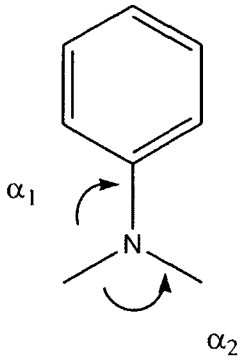


Figure 4. Donors (D) and acceptors (A) for compounds used in the calculated comparisons of C-N bond lengths and dihedral angles in pentadienals **1a-10a** and dicyanovinyl derivatives **1b-10b**.

After attempting various correlations of calculated physical properties, the structures were compared by plotting their calculated Csp^2-N bond lengths and dihedral angles. The dihedral angles were defined by the planes Csp^3-N-Csp^2 and Csp^3-N-Csp^3. The dihedral angles and Csp^2 values were intended as measures of conjugation in the π system, and pyramidalization at N, respectively. Pyramidalization is a deformation of a trigonal planar species into a tetrahedral molecular geometry.



$\alpha_1 = Csp^3\text{-}N\text{-}Csp^2$
$\alpha_2 = Csp^3\text{-}N\text{-}Csp^3$

Figure 5. The α_1 plane describes the Csp^3-N-Csp^2angle, while the α_2 plane describes the Csp^3-N-Csp^3 angle. The dihedral angle is the planes between angle α1 and angle α2.

Pyramidalization is decreased by ring strain in the azacycloalkyl group, and data points for the more highly strained compounds are shown by compounds **5-7** in Figure 6. Pyramidalization is increased by *n*-alkyl groups that have higher rotational freedom, as in compounds **3**, **9**, and **10**. Compounds **2** appear in a cluster with compounds with high experimental β values, whereas compound **1** lies closer to piperidine **8** and azacycloheptane **9**. Compound **1a** was chosen as a synthetic target due to the similarity in structure and synthetic pathway to compound **2a** and expected contrast in properties.

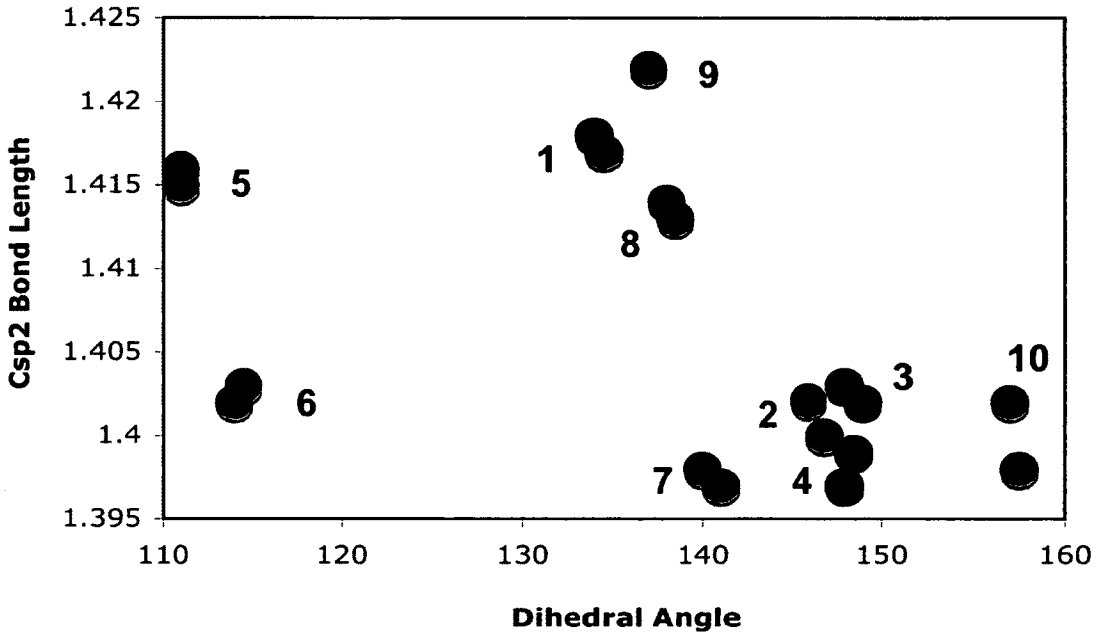


Figure 6. Data points for compounds containing exocyclic azacycloalkanes are shown in blue, those with heterocyclic rings shown in green, and known compounds **3a,b** and **4a,b** are shown in red.

Properties

Spectroscopic properties of the pentadienals **1a-4a** are shown in Table 1.

Table 1. Calculated and experimental spectroscopic properties of pentadienals [a]Calculated using AM1 in PC Spartan with no solvent. [b] Calculated using B3LYP geometry and ZINDO in $CHCl_3$; [c] Experimental data from (Cheng, 1991).

Compound	**Calcd β ($x10^{-30}$ esu) (exptl)** [a]	**Calcd [a]μ (D) (exptl)**	**Calcd λ_{max} (nm) (log ε)** [b]	**Exptl λ_{max} (nm) (log ε)**	**Exptl IR C=O (cm^{-1})**
1a	23.8, 3475 au [b]	5.58	388 (4.81) [b]	418 (4.41)	1661
2a	32.2, 4651 au [b]	6.20	400 (4.81) [b]	430 (4.55)	1665
3a	30.4 (52)	5.96 (6.0)	—	—	—
4a	34.5 ()	6.11	—	446 (4.51)	1660

Solvatochromism

It is widely known that D-π-A dyes exhibit interesting and potentially useful properties including solvatochromism and nonlinear optical behavior (Marder, 1994). All compound studied exhibit positive solvatochromism, which is defined as a shift in λ_{max} to longer wavelengths with increased solvent polarity. A correlation between intramolecular charge transfer band in the UV/visible region and solvent polarity is a

good indication of the contributions of a charge separated resonance structure to the excited state from molecules with a strong n-π^* and π-π^* transitions. The neutral and quinoidal charge-separated resonance structures for **2a** are shown in Figure 7.

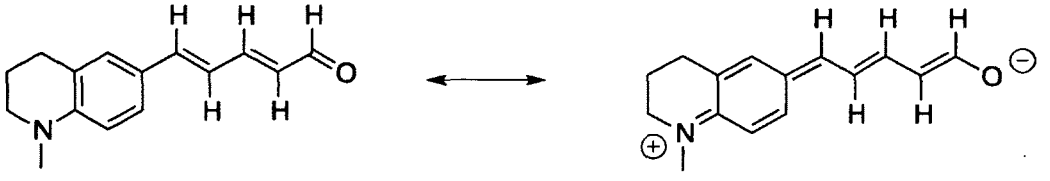
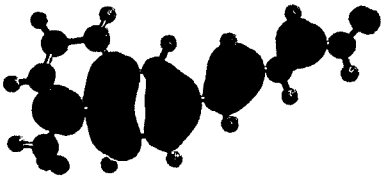
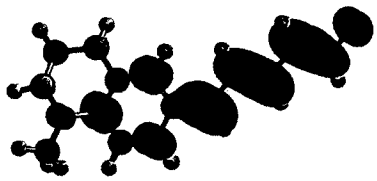


Figure 7. Resonance structures for **2a**.

The highest occupied molecular orbital (HOMO) and lowest unoccupied molecular orbital (LUMO) shown in Figure 8 illustrate calculated electron density in the ground and first excited states for **2a**, respectively. Although the calculations used for these frontier molecular orbitals did not take solvent effects into account, it is clear that both the donor and acceptor are delocalized throughout the π system.



a



b

Figure 8. Molecular Orbital Maps of **2a** maps calculated using the HF321G* basis set in Spartan 4.1 for the HOMO (a) and the LUMO (b).

UV-VIS Spectrometry and Solvatochromism

Solvatochromic studies on donor-acceptor polyenes were performed with UV/vis spectroscopy using a wide variety of solvents (Appendix A). The calculated and experimental λ_{max} values were then plotted against solvent polarity parameters to look for trends. Since UV data for donor-π-acceptor aryl(heteroaryl)-azo dyes were found to correlate well with solvent parameters from both the π^* and E_T^N scales (Raposa, Sousa, 2005), these solvent polarity scales were applied. The most widely-used solvent polarity scale is the normalized $E_T(30)$ scale, (E_T^N). The polarity scale is based on solvent effects in a highly delocalized, but negatively solvatochromic, betaine, **18**. (Reichardt, 1994).

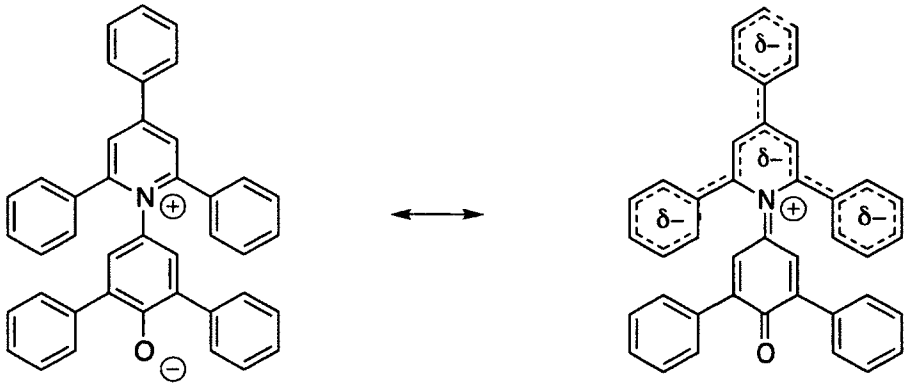


Figure 9. Delocalized structure of **18.**

The π* polarity scale, (Kamlet, 1977), which derives its name from its correlation with solvatochromic effects on n→ π* and π→ π* electronic spectral transitions in at least seven indicator solutes, is also effective for explaining the effects of other solvent properties such as polarity/polarizability, and the acidity and the basicity of the solvents.

Figure 10 shows the calculated λ_{max} for compound **1a** and the E_T^N polarity scale. This graph suggests that for calculated λ_{max} values, the E_T^N solvent parameter scale produces a linear plot. The linear relationship between E_T^N and calculated λ_{max} has a R^2 = 0.83264. The R^2 value indicates that calculated λ_{max} values are somewhat linear. Chlorinated solvents and hydrogen bonding solvents typically give skewed results.

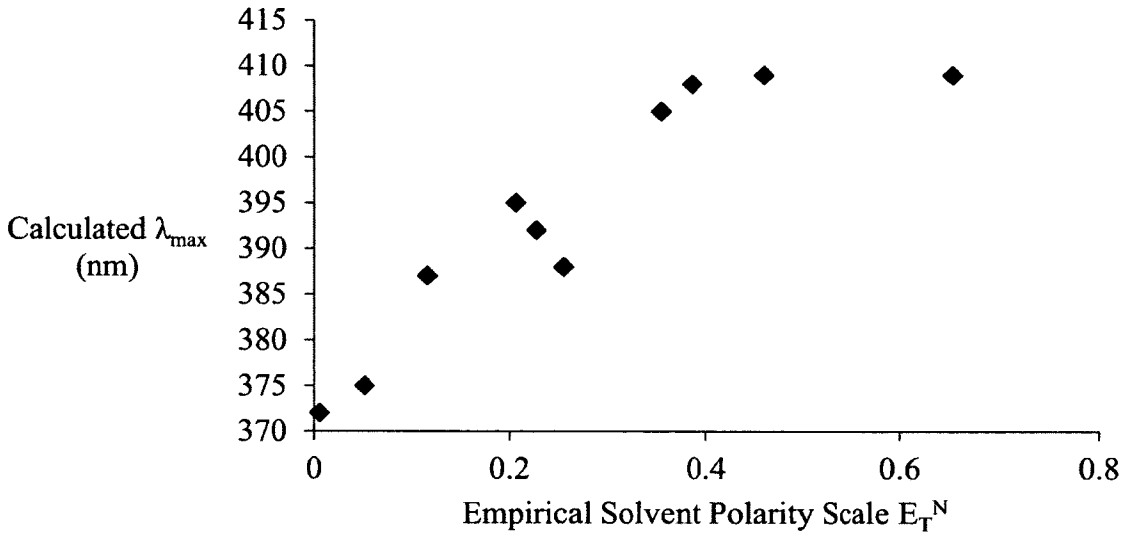


Figure 10. Solvent polarity parameter E_T^N plotted against calculated λ_{max} values for **1a**. Solvents from left to right on the polarity scale are C_6H_{12}, CCl_4, ethyl ether, THF, ethyl acetate, $CHCl_3$, C_3H_6O, DMF, CH_3CN, and ethanol.

Figure 10 also shows a positive solvatochromic shift for **1a**. Positive solvatochromism refers to a shift to longer wavelengths with increased solvent polarity. The correlation of λ_{max} with the solvent polarity parameter is a good measure of the contribution of a charge separated resonance structure to the excited state for molecules with strong n-π and π-π* transitions. Calculated wavelengths (λ_{max}) were plotted against the π* solvent polarity scale and no discernible correlations were seen. However, the E_T^N solvent parameter correlates nearly linear with calculated λ_{max} for **1a** and also **2a** better than the π* parameter.

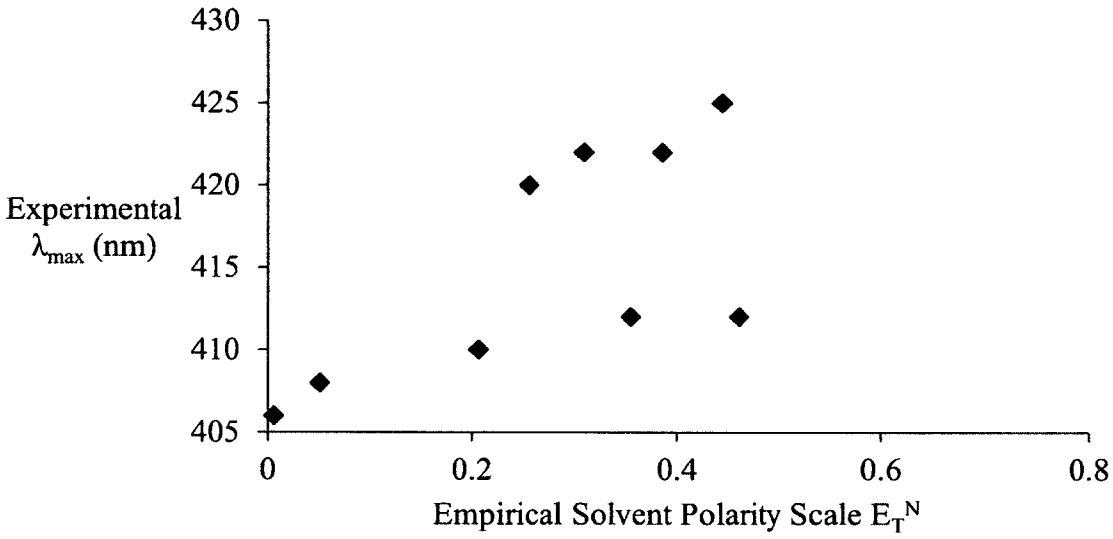


Figure 11. Solvent polarity parameter E_T^N plotted against experimental λ_{max} values for **1a**. Solvents from left to right on the polarity scale are C_6H_{12}, CCl_4, THF, $CHCl_3$,$CHCl_2$, C_3H_6O, DMF, DMSO, and CH_3CN. $R^2 = 0.454$.

As seen by the R^2 value, experimental λ_{max} values do not produce a linear correlation when plotted against the empirical solvent polarity scale of E_T^N.

For comparison, **1a** and **2a** experimental values of λ_{max} were plotted against the π^* solvent polarity scale as shown in Figure 12.

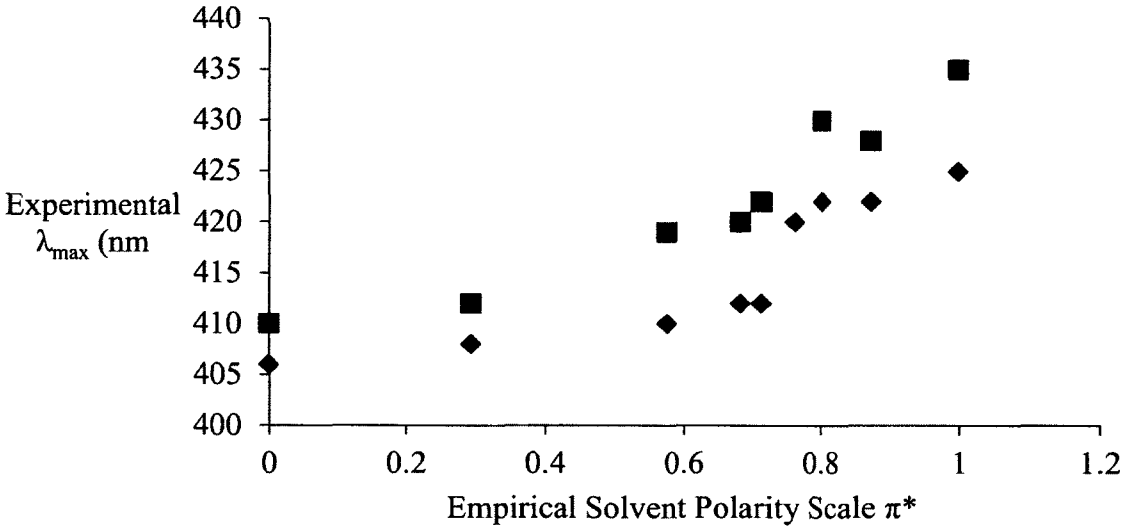


Figure 12. Experimental λ_{max} versus π^* for **1a** (blue) and **2a** (red).

Solvents from left to right on the polarity scale are C_6H_{12}, CCl_4, THF, $CHCl_2$, C_3H_6O, DMF, DMSO, and CH_3CN. R^2 = 0.454 (**1a**), R^2 = 0.5155 (**2a**)

The π^* polarity scale shows a more linear correlation of experimental data for both compounds **1a** and **2a**. Chlorinated solvents represent anomalous points deviating from the linear relationship. For example, the point for chloroform ($CHCl_3$) for **2a** was left off of Figure 12. It can also be seen that λ_{max} values for tetrahydroquinoline (**2a**) are generally larger than λ_{max} values for **1a**.

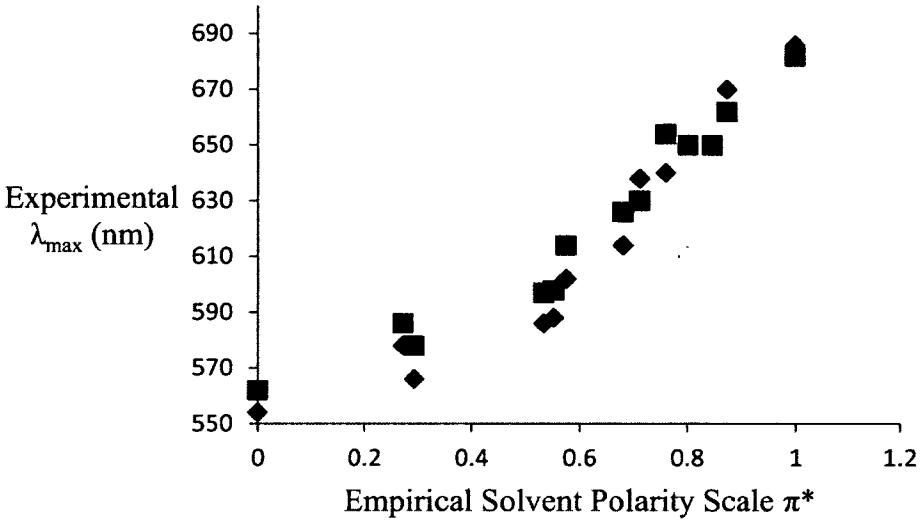


Figure 13. Experimental λ_{max} for **1c** (blue) and **2c** (red) vs. π^* solvent polarity scale. Solvents from left to right on the polarity scale are C_6H_{12}, CCl_4, THF, $CHCl_2$, C_3H_6O, DMF, DMSO, and CH_3CN. $R^2 = 0.824$ (**1a**), $R^2 = 0.9198$ (**2a**).

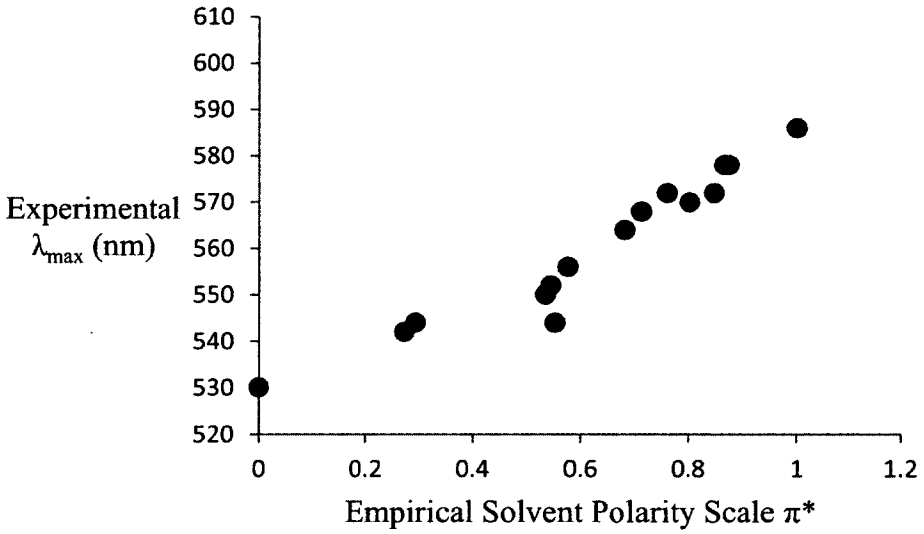


Figure 14. Experimental λ_{max} for **3c** vs. π^* solvent polarity scale. Solvents from left to right on the polarity scale are C_6H_{12}, ether, CCl_4, toluene, ethyl acetate, dioxane, THF, C_3H_6O, CH_3CN, $CHCl_3$, $CHCl_2$, pyridine, DMF, and DMSO. $R^2 = 0.8984$.

The π^* parameter was found to correlate linearly with the solvatochromism of the TB derivatives **1c**, **2c** (Figure 13) and **3c** (Figure 14). ΔS is defined as the differences between the λ_{max} in the most polar (DMSO) and the least polar (dioxane). In TB derivatives, the ΔS was measured as 104 nm for **1c**, 120 nm for **2c**, and 42 nm for **3c**.

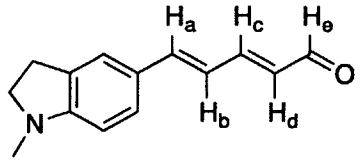
The good solubility of the TB derivatives allowed a wider range of solvents to be used. Therefore, the π^* parameter was used to compare trends in **1c**, **2c** (Figure 13) and **3c** (Figure 14). Although hydrogen bonding can produce anomalous data points, most of the solvents used in this study are hydrogen bonding acceptors or non-hydrogen bonding solvents, which do not interact strongly with the dyes in this study. Other solvents with both donating and acceptor properties (ethanol, chloroform, and nitromethane) exhibited solvatochromism consistent with trends.

ΔS for TCF derivatives are lower than TB derivatives because TCF derivatives are less soluble. ΔS values are 40 nm for **1d**, 44 nm for **2d**, and 60 nm for **3d**. Finally, aldehydes are much weaker acceptors: a ΔS value of 22 nm was observed for **1a** but ΔS was only 12 nm for **2a**.

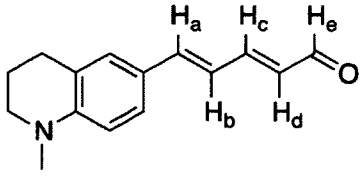
NMR Spectrometry and Solvatochromism

NMR solvatochromism is expected in the dyes studied due to the effect of the ground state electronic structure on the bond length alternation in the molecules. Unless steric effects complicate the relationship (Kwon, 2005), ^{13}C NMR shifts were observed to correlate well with DFT charge densities and therefore have the potential to be used as an experimental probe of pi donor strengths. However, compounds in the study were much

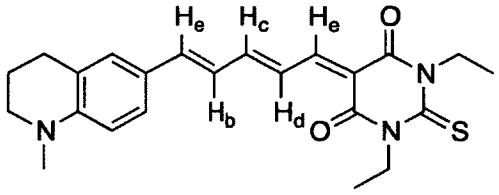
more soluble in $CDCl_3$ than other common NMR solvents, so it was not possible to study solvent effects in ^{13}C NMR. Here we examine the solvatochromic effect on proton chemical shifts for aldehydes **1a** and **2a** in $CDCl_3$, DMSO-d_6, and acetone- d_6. Figure 16 illustrates that the solvent dependence upon chemical shift in **1a** is minimal and the same trend is observed for **2a** (Figure 17).



1a



2a



2c

Figure 15. Proton assignments for **1a**, **2a**, and **2c**.

For NMR studies it was found that NMR shifts correlate better using the E_T^N solvent polarity scale.

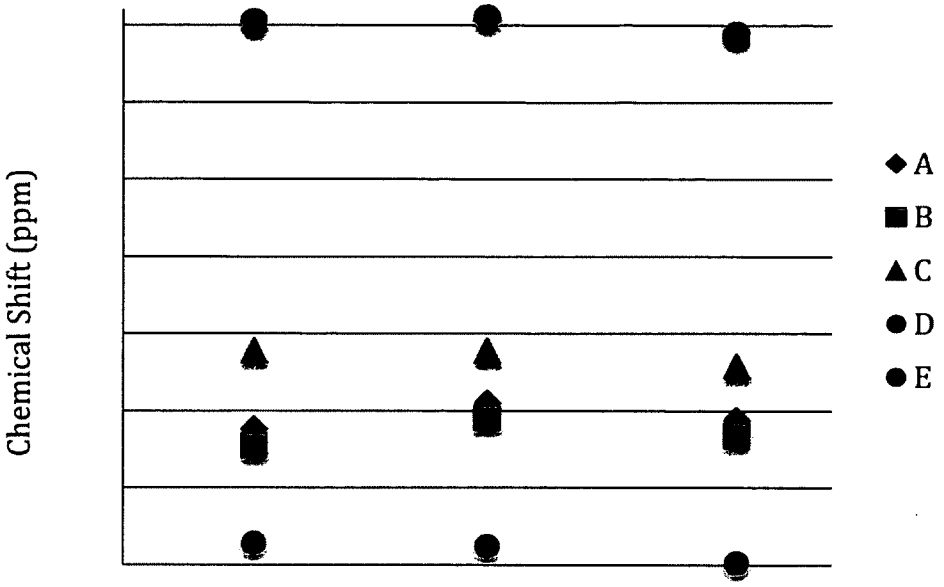


Figure 16. Chemical shifts vs. E_T^N polarity scale for **1a.** A=blue, B=red, C=green, D=purple, E=orange.

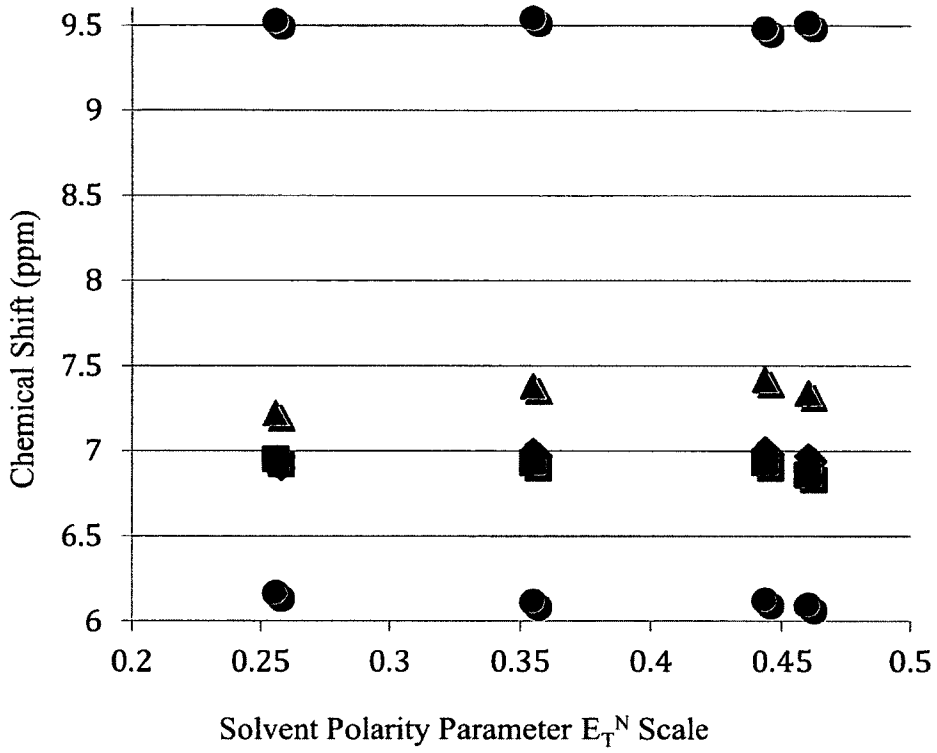


Figure 17. Chemical shifts vs. E_T^N polarity scale for **2a.** A=blue, B=red, C=green, D=purple, E=orange.

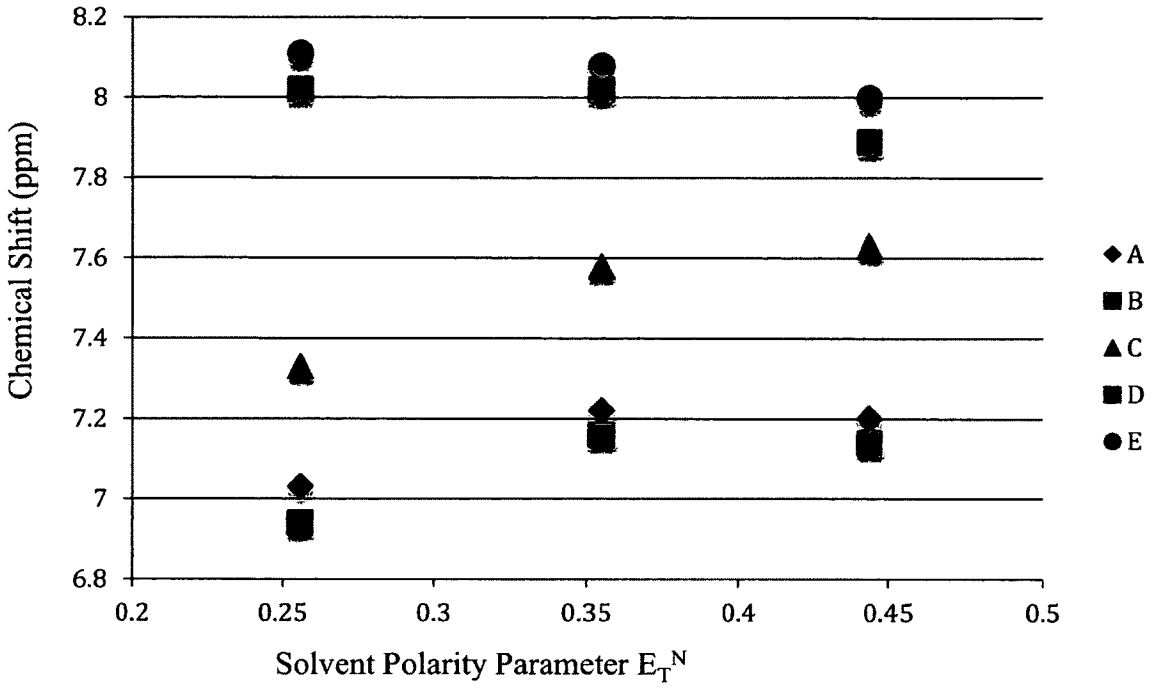


Figure 18. Chemical shifts vs. E_T^N polarity scale for **2c.** A=blue, B=red, C=green, D=black, E=orange.

The difference in solvatochromism for **2a** and **2c** can be explained by the larger contribution of the charge-separated resonance structures in the TB derivatives to the ground state, as shown in Figure 19 for **3c**. The delocalized structures have been observed in polar solvents for **3c** as a photoinduced ICT.

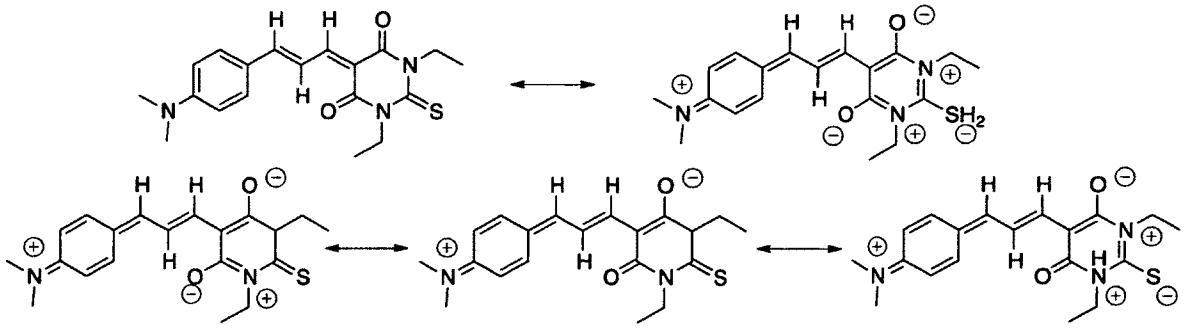


Figure 19. Resonance structures for charge separated forms of **3c** (n=1).

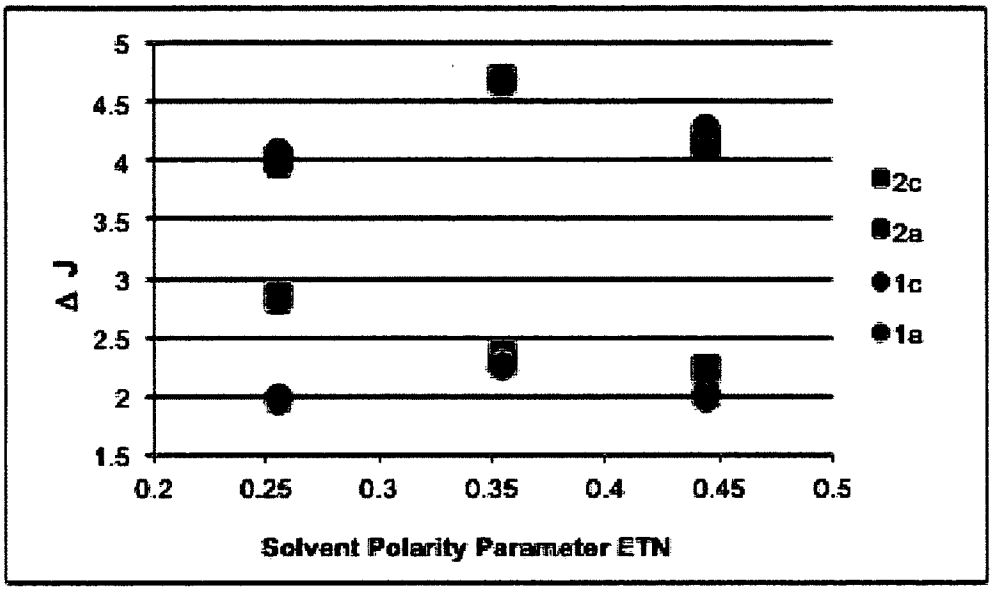


Figure 20. Plot of solvent polarity parameter E_T^N vs. ΔJ for **1a**, **2a**, **1c** and **2c**.

Figure 20 illustrates the correlation between bond length alternation (BLA) and solvent polarity in aldehydes **1a** and **2a** and TB derivatives **1c** and **2c.** Coupling constants J are larger for protons on the double bonds than those between double bonds. For example, in **1a** in $CDCl_3$, J_{ab} =15.4 and J_{bc} =11.0. (Appendix B). The ΔJ is defined as the difference between the average of J values for each type of coupling. The larger the ΔJ, the more BLA. Figure 18 illustrates that aldehydes **1a** and **2a** are dienes whereas the p electrons in the TB derivatives **1c** and **2c** are more delocalized. The ΔJ values for **1c-4c** are shown in Table 3. The order of increasing DJ **1c** < **3c** < **4c** < **2c** indicates that the new molecules are potentially the most (**1c**) and least (**2c**) delocalized of the series.

Table 2. ΔJ values Calculated from NMR Coupling Constants. Spectra were taken in $CDCl_3$ for Compounds **1-4c**.

Compound	**1c**	**2c**	**3c** [a, b]	**4c** [a]
ΔJ	2.00	2.85	2.25	2.50

[a] Blanchard-Desce, M. *et. al. European J. Chem.* **1997,** [b] This compound is a variation of **3c** with N-butyl groups instead of N-methyl.

Physical Properties

Stability. Due to the strong blue green color of the product powders **1c, 1d, 2c,** and **2d,** melting points were measured using differential scanning calorimetry. Table 4 collects the melting points for **1a** and **2a**, and the decomposition points for the derivatives **1c**, **2c**, **1d** and **2d**. Unexpectedly, the melting point for **2a** is smaller than that of **1a**, and the trend continues with lower decomposition points for **2c** and **2d**. The solubility of the TCF derivatives increased from the indolinyl derivative (**1d)** to tetrahydroquinolinyl derivative (**2d)** to the dimethylaminophenyl derivative (**3d**, n=1).

Table 3. Transition temperatures (°C) and enthalpies (in italics, J/g) of **1a**, **2a**, **1c**, **2c**, **1d**, and **2d**. Values were determined by DSC (heating rate 5 °C/min).

Compounds	**Melting points (°C)** **Enthalpies (J/g)**	**Decomposition Temperature (°C)**
1a	91.5 *(63.7)*	—
2a	76.5 *(60.9)*	—
1c	—	206
2c	—	193
1d	—	221
2d	—	189

CHAPTER IV

CONCLUSIONS

In this study, computational and spectroscopic methods were used to investigate the effect of geometry of the donor group in D-π-A compounds. New compounds **1a** and **2a** were synthesized in 28 percent and 20 percent overall yield, respectively, using established methods. In addition, derivatives of these aldehydes, **1c** and **2c** were synthesized in good yield. Compounds **1d** and **2d** were also made, but were impure, so limited analysis was performed.

Calculations using ZINDO/S on B3LYP geometries predicted larger expected UV solvatochromism and high hyperpolarizabilities for **2a** than for **1a**. Calculations at the AM1 and ZINDO levels predict that **2a** β values will correlate closely with compounds having high experimental β values such as **3a** and **4a.** Additionally, calculations using AM1, predicted that the geometries of **2a** and **2b** resembled those of **3a**, **3b**, **4a**, and **4b** more closely than those of **1a** and **1b**. All compounds in this study exhibited positive solvatochromism of the visible ICT band. The largest ΔS (120 nm) was observed for compound **2c**. Chemical shift solvatochromism was observed for **1c** and **2c** in ^{1}H NMR. Coupling constant analysis revealed strong bond length alternation for aldehydes for **1a, 2a, 3a** (ΔJ 4.1-4.7 Hz) and more delocalization for **1c, 2c,** and **3c** (ΔJ 2.0-2.8 Hz). The aldehydes were unstable in solution and thermal analysis showed a melting point of 93.1 °C for **1a** and 76.5 °C for **2a** with decomposition over 200 °C. Derivatives (TB and TCF) were stable in solution and melted with rapid decomposition between 175 °C and 400 °C.

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PART II. LONGITUDINAL STUDY COMPARING ONLINE VERSUS FACE-TO-FACE COURSE DELIVERY IN INTRODUCTORY CHEMISTRY

CHAPTER 1

INTRODUCTION

It is difficult to find an institution of higher learning that does not offer some sort of online coursework. According to Krakovsky (2010), the growth of online only colleges and degree programs is testament to the attractiveness and convenience of taking courses via the internet. The pressure for colleges to provide more courses online in order to stay competitive is increasing and yet little is known about how effective these courses are, especially in the field of chemistry.

Distance education did not begin with the advent of the internet. According to Moore and Kearsley (2012), distance learning had its beginnings during the agrarian era in the mid-1800's precipitated by the need to offer educational opportunities for a geographically dispersed population. Correspondence courses filled this need nicely; later, radio and television provided even more opportunities for distance learning. Simonson, Smaldino, Albright, and Zvacek (2012) argue that with the development of the internet and the speed and affordability of home computers, distance learning is booming at all levels from kindergarten through college all around the world.

Educators, administrators, and politicians alike have taken an interest in distance learning. In Kirtman's article *Online versus In-Class Courses* (2001), she estimates at the time of her study, nearly three million students were enrolled in online courses of some type. In 2000-2001, 56% of two- and four-year degree-granting institutions offered some form of distance learning. Of those institutions, 90% delivered at least some of their courses online (D'Orsie & Day, 2006). It is estimated that four million students participated in at least one online course in the fall of 2007 (Allen & Seaman, 2008). At

some universities, most or all instruction occurs online. For example, the University of Phoenix, where all degrees are accomplished via an online program, is ranked fourth in terms of degree production for minority baccalaureates (Borden, 2009).

Many universities and colleges do not want to be left behind in the race to provide online courses. Regardless of the type of institution of higher learning, there is a competitive need to provide the flexibility and convenience of learning online. Online courses provide a way for institutions to offer anytime, anywhere education to accommodate students in disadvantaged locations and to attract students to their programs. In addition, the modern college student is seeking pathways to education other than the face-to-face attendance at traditional colleges. These students are "interested in [qualifications from] small modules and short programs... and in learning that can be done at home and fitted around work, family, and social obligations" (Bates, 200,. p. 5).

A publication by the Alfred P. Sloan Foundation (2008) indicated that in the fall of 2007, community colleges were particularly active in online education because so many of their students are non-traditional. They define non-traditional as older, full- and part-time working students with children. Many community college students balance work and family obligations, and there is a strong appeal among these students for taking classes whenever time permits. While community colleges historically enroll a larger percentage of non-traditional students than four-year colleges and universities, the non-traditional student population is increasing at all institutions which makes the need to consider this type of learner more universal (Christie, 2007).

This trend can be seen at Sinclair Community College, where this study took place. Sinclair is a comprehensive college that is authorized to grant associate degrees in

the sciences, applied sciences, arts, and individualized and technical study. According to Nancy Thibeault, Sinclair's director of distance learning, Sinclair had an enrollment of 25,000 students in 2009, making it the largest community college at a single location in the state of Ohio. The Fall 2009 quarter marked the 30th year that Sinclair Community College offered online learning. Approximately 6,000 online students are enrolled each quarter and Sinclair has seen up to a 30% annual growth rate in online students. Between 2003 and 2010, the online enrollment at Sinclair tripled, from 3,191 to 11,850. Sinclair's distance learning division has become the largest online learning provider in southwest Ohio (Thibeault, 2011).

Although there have been extensive studies in online learning, there is very limited information about success rates when compared to students in traditional face-to-face (FtF) class formats. When one focuses on college chemistry courses there is virtually no data about the effectiveness of online college chemistry courses.

CHAPTER II

REVIEW OF EXISTING LITERATURE

A search of the literature to understand more about how the method of content delivery impacts learning indicates there is no universal agreement as to what type of course delivery is most effective. This review of literature is organized into three sections: studies that found no difference in student performance based on method of delivery, studies concluding that online delivery was superior to face-to-face delivery, and studies concluding that online delivery was less effective than other delivery methods.

Delivery Method Had No Impact

Many studies across a number of disciplines suggesting that the delivery method used during instruction has no impact on student success. The Institute for Higher Education Policy reviewed the effectiveness of distance learning in higher education and indicated that "regardless of the technology used, distance courses compare favorably with classroom-based (FtF) instruction and enjoy high student satisfaction." (Phipps & Merisotis, 1999, p 4). Most of these studies focused on student satisfaction with, and attitudes about, distance learning and not necessarily on student achievement in the course. This finding could be explained by the fact that students value the convenience of the online course delivery more than what they may have actually learned in the course. However, attitude and individual learning style has been shown to affect student success (Phipps & Merisotis, 1999). Sankaran, Sankaran, and Bui (2000) found that learning performance was directly related to student attitudes and learning strategies. When offered a choice of delivery modes, students sought out instructional methods where they

have succeeded in the past, or where they have felt most comfortable. Although a student's attitude toward a course is valuable information, educators would be more interested if this positive attitude could be connected to greater mastery of the content and better grades. One such study performed by Caywood and Duckett (2003) compared graduate students in a teacher education program who chose to be online learners to those attending traditional face-to-face courses. Students were allowed to choose between an online or FtF setting in a behavioral management course. The performance of these students was evaluated using quizzes during the course and a follow up observational evaluation conducted by a master teacher, based on the students' ability to apply the content from the course in their own teaching. Their findings indicate that neither assessment showed any significant difference in the two populations of students (Caywood & Duckett, 2003,. p. 103).

Hiltz (1992) reported no significant difference in grades earned by students in a face-to-face learning environment versus a virtual classroom. This was based on the results from five different courses in computer science, math, management, introductory sociology, and statistics. All five undergraduate courses used the same teacher, textbook, and tests for both modes of instruction.

Many of the studies cited by the Institute for Higher Education Policy found no statistically significant differences between sections of courses offered online and those same courses offered in a more traditional FtF format (Phipps & Merisotis, 1999). One such study by Carey (2001) found that student outcomes were comparable when considering nearly identical sections of junior-level courses in business management information systems at a small urban university. The sections were identical except for

the method of delivery. The data collected by Carey included differences between pre- and post-tests, score grades, and student satisfaction. In the field of education, there were examples where no significant difference in achievement was found, but most of the studies where no statistically significant difference was found across various disciplines focused their analysis on student attitudes or other affective components of learning rather than content mastery.

Online Learning Was Better

The US Department of Education performed an exhaustive meta-analysis of online learning in 2009 (Means *et al*., 2009). They indicated that there was a vast amount of research done on the subject of online learning, including 1000 empirical studies from 1996 through 2008. Many of these studies indicated that there was a significant difference in student success based on the mode of delivery and there was evidence to suggest that online learners performed better than their face-to-face counterparts. This analysis covered a wide range of disciplines and learning environments including K-12 education, career technical education, medical education, corporate and military training, and higher education (Means *et al*, 2009). Proponents of online learning argue that the online format requires students to take more individual responsibility for their learning. In addition, many online courses have daily or weekly discussion posts, quizzes, and content assessments, which represent more assessment opportunities than traditionally seen in FtF courses especially as enrollments continue to increase. Hannay and Newvine found that "Students who chose DL [distance learning] classes may be more self-disciplined and more self-motivated than those who choose traditional lecture classes, as they recognize that they will be expected to work more independently in these classes"

(Hanney & Newvine, 2006, p. 1). This suggests that students who choose online formats are typically more motivated and better prepared for learning in the virtual setting. The US Department of Education study found that "on average, students in online learning conditions performed modestly better than those receiving face-to-face instruction" (USDE,2010, p. ix). This study analyzed both K-12 and adult learning environments, including higher education and military training across a wide range of disciplines. This study found that these positive results applied primarily to adults. Additionally, these results may be misleading because the study defined online instruction to include blended courses that incorporated online supplements with face-to-face interaction. The researchers of this study indicated that the blended courses often provided more frequent learning opportunities along with pedagogical methods not afforded to the strictly face-to-face, or the strictly online courses. Moreover, these frequent learning opportunities were not afforded to the solely online students. Since it is unclear how the blending of delivery methods impacts either side, it makes drawing definitive conclusions about the relative effectiveness of online offerings versus face-to-face offerings difficult.

In 2000, Maki, Maki, Patterson, and Whittaker (2000) compared two sections of the same college psychology course. One section was taught in a traditional face-to-face format, while the other section was taught entirely online. These two sections were taught by the same instructor, used the same textbook, and used the same in class examinations. They concluded that the online students performed better on both in-class examinations and content knowledge assessed by a third party source based on questions pulled from a psychology GRE practice test booklet. Students in both formats were assessed four times during the semester using in-class examinations.

Face-to-Face Instruction was better

Community colleges and two-year institutions have historically focused on the needs of non-traditional students. Many of these students have full time jobs, family obligations, and other responsibilities. During a slow economy, like that currently experienced by the United States and Europe, enrollments in community colleges are high. This is due to the fact that people may be out of a job or exploring second careers. Community colleges are working to explore different strategies and distance learning is one such option for encouraging people to go back to school or to start back after an extended absence. Lorenzo indicated that in 2000, online education had doubled from the previous decade. He further stated that "No previous form of distance education has grown so rapidly or as consistently, and community colleges have been at the vanguard of that transition" (Lorenzo, 2010, p. 97). Community colleges have been pioneers in the development of online learning yet many of them have guaranteed admission policies, and their students on average are typically not as prepared for post-secondary education as the students enrolled at universities. Compared to four-year institutions, community colleges enroll more students with work and family responsibilities and typically have very few students living on campus. As a result, community colleges promote their online courses more and have higher online enrollment. Large comprehensive and Research I institutions have historically been more resistant to the use of distance education of any kind, due in part to their size and the resistance of their faculty members to instructional methods other than chalk and talk lectures. Marshall argues that "...university culture and existing capability constrain such innovation and to a large extent determine the nature and extent of organizational change" (Marshal, 2011, p. 22).

There appears to be evidence that there are additional educational risks for students who take online classes, due in part to the lack of contact with the professor and the fact that motivation of the learning falls entirely on the student in the online course. Students enrolled in distance education courses have a higher failure and dropout rate than students taking face-to-face courses according to a study by the Community College Research Center at the Teachers College at Columbia University. This study used statistics of over 50,000 community college students enrolled in both online and face-to-face colleges over a five year period. Brown (2011) refers to this same study, citing that online students were 9 percent less likely to complete courses than their FtF counterparts. Online students who required remedial work did worse still and were 13 percent less likely to complete their course than students who took face-to-face courses. (Brown, 2001, p.1). Although community colleges are paving the way for innovations in online learning, there is evidence that community college students are more at risk for failure in online settings.

Brown and Lidehom (2002) evaluated three identical courses offered in microeconomics: face-to-face, hybrid, and entirely online. The face-to-face course served a large population of students that met three times a week for one hour. The hybrid course only met for two hours a week and supplemented the missing hour with online materials. The online course was developed by online web designers along with departmental instructors of the course and this study's authors. The online course had access to the streaming lecture offered for the face-to-face students along with online materials. Their results indicated that students in the online course performed significantly worse in examinations than students in the live course offering. These

students performed worse despite having higher ACT scores and had accumulated more credits toward graduation than students in the hybrid or face to face sections. There were no significant differences seen between the hybrid course and either the face-to-face or online courses. In addition, online students underperformed in specific content areas of microeconomics and in applying abstract material in the course. They stated that "Choosing a completely online course carries a penalty that would need to be offset by significant advantages in convenience or other factors important to the student" (Brown, 2002, p. 447).

Literature Reviewing Online Science Courses

An extensive literature search was conducted to locate studies done in the field of chemistry comparing student success in online versus face-to-face courses. All available library searches were performed using the Education Full-text database, Education Research Complete database, EBSCO, ERIC Data base, SciFinder Scholar Web, Chemistry Central, Web of Science, including *The Journal of Chemical Education*, the *American Journal of Distance Learning. The Journal of Chemical Education* contained studies done on such topics as virtual laboratories, and online chemistry discussions. There were no findings directly comparing face-to-face with online formats in chemistry courses. The search was expanded to other sciences including physics and biology, and similar results were obtained.

Thomas Russell wrote a book in 2001 titled *The No Significant Difference Phenomenon,* which took a comprehensive look at 355 research papers and reports that looked at online and distance education courses compared to traditional classroom courses, and how these were related to student outcomes. Since the release of the book,

Russell developed a web site, No Significant Difference, http://www.nosignificantdifference.org/about.asp. The web site, which was developed in 2005, serves as database for all the papers and reports from Russell's book. It additionally updates its archives by adding any studies that continue to research the topic of online versus facet-to-face courses and student success. The search engine embedded in the web site allows for researchers to search articles using all years, or specific years, and allowing for key words to assist in the search. Furthermore, searches can be performed selecting the following choices: no significant difference, better in the classroom, better with technology, and mixed results.

Colloquially, hard sciences are considered to be physics, chemistry, biology, geology and astronomy. Searches were conducted on Russell's web site using the keyword, "chemistry" for all four of the choices. Only one study was found, *Inter-institutional Teaching by Television in the Oregon State Systems of Higher Education: Report 1.* This article was published in 1960, and it found that from 1957-1959, there were no differences found in final examinations of chemistry students. Location of this article was not possible. When the search was expanded to physics, three articles were retrieved, two citing no significant difference, and one citing a significant difference. In biology, five articles were retrieved, four citing no significant difference, and one citing mixed results. Mathematics returned six results. No results were returned for astronomy and geology.

Research Questions

This study was designed to answer the following research questions.

1. Is there any difference in the performance of students enrolled in online versus face-to-face learning environments?
2. What differences exist between the students taking the online vs. face-to-face course?
3. What effect do overall GPA, full-time status, placement scores, success in other online courses, and remediation course enrollments have on student success?

CHAPTER III

METHODOLOGY

Design

This study was carried out in Introductory Chemistry (CHE 120), the first course of a three-quarter sequence designed primarily for allied health students at Sinclair Community College, a large urban community college in southwest Ohio. The study participants were grouped according to the method of delivery used in the section in which they were enrolled. Data was collected from all sections of the Introductory Chemistry course taught from 2003 to 2011. The two methods of instructional delivery were developed and taught by the same instructor at the same institution. All exams and quizzes were graded by the same instructor to avoid consistency and reliability issues. For all nine years studied, students in both formats used the same textbooks and laboratory experiments and took the same cumulative final. The instructor used the same lecture notes for the online course and the face-to-face courses. These notes were posted in the course management system in PowerPoint format. In 2009, audio was added to the PowerPoint notes to simulate the lecture received by face-to-face students. There was a laboratory component for both courses which was carried out in parallel laboratory sessions held on campus. The content and instruction in both types of delivery was synchronized in every possible way with the exception of the additional assessments in the online course.

Face-to-Face Course

The FtF class met for two 75-minutes lectures per week, for 10 weeks. The material was covered at an average pace of one chapter per week. Every week there was a quiz covering the material from the previous week and there was a cumulative exam. The co-requisite lab course counted for 20% of the overall grade. There were no other assessments besides the ten quizzes, the cumulative final, and the laboratory experiments. Over the course of the nine years, the FtF course was limited to 32 students per section.

Online Course

The online course was designed by the instructor of the FtF introductory chemistry course, along with web designers and course developers employed by the institution. The course originally used WEBCT® as the course management system platform. Later, Blackboard and most recently Angel was used to manage the course. The course delivered in the online format consisted of ten online quizzes, ten discussion posts, and three exams. The three exams were taken on campus in a supervised testing center on campus for security reasons. The online students took the same cumulative final as the FtF class. The online students were also required to attend the same laboratory course on campus as the FtF students which also counted for 20% of the grade for the online students. During the nine years data was collected, the online sections of the course saw a steady increase in enrollment plateauing in 2008 as seen by Figure 1.

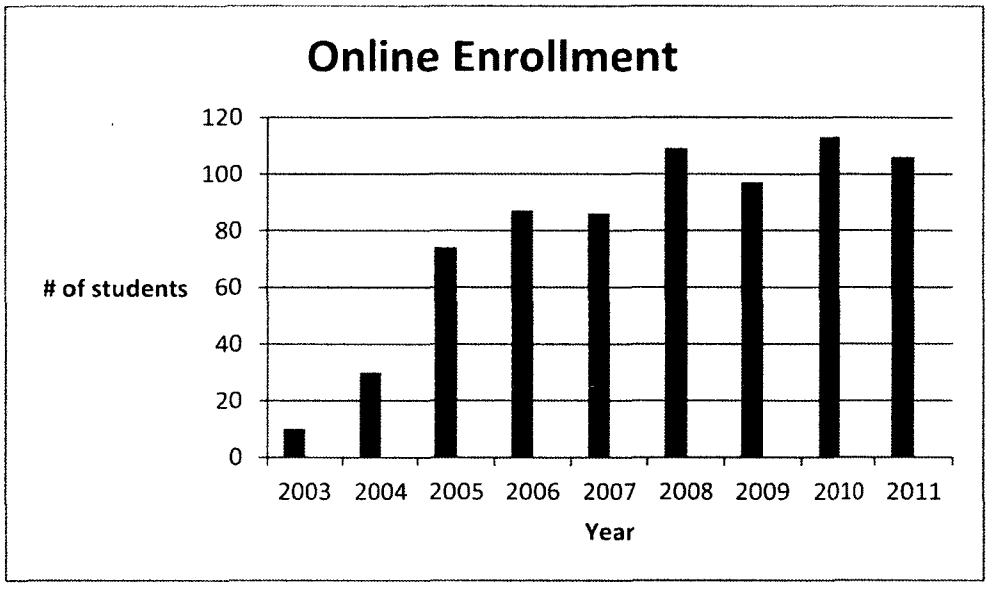

Figure 1: Enrollment in online CHE 120, from 2003 to 2011.

Participants

The majority of students enrolled in the chemistry course majored in courses in the life and health division, with over half of all those students consisting of nursing majors. Student fields of study are represented in Table 2.

	FtF	Online
Business and Public Services	81	101
Liberal Arts & Sciences	128	123
Life & Health	526	306
STEM	40	29
Personal Interest & Undeclared	113	153
Total	888	712

Figure 2. Academic divisions of all enrolled chemistry students.

Demographic data were collected to see if there were any differences in the students who enrolled in online sections of the course versus those enrolled in the traditional format. The data consisted of gender and age. 78 % of all participants were female for both formats. This is understandable given that this course was predominately populated by students seeking allied health degrees, which are primarily females at the institution where the data was collected. There were significantly more females enrolled in the course regardless of the format, but the difference between genders in the two modes of delivery was not statistically different. There was a slight difference in ethnic status, with 73.5% of online students being non-minorities and 67% of FtF students being non-minorities. This difference was statistically significant ($X^2 = 22, p = 0.0001$). The median age of the online students was 30, whereas the median age of the face-to-face students was 26.8. This age difference was statistically significant ($F = 1.15$, $p = .0505$). The demographic data are summarized in Figure 3 below.

	FACE-TO-FACE	ONLINE	OVERALL
GENDER			
Male	22.44%	20.90%	21.75%
Female	77.56%	79.10%	78.25%
ETHNIC STATUS			
Minority	19.31%	10.98%	15.57%
Non-minority	66.77%	73.54%	69.82%
Unknown	13.92%	15.48%	14.62%
AGE			
Minimum	15	15	15
Maximum	62	60	62
Average	26.8	30.0	28.2

Figure 3. Demographic data for the students in the face-to-face and the online course.

Many students attending community college are not as prepared as they should be for post-secondary education. One of the benefits of a community college education is that it can help students fill those educational gaps with developmental courses. Since this study took place at a community college, additional data was collected on the number of developmental studies courses taken by each student as a measure of their preparedness. These data included the following information: student success in other online courses, course load in the quarter the chemistry course was taken, overall GPA, and enrollment in developmental courses.

Study

The goal of this study was to compare student success in chemistry. Several methods of statistical analysis were employed to analyze the data. X^2 and student *t*-tests were carried out to look for significant differences for the following comparisons:

1. Success rates of FtF versus online students.
2. Success rates of students who needed remediation versus those who did not need remediation.
3. Success rates of students who passed developmental math versus those who did not pass developmental math.
4. Success rates of students who have had success in other web courses.
5. Correlations between math, reading, and writing placement scores and success in Chemistry 120.
6. Correlations between cumulative GPA and a student's full time status.

CHAPTER IV

RESULTS

Student success in the course was defined as earning an A, B, or C as the final grade at the end of the term. Students who scored a D, F, or W (withdrawal) were labeled as non-successful. The grading scale used was 90-100% for an A, 80-90% for a B, 70-80% for a C, 60-70% for a D, and below 60% for an F.

The data showed that the overall success rate for the online students was significantly lower than for face-to-face students. These results showed that 66 percent of students in the face-to-face course were successful while only 54 percent of the students in the online course were successful. ($X^2 = 25.572$, $p < .001$). The results are summarized in Figure 4.

	Face-to-Face (# of students)	Online (# of students)
Not successful	311	345
Successful	616	411

Figure 4. Success Rates for students in the FtF and online courses.

Not surprisingly, a significantly higher success rate was found among better prepared students. Students not taking developmental courses were assumed to be the better prepared group and students taking developmental courses were considered to be less prepared. Most developmental courses address reading, writing and math skills not obtained in a student's previous coursework, either in high school or in their college preparation for certain educational tracks. This suggests that students in developmental courses are not as prepared as students who do not need to take these classes. This

corresponds to numerous studies stating that students with better high school preparation do better in college chemistry. This correlation is especially strong when it comes to the relationship with chemistry success and mathematics. Many concepts in chemistry have a mathematical component. The introduction to Chemistry course in this study used mathematics in concepts including stoichiometry, unit conversions, balancing chemical equations, and applying gas law equations. According to Wagner, Sasser, and DiBiase (2002), a strong background in mathematics is a significant predictor of success in college chemistry courses and this study bears that out as well.

The overall success rate for students who did not require developmental studies (70%) was significantly higher than for those students who needed remediation (54%), $X^2 = 44.9466, p < .001$. These results can be found in Figure 5.

	# of student not taking developmental courses	# of students who took developmental courses
Failed Chemistry 120	223	433
Passed Chemistry 120	520	507

Figure 5. Success rates for students who did or did not take developmental courses.

Given the importance of mathematics in the study of chemistry, particular focus was given to student enrollment in developmental mathematics courses. The courses in developmental mathematics available to students were Basic Mathematics I, Basic Mathematics II, and Introduction to Algebra. For students without solid mathematical skills, chemistry can prove to be an even greater challenge. Students who failed a developmental math courses were also likely to fail chemistry as well. This was true for both developmental math courses, whether basic mathematics (DEV 085, Figure 6) or

algebra skills (DEV 108, Figure 7). The overall pass rates for Chemistry 120 students who passed DEV 085 (93%) was significantly higher than the rate for Chemistry 120 students who did not pass DEV 085 (64%),.$X^2 = 636.032$, $p < .001$.

	Failed DEV 085	Passed DEV 085
Not Successful	219	52
Successful	15	653

Figure 6. Students needing DEV 085, Basic Mathematics II (prerequisite: placement test score or equivalent).

	Failed DEV 108	Passed DEV 108
Not Successful	298	54
Successful	45	679

Figure 7. Students needing DEV 108 Introduction to Algebra (prerequisite: DEV 085 or equivalent).

The overall pass rate for Chemistry 120 students who passed DEV 108 (90%) was significantly higher than the pass rate for Chemistry 120 students that did not pass DEV 108 (7%), $X^2 = 671.1362$, $p < .001$.

As a measure of the student's level of comfort with online class offerings in general, the number of online courses the student has taken can be evaluated. A report by Harrell and Bower (2011) found that experience with web based courses was a strong factor in success, especially in community colleges. They state, "An examination of

community college students in online courses found that lack of experience in taking online courses had a negative impact on success" (Harrell & Brown, 2011,p. 180).

Independent sample *t*-tests were run to determine whether there was a significant difference in each variable in the online and FtF sections of CHE 120. These tests work for variables that can be treated as if they were continuous. The results of this study showed that there was a significant effect of other web course success on the success rate for students taking Introductory Chemistry online ($t = 23.19$, $p < .0001$).

Comparing Face-to-Face students with online students

Additionally, another goal of this study was to determine how online students were different from the students that enrolled in the FtF section of CHE 120. It was found that the incoming online students were older, took fewer developmental courses, and had a higher overall grade point average (GPA). An analysis of these data also showed that online students had higher placement test scores in arithmetic, reading and writing. However, the online students did not have higher significantly different scores in college mathematics, which typically involves higher-level math concepts, including algebra.

Face-to-Face					
Analysis of Variance					
Source	**Deg F.**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
Model	6	2.84179	0.47363	16.45	<.0001
Error	18	0.51821	0.02879		
Corrected Total	24	3.36			
Variable	**Parameter Estimate**	**Standard Error**	**Type II SS**	**F Value**	**Pr > F**
Intercept	0.97142	0.29221	0.31817	11.05	0.0038
Math score	-0.00664	0.00145	0.60048	20.86	0.0002
College math score	-0.00301	0.00161	0.10034	3.49	0.0783
Reading score	-0.009	0.00263	0.33775	11.73	0.003
Writing score	0.00652	0.00248	0.19941	6.93	0.0169
Cumulative GPA	0.17046	0.0378	0.58538	20.33	0.0003
Full Time status	0.33158	0.07506	0.56178	19.51	0.0003

Figure 8. Statistical data of face-to-face students.

A stepwise regression performed for the face-to-face data provided a statistically significant model. ($p < .0001$). Based on the p values the data show that for FtF, the variables of mathematics, reading and writing scores are significant. It also shows a significant contribution for cumulative GPA and full-time status of students. The parameter values of placement scores in mathematics, college mathematics and reading indicate a negative correlation, indicating that higher scores actually led to lower levels of student success. The parameter values for writing, cumulative GPA, and full time status have a positive correlation.

Web					
Analysis of Variance					
Source	**DF**	**Sum of Squares**	**Mean Square**	**F value**	**Pr > F**
Model	6	4.60868	0.76811	8.48	0.0002
Error	18	1.63132	0.09063		
Corrected Total	24	6.24			
Variable	**Parameter Estimate**	**Standard Error**	**Type II SS**	**F Value**	**Pr > F**
Intercept	0.3723	0.53447	0.04397	0.49	0.495
Math score	0.00445	0.0027	0.24568	2.71	0.117
Col. math score	-0.00337	0.00438	0.05379	0.59	0.451
Reading score	-0.00747	0.00462	0.23758	2.62	0.1228
Writing score	-0.000755	0.00437	0.00271	0.03	0.8647
FT	0.334	0.13139	0.58569	6.46	0.0204
Success other web	0.74466	0.15642	2.05394	22.66	0.0002

Figure 9 . Statistical data of online students.

The stepwise regression also showed a significant model for the online data. The regression analysis indicated that full time status and success in other web based classes were significant. Success in other web courses has been shown to contribute to higher success in online courses (Harrell, 2011), but this study also shows that students enrolled full time did do better in the online chemistry course.

CHAPTER V

CONCLUSIONS

In general the online students were better prepared but not as successful as the FtF students. Online students had better placement scores and higher GPAs, suggesting stronger students than those in the FtF on average. Surprisingly, the results indicate that students enrolled in face-to-face sections of introductory chemistry are significantly more successful than their online counterparts. The review of the data indicated that the students in the online course had significantly higher cumulative GPAs than students in the face-to-face delivery method. Using cumulative grade point is only one method of measuring student quality. In this study it was also shown that these same online students also did better on their placement scores in reading and writing indicating that on the average they were better prepared students. Online courses require more reading and writing than FtF courses because of the absence of direct contact with professors. One might have predicted their higher performance in reading and writing would have led to higher performance in their chemistry courses.

Taking developmental courses are another indicator of student preparedness. It was found that students who did not need developmental studies had a significantly higher overall success rate in taking chemistry. This may suggest that the developmental classes were not successful in preparing the students for their general education requirements. The data here shows a very strong correlation between not having to take developmental courses and succeeding in introduction to chemistry, which would create another advantage for the online students.

As mentioned earlier, mathematics plays a very strong role in the first semester of an introduction to chemistry course. Historically, mathematics has always been a challenge for a large part of the student population. This is especially true at community colleges where the admission policy is far less strict than at public or private universities. Many community college students depend on these developmental classes to prepare them for the courses required for their chosen field of study. At Sinclair Community College, a significant portion (90 percent) of first-time-at-college students who enroll in a given academic year need to take non college-level course work in mathematics. Nearly one third of these students require developmental courses in English and reading (Jolly, 2012).

It was also found that a student's comfort level, and their success and completion of other online or distance courses had a positive influence on their success in introduction to chemistry. This result should be of particular interest to academic advisors at institutions that offer online courses. As a benchmark when placing students in online courses, their past success in online courses should be carefully examined. Online courses not only involve the understanding and application of the content, but also they require significant skills in organization, reading comprehension, and independent study. Additionally, online courses require computer and internet proficiency. In this study, the online course used Angel software as its course management system platform. A certain amount of proficiency in navigating these course management systems is required for students. Certain applications for online courses in these course management systems include: drop boxes, discussion forums, online quizzes, online

homework, web links, and online lectures. Students not familiar with these systems will typically find the course more challenging based on these applications.

When comparing the types of students that takes online courses versus those choosing FtF, it was found that students who took the online course were typically older. Traditional students are considered those that enroll directly after high school and those that consider college their full time job. In addition to being older these students had higher test scores in arithmetic, reading and writing.

While this study did not set out to explain why the face to face students performed better, other studies have looked at the advantages of the face to face environment (Brown, 2011). One might speculate that online learning does not engage the students in the way that the face-to-face instruction accomplishes. Moreover, in a face-to-face environment, a professor in the classroom and can more easily hold a student's attention and recognize when a student may not be grasping a critical concept. Furthermore, professors can hold their students more accountable due to the personal interaction between student and instructor. In conclusion, if online learning is to succeed as an alternative to the traditional classroom, it must address the issues found in this study.

CHAPTER VI

IMPLICATIONS

There seems to be a tradeoff for students that if they want the convenience of online courses, there must be a reduction in quality. It has been shown in this study that face-to-face instruction has significantly more successful students in chemistry versus students in online courses. Literature is mixed, some studies reported no difference, some argued that online instruction develops more successful students, and others argued still that face-to-face instruction was better, but no studies that were reviewed looked at the issue of relative success of students based on data drawn specifically from chemistry courses.

No matter your opinion of online courses, the presence of online courses and online institutions cannot be ignored. The popularity of online learning exists because it helps students by providing flexibility of time and convenience. It provides the opportunity for students to take classes that under ordinary circumstances they would be unable to attend. In this study, while the FtF students were deemed more successful the data indicated that a percentage of students enrolled in the online sections did in fact learn. 54% of online students in this study were deemed successful. These students may not be able to obtain a degree if it were not for these online courses. If online learning was abandoned, we would be telling these students that a degree is unobtainable for them based on logistics.

Dedicated educators must not dismiss online learning but must use it wisely and in full appreciation for its strengths and weaknesses. This proposes a problem since all of

the strengths and weaknesses are not entirely understood. Even if this was studied thoroughly, there still exists the fact that over half of the students are successful. For now, educators and advisors should caution students before they take an online course. Students should consider that they may not learn chemistry as well as they would in a face to face setting. If a student is interested in certain fields like pharmacy, medical school or engineering they might be better served to enroll in a face-to-face course. On the other hand, if a student is pursuing an arts degree or wants to be an English teacher, they might want to take the online course for convenience, earn their credit and place more of their efforts in courses more closely related to their field. If a student has been successful in other internet courses, an online chemistry course may satisfy their goals for the course. This study also gives advisors a baseline on how to steer students to or away from online courses.

Educators need to better understand the strengths and weaknesses of online learning. More studies need to be done to determine what makes online work better, what factors make it work less well, and improve upon its effectiveness. More precisely, more studies need to be done to determine where online is especially a disservice to learners.

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APPENDICES

Appendix A: UV and NMR Solvent Dependent Data

Table A.1: Solvent Dependent UV Data for Aldehydes

Solvent	**1a** λ_{max} (nm)	**2a** λ_{max} (nm)
Cyclohexane	406	410
CCl_4	408	412
THF	410	419
C_3H_6O	412	420
CH_3CN	412	422
$CHCl_3$	420	434
CH_2Cl_2	422	430
DMF	422	428
DMSO	425	435

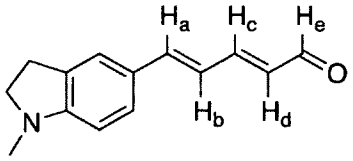
Table A.2 Solvent Dependent UV Data for TB Derivatives

Solvent	**1c** λ_{max} (nm)	**2c** λ_{max} (nm)	**3c** λ_{max} (nm)
Cyclohexane	554	562	530
Ether	578	586	542
CCl_4	566	578	544
Toluene	586	597	550
CH_3CH_2OH	-	654	574
Ethyl acetate	-	-	552
dioxane	588	598	544
THF	602	614	556
C_3H_6O	614	626	564
CH_3CN	638	630	568
$CHCl_3$	640	654	572
CH_2Cl_2	610	650	570
CH_3NO_2	decomp	650	572
Pyridine			578
DMF	670	662	578
DMSO	686	682	586
CF_3CH_2OH			600

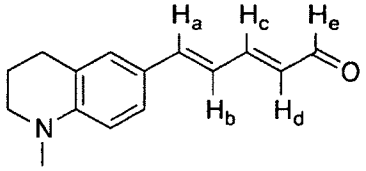
Table A.3 Solvent Dependent UV Data for TCF Derivatives

Solvent	**1d** λ_{max} (nm)	**2d** λ_{max} (nm)	**3d** λ_{max} (nm)
Toluene	-	636	-
Ethanol	646	668	602
Dioxane	602	630	578
THF	614	638	590
C_3H_6O	614	636	594
CH_3CN	612	654	594
$CHCl_3$	670	680	606
CH_2Cl_2	656	678	611
CH_3NO_2	-	650	-
DMF	642	656	610
DMSO	642	674	638
CF_3CH_2OH	-	-	658

Table A.4 Solvent-Dependent Chemical Shift and Coupling Constant Data for **1a** and **2a.**



1a

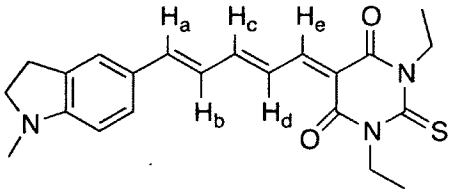


2a

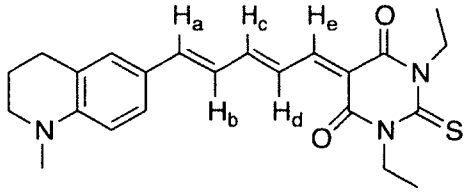
1a	**δ**	**(ppm)**							
Solvent	**A**	**B**	**C**	**D**	**E**				
$CDCl_3$	6.88	6.77	7.39	6.14	9.52				
C_3D_6O	7.05	6.95	7.39	6.12	9.55				
CD_3CN	6.94	6.84	7.29	6.01	9.44				
$CDCl_3$	6.88	6.77	7.39	6.14	9.52				
	J (Hz)								
Solvent	**AB**	**BA**	**BC**	**CB**	**CD**	**DC**	**DE**	**ED**	**Δ J**
$CDCl_3$	15.4	15.5	10.9	11.2	14.7	14.9	8	8	**4.08**
C_3D_6O	15.4	15.4	10.9	10.9	14.9	15	8	8.1	**4.28**
CD_3CN	15.4	15.5	10.4	10.9	14.9	15.5	8	8	**4.7**

2a	**δ**	**(ppm)**							
Solvent	**A**	**B**	**C**	**D**	**E**				
$CDCl_3$	6.93	6.95	7.22	6.16	9.52				
C_3D_6O	7	6.93	7.38	6.11	9.54				
CD_3CN	6.97	6.86	7.34	6.09	9.51				
$CDCl_3$	6.93	6.95	7.22	6.16	9.52				
DMSO	7.01	6.93	7.42	6.12	9.48				
	J (Hz)								
	AB	**BA**	**BC**	**CB**	**CD**	**DC**	**DE**	**ED**	**Δ J**
C_3D_6O	15.5	15.5	10.9	10.6	15.2	15.5	8.1	8	**4.7**
CD_3CN	15.5	15.1	10.7	10.9	15.5	14.9	8.1	8.1	**4.45**
$CDCl_3$	15.1	15.4	10.9	11.2	14.7	15	8.1	8.6	**4**
DMSO	15.5	14.9	10.9	10.9	14.9	14.9	8.1	8	**4.15**

Table A.5 Solvent-Dependent Chemical Shift and Coupling Constant Data for TB Derivatives



1c

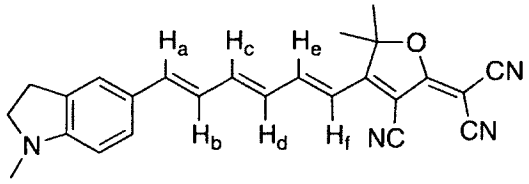


2c

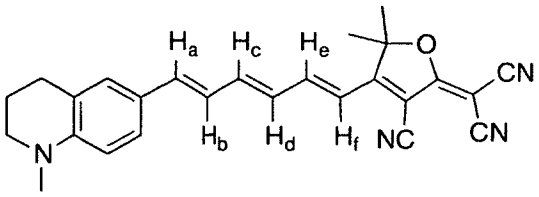
1c	**δ**	**(ppm)**							
Solvent	**A**	**B**	**C**	**D**	**E**				
$CDCl_3$	7.05	6.94	7.33	8.02	8.13				
C_3D_6O	7.25	7.16	7.58	8.02	8.07				
DMSO	7.26	7.17	7.66	7.91	8.03				
CD_3CN	7.12	7.06	7.46	7.95	8.04				
	J (Hz)								
	AB	**BA**	**BC**	**CB**	**CD**	**DC**	**DE**	**ED**	**Δ J**
$CDCl_3$	14.9	14.9	11.5	11.5	13.7	13.2	13.2	12.6	**1.98**
C_3D_6O	14.9	14.9	10.9	10.9	13.2	13.2	12.6	12.6	**2.3**
DMSO	14.9	14.9	11.5	11.45	13.75	13.2	13.1	12.6	**2.03**
CD_3CN	14.9	14.1	10.55	10.3		13.8	13.8	12.6	**2.19**

2c	**δ**	**(ppm)**							
Solvent	**A**	**B**	**C**	**D**	**E**				
$CDCl_3$	7.03	6.94	7.33	8.02	8.11				
C_3D_6O	7.22	7.16	7.58	8.02	8.08				
DMSO	7.2	7.14	7.63	7.89	8				
CD_3CN	-	-	7.5	7.98	8.07				
	J (Hz)								
Solvent	**AB**	**BA**	**BC**	**CB**	**CD**	**DC**	**DE**	**ED**	**Δ J**
$CDCl_3$	14.9	14.9	11.5	10.9	13.7	13.2	13.2	12.6	**2.85**
C_3D_6O	14.9	14.9	10.3	10.9	13.2	12.9	12.9	12.4	**2.35**
DMSO	14.9	14.9	10.6	10.9	13.8	13.2	13.2	13.1	**2.25**
CD_3CN	-	-	-	10.9	13.7	13.7	12.7	13.1	-

Table A.6 Solvent-Dependent Chemical Shift and Coupling Constant Data for TCF Derivatives



1d



2d

1d	**δ**	**(ppm)**				
Solvent	**A**	**B**	**C**	**D**	**E**	**F**
$CDCl_3$	6.36	6.85	7.61	7.14	7.44	6.69
DMSO	6.55	7.19	7.77	7.4	7.52	6.75
CD_3CN	6.51	7.04	7.62	7.25	7.48	6.73

Appendix B: IRB Approval

December 13, 2012
Patrick Greco, Dr. Amy Phelps
Department of Chemistry
Protocol Title: "Longitudinal study comparing online versus face to face course delivery in introductory chemistry"
Protocol Number: 13-160

Dear Investigator(s),
The exemption is pursuant to 45 CFR 46.101(b) (4). This is because the research that was conducted involved the study or collection of existing data that was de-identified.
You will need to submit an end-of-project report to the Office of Compliance upon completion of your research. Complete research means that you have finished collecting data and you are ready to submit your thesis and/or publish your findings. Should you not finish your research within the three (3) year period, you must submit a Progress Report and request a continuation prior to the expiration
date. Please allow time for review and requested revisions. Your study expires on December 13,2015.

Any change to the protocol must be submitted to the IRB before implementing this change. According to MTSU Policy, a researcher is defined as anyone who works with data or has contact with participants. Anyone meeting this definition needs to be listed on the protocol and needs to provide a certificate of training to the Office of Compliance. If you add researchers to an approved project, please forward an updated list of researchers and their certificates of training to the Office of Compliance before they begin to work on the project. Once your research is completed, please send us a copy of the final report questionnaire to the Office of Compliance. This form can be located at www.mtsu.edu/irb on the forms page. Also, all research materials must be retained by the PI or faculty advisor (if the PI is a student) for at least three (3) years after study completion.
Should you have any questions or need additional
information, please do not hesitate to contact me.
Sincerely,
Andrew W. Jones
Andrew W. Jones
Graduate Assistant
Compliance Office
615-494

Appendix C: Part II Statistical Data

web	overall		DEV	ftf	web	overall
2.75	2.67		took a DEV class	64.62%	45.11%	55.85%

average placement test scores	ftf	web	overall	
reading	76.99 (740)	80.55 (476)	78.38 (1216)	
writing	73.54 (740)	80.28 (479)	76.19 (1219)	
arithmetic	58.76 (818)	67.72 (579)	62.47 (1397)	
math	50.28 (501)	49.84 (449)	50.07 (950)	
college math	29.94 (34)	23.93 (46)	26.48 (80)	
Note that the math scores are tiered:				Table is in
to take the college math placement				score (number)
you must pass a threshold on the				format
math placement test. To take the				
math placement test, you must score				
above the threshold on the arithmetic				
placement test. That explains the large				
drop in the number of students that				
took each respective math test (the number				
in parens).				

Chemistry Grades

FTF Grade_Cd				
Grade	**Frequency**	**Percent**	**Cumulative Frequency**	**Cumulative Percent**
A	247	26.65	247	26.65
B	203	21.9	450	48.54
C	166	17.91	616	66.45
D	53	5.72	669	72.17
F	95	10.25	764	82.42
I	4	0.43	768	82.85
W	159	17.15	927	100
non-success	311	33.55	311	33.55
success	616	66.45	927	100
Web Grade_Cd				
Grade	**Frequency**	**Percent**	**Cumulative Frequency**	**Cumulative Percent**
A	159	21.03	159	21.03
B	149	19.71	308	40.74
C	103	13.62	411	54.37
D	47	6.22	458	60.58
F	112	14.81	570	75.4
I	4	0.53	574	75.93
W	182	24.07	756	100
non-success	345	45.63	345	45.63
success	411	54.37	756	100

	chem 120 coursework success		
success in other internet courses	**FTF**	**Web**	**Overall**
success	63.19%	65.15%	64.07%
non-success	36.81%	34.85%	35.93%

DEV Grades FTF

for all FTF classes				
DEV064_grade	**Frequency**	**Percent**	**Cumulative**	**Cumulative**
			Frequency	**Percent**
P	13	25.49	13	25.49
S	38	74.51	51	100
success	51			
non-success	0			
DEV065_grade	**Frequency**	**Percent**	**Cumulative**	**Cumulative**
			Frequency	**Percent**
A	80	30.42	80	30.42
B	109	41.44	189	71.86
C	43	16.35	232	88.21
F	2	0.76	234	88.97
N	2	0.76	236	89.73
P	20	7.6	256	97.34
W	7	2.66	263	100
success	252			
non-success	11			
DEV075_grade	**Frequency**	**Percent**	**Cumulative**	**Cumulative**
			Frequency	**Percent**
N	1	0.7	1	0.7
P	66	46.15	67	46.85
S	74	51.75	141	98.6
W	2	1.4	143	100
success	140			
non-success	3			
DEV084_grade	**Frequency**	**Percent**	**Cumulative**	**Cumulative**
			Frequency	**Percent**
N	6	6.74	6	6.74
P	17	19.1	23	25.84
S	64	71.91	87	97.75

W	2	2.25	89	100
success	81			
non-success	8			
DEV085_grade	**Frequency**	**Percent**	**Cumulative**	**Cumulative**
			Frequency	**Percent**
A	106	29.61	106	29.61
B	121	33.8	227	63.41
C	85	23.74	312	87.15
F	10	2.79	322	89.94
N	6	1.68	328	91.62
P	25	6.98	353	98.6
W	5	1.4	358	100
success	337			
non-success	21			
DEV108_grade	**Frequency**	**Percent**	**Cumulative**	**Cumulative**
			Frequency	**Percent**
A	112	22.76	112	22.76
B	155	31.5	267	54.27
C	131	26.63	398	80.89
F	18	3.66	416	84.55
N	19	3.86	435	88.41
P	22	4.47	457	92.89
W	31	6.3	488	99.19
Z	4	0.81	492	100
success	420			
non-success	72			
DEV110_grade	**Frequency**	**Percent**	**Cumulative**	**Cumulative**
			Frequency	**Percent**
A	102	29.82	102	29.82
B	112	32.75	214	62.57
C	67	19.59	281	82.16
F	7	2.05	288	84.21
I	1	0.29	289	84.5
N	9	2.63	298	87.13

P	26	7.6	324	94.74
W	16	4.68	340	99.42
Z	2	0.58	342	100
success	307			
non-success	35			
DEV130_grade	**Frequency**	**Percent**	**Cumulative**	**Cumulative**
			Frequency	**Percent**
C	1	50	1	50
W	1	50	2	100
success	1			
non-success	1			
* A B C P S = success				
other = non-success				

DEV Grades Web

for all online classes				
DEV064_grade	**Frequency**	**Percent**	**Cumulative**	**Cumulative**
			Frequency	**Percent**
P	4	28.57	4	28.57
S	9	64.29	13	92.86
U	1	7.14	14	100
success	13			
non-success	1			
DEV065_grade	**Frequency**	**Percent**	**Cumulative**	**Cumulative**
			Frequency	**Percent**
A	28	34.57	28	34.57
B	32	39.51	60	74.07
C	11	13.58	71	87.65
F	3	3.7	74	91.36
N	1	1.23	75	92.59
P	5	6.17	80	98.77
Z	1	1.23	81	100
success	76			
non-success	5			
DEV075_grade	**Frequency**	**Percent**	**Cumulative**	**Cumulative**
			Frequency	**Percent**
F	2	5.26	2	5.26
N	2	5.26	4	10.53
P	12	31.58	16	42.11
S	22	57.89	38	100
success	34			
non-success	4			
DEV084_grade	**Frequency**	**Percent**	**Cumulative**	**Cumulative**
			Frequency	**Percent**
P	5	19.23	5	19.23
S	19	73.08	24	92.31

U	1	3.85	25	96.15
W	1	3.85	26	100
success	24			
non-success	2			
DEV085_grade	**Frequency**	**Percent**	**Cumulative**	**Cumulative**
			Frequency	**Percent**
A	48	29.63	48	29.63
B	70	43.21	118	72.84
C	28	17.28	146	90.12
F	3	1.85	149	91.98
N	2	1.23	151	93.21
P	6	3.7	157	96.91
W	3	1.85	160	98.77
Z	2	1.23	162	100
success	152			
non-success	10			
DEV108_grade	**Frequency**	**Percent**	**Cumulative**	**Cumulative**
			Frequency	**Percent**
A	82	29.39	82	29.39
B	90	32.26	172	61.65
C	57	20.43	229	82.08
F	9	3.23	238	85.3
I	1	0.36	239	85.66
N	14	5.02	253	90.68
P	12	4.3	265	94.98
W	12	4.3	277	99.28
Z	2	0.72	279	100
success	241			
non-success	38			
DEV110_grade	**Frequency**	**Percent**	**Cumulative**	**Cumulative**
			Frequency	**Percent**
A	53	43.44	53	43.44
B	47	38.52	100	81.97
C	10	8.2	110	90.16

F	2	1.64	112	91.8
N	2	1.64	114	93.44
P	5	4.1	119	97.54
W	3	2.46	122	100
success	115			
non-success	7			
DEV130_grade	**Frequency**	**Percent**	**Cumulative**	**Cumulative**
			Frequency	**Percent**
no online students in CHE-120 took DEV 130				

CHE 120 Success Rates

	Chem 120 Success Rates:						
	FTF	web					
fail 120	311	345		the observed numbers			
succeed 120	616	411		are in in each cell			
	chi-square = 25.572						
	p<.001		the overall pass rate for online students is significantly				
			lower than it is for face to face interactions				
	Here are the detailed statistical results						
	Table of success by web						
			web		**Total**		
			0	**1**			
	success		311	345	656		
	0	**Frequency**					
		Percent	18.48	20.5	38.98		
		Row Pct	47.41	52.59			
		Col Pct	33.55	45.63			
	1	**Frequency**	616	411	1027		
		Percent	36.6	24.42	61.02		
		Row Pct	59.98	40.02			
		Col Pct	66.45	54.37			
			927	756	1683		
	Total	**Frequency**					
		Percent	55.08	44.92	100		
	Statistic	**DF**	**Value**	**Prob**			

	Chi-Square	1	25.572	<.0001			
	Likelihood Ratio Chi-Square	1	25.555	<.0001			
	Continuity Adj. Chi-Square	1	25.0664	<.0001			
	Mantel-Haenszel Chi-Square	1	25.5568	<.0001			
	Phi Coefficient		-0.1233				
	Contingency Coefficient		0.1223				
	Cramer's V		-0.1233				
	Fisher's Exact Test						
	Cell (1,1) Frequency (F)	311					
	Left-sided Pr <= F	2.79E-07					
	Right-sided Pr >= F	1					
	Table Probability (P)	1.14E-07					
	Two-sided Pr <= P	4.91E-07					
	Chem 120 Success Rates:						
	no DEV needed	needed DEV					
fail 120	223	433		the observed numbers			
succeed 120	520	507		are in in each cell			
	chi-square = 44.9466						

	p<.001						
		the overall pass rate for students who did not require					
		DEV instruction (70%) is significantly higher than the pass					
		rate for those that needed remediation (53.9%)					
	Table of success by took_dev						
			took_dev		**Total**		
			0	**1**			
	success		223	433	656		
	0	**Frequency**					
		Percent	13.25	25.73	38.98		
		Row Pct	33.99	66.01			
		Col Pct	30.01	46.06			
	1	**Frequency**	520	507	1027		
		Percent	30.9	30.12	61.02		
		Row Pct	50.63	49.37			
		Col Pct	69.99	53.94			
			743	940	1683		
	Total	**Frequency**					
		Percent	44.15	55.85	100		
	Statistic	**DF**	**Value**	**Prob**			
	Chi-Square	1	44.9466	<.0001			
	Likelihood Ratio Chi-Square	1	45.4758	<.0001			
	Continuity Adj. Chi-Square	1	44.2743	<.0001			
	Mantel-Haenszel Chi-Square	1	44.9199	<.0001			
	Phi Coefficient		-0.1634				
	Contingency Coefficient		0.1613				

	Cramer's V		-0.1634				
	Fisher's Exact Test						
	Cell (1,1) Frequency (F)	223					
	Left-sided Pr <= F	1.10E-11					
	Right-sided Pr >= F	1					
	Table Probability (P)	5.57E-12					
	Two-sided Pr <= P	1.94E-11					
	Chem 120 Success Rates:						
	fail 085	succeed 085					
fail 120	219	52		the observed numbers			
succeed 120	15	653		are in in each cell			
	chi-square = 636.032						
	p<.001						
		the overall pass rate for CHE-120 students who passed					
		DEV 085 (92.6%) is significantly higher than the pass					
		rate for CHE-120 students that did not pass 085 (6.4%)					
	Table of success by DEV085_success						

			DEV085_success		Total		
			0	1			
	success		219	52	271		
	0	Frequency					
		Percent	23.32	5.54	28.86		
		Row Pct	80.81	19.19			
		Col Pct	93.59	7.38			
	1	Frequency	15	653	668		
		Percent	1.6	69.54	71.14		
		Row Pct	2.25	97.75			
		Col Pct	6.41	92.62			
			234	705	939		
	Total	Frequency					
		Percent	24.92	75.08	100		
	Frequency Missing = 744						
	Statistic	DF	Value	Prob			
	Chi-Square	1	636.032	<.0001			
	Likelihood Ratio Chi-Square	1	645.8609	<.0001			
	Continuity Adj. Chi-Square	1	631.8398	<.0001			
	Mantel-Haenszel Chi-Square	1	635.3546	<.0001			
	Phi Coefficient		0.823				
	Contingency Coefficient		0.6355				
	Cramer's V		0.823				
	Fisher's Exact Test						
	Cell (1,1) Frequency (F)	219					
	Left-sided Pr <= F	1					
	Right-sided Pr >= F	1.21E-141					

	Table Probability (P)	2.02E-139					
	Two-sided Pr <= P	1.21E-141					
	Chem 120 Success Rates:						
	fail 108	succeed 108					
fail 120	298	54		the observed numbers			
succeed 120	45	679		are in in each cell			
	chi-square = 671.1362						
	p<.001						
		the overall pass rate for CHE-120 students who passed					
		DEV 108 (89.9%) is significantly higher than the pass					
		rate for CHE-120 students that did not pass 108 (7.4%)					
	Table of success by DEV108_success						
			DEV108_success		**Total**		
			0	**1**			
	success		298	54	352		
	0	**Frequency**					
		Percent	27.7	5.02	32.71		
		Row Pct	84.66	15.34			

		Col Pct	86.88	7.37			
	1	**Frequenc y**	45	679	724		
		Percent	4.18	63.1	67.29		
		Row Pct	6.22	93.78			
		Col Pct	13.12	92.63			
			343	733	1076		
	Total	**Frequenc y**					
		Percent	31.88	68.12	100		
	Frequency Missing = 607						
	Statistic	**DF**	**Value**	**Prob**			
	Chi-Square	1	671.13 62	<.000 1			
	Likelihood Ratio Chi-Square	1	708.13 25	<.000 1			
	Continuity Adj. Chi-Square	1	667.52 88	<.000 1			
	Mantel-Haenszel Chi-Square	1	670.51 25	<.000 1			
	Phi Coefficient		0.7898				
	Contingency Coefficient		0.6198				
	Cramer's V		0.7898				
	Fisher's Exact Test						
	Cell (1,1) Frequency (F)	298					
	Left-sided Pr <= F	1					
	Right-sided Pr >= F	2.38E-155					
	Table Probability (P)	1.88E-153					
	Two-sided Pr <= P	2.38E-155					

ANOVA

FTF Classes :								
	parameter	estimate	SE	T	p-value			
	intercept	0.108264	0.012851	8.42	<.0001			
	success_other_web	0.880334	0.016357	53.82	<.0001			
							significant result	
Web Classes :								
	parameter	estimate	SE	T	p-value			
	intercept	0.041903	0.025689	1.63	0.1033			
	success_other_web	0.770195	0.033205	23.19	<.0001			
	So there is a significant effect of other web course success on the success rate in CHE-120							

Correlations

ALL												
	Pearson Correlation Coefficients											
	arith_score	**math_score**	**colmath_score**	**read_score**	**write_score**	**Cumulative_GPA**	**FT**	**success_other_web**	**DEV085_success**	**DEV108_success**	**grade85**	**grade108**
success	0.15851	0.17465	-0.12692	0.09149	0.06562	0.48766	0.17782	0.7436	0.81274	0.78156	0.26941	0.27092
	<.0001	<.0001	0.2619	0.0014	0.0219	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
	1397	950	80	1216	1219	1601	1601	1601	889	1018	436	611
FTF												
	Pearson Correlation Coefficients											
	arith_score	**math_score**	**colmath_score**	**read_score**	**write_score**	**Cumulative_GPA**	**FT**	**success_other_web**	**DEV085_success**	**DEV108_success**	**grade85**	**grade108**
	0.13604	0.16638	-0.15134	0.13526	0.10127	0.52676	0.23361	0.86333	0.81077	0.79144	0.31275	0.30386
	<.0001	0.0002	0.3929	0.0002	0.0058	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
	818	501	34	740	740	889	889	889	538	609	300	393
web												
	Pearson Correlation Coefficients											
	arith_score	**math_score**	**colmath_score**	**read_score**	**write_score**	**Cumulative_GPA**	**FT**	**success_other_web**	**DEV085_success**	**DEV108_success**	**grade85**	**grade108**
	0.24485	0.18382	-0.2119	0.06911	0.06731	0.47041	0.06931	0.61393	0.82006	0.77662	0.22832	0.27937
	<.0001	<.0001	0.1574	0.1322	0.1413	<.0001	0.0645	<.0001	<.0001	<.0001	0.0075	<.0001
	579	449	46	476	479	712	712	712	351	409	136	218

PART II Statistical Data Using T-Tests

Variable: Age web students are significantly older

web	N	Mean	Std Dev	Std Err	Minimum	Maximum
0	889	26.7188	8.6821	0.2912	15.0000	62.0000
1	712	29.9312	8.0957	0.3034	15.0000	60.0000
Diff (1-2)		-3.2124	8.4264	0.4238		

web	Method	Mean	95% CL Mean		Std Dev	95% CL Std Dev	
0		26.7188	26.1473	27.2903	8.6821	8.2964	9.1056
1		29.9312	29.3355	30.5268	8.0957	7.6960	8.5396
Diff (1-2)	Pooled	-3.2124	-4.0436	-2.3812	8.4264	8.1442	8.7290
Diff (1-2)	Satterthwaite	-3.2124	-4.0372	-2.3875			

Method	Variances	DF	t Value	Pr > |t|
Pooled	Equal	1599	-7.58	<.0001
Satterthwaite	Unequal	1562.6	-7.64	<.0001

Equality of Variances				
Method	Num DF	Den DF	F Value	Pr > F
Folded F	888	711	1.15	0.0505

Variable: Cumulative_GPA (Cumulative_GPA_Ct) web students have a significantly higher GPA

web	N	Mean	Std Dev	Std Err	Minimum	Maximum
0	889	2.6281	0.9160	0.0307	0	4.0000
1	712	2.7679	0.8851	0.0332	0	4.0000
Diff (1-2)		-0.1397	0.9024	0.0454		

web	Method	Mean	95% CL Mean		Std Dev	95% CL Std Dev	
0		2.6281	2.5678	2.6884	0.9160	0.8753	0.9607
1		2.7679	2.7028	2.8330	0.8851	0.8413	0.9336
Diff (1-2)	Pooled	-0.1397	-0.2288	-0.0507	0.9024	0.8722	0.9348
Diff (1-2)	Satterthwaite	-0.1397	-0.2284	-0.0511			

Method	Variances	DF	t Value	Pr > |t|
Pooled	Equal	1599	-3.08	0.0021
Satterthwaite	Unequal	1544.2	-3.09	0.0020

Equality of Variances				
Method	Num DF	Den DF	F Value	Pr > F
Folded F	888	711	1.07	0.3359

Variable: Term_GPA (Term_GPA_Ct)

web	N	Mean	Std Dev	Std Err	Minimum	Maximum
0	889	2.4689	1.2196	0.0409	0	4.0000
1	712	2.4370	1.2749	0.0478	0	4.0000
Diff (1-2)		0.0318	1.2444	0.0626		

web	Method	Mean	95% CL Mean		Std Dev	95% CL Std Dev	
0		2.4689	2.3886	2.5491	1.2196	1.1654	1.2790
1		2.4370	2.3432	2.5308	1.2749	1.2119	1.3448
Diff (1-2)	Pooled	0.0318	-0.0909	0.1546	1.2444	1.2028	1.2891
Diff (1-2)	Satterthwaite	0.0318	-0.0915	0.1552			

Method	Variances	DF	t Value	Pr > |t|
Pooled	Equal	1599	0.51	0.6110
Satterthwaite	Unequal	1493	0.51	0.6128

Equality of Variances				
Method	Num DF	Den DF	F Value	Pr > F
Folded F	711	888	1.09	0.2112

Variable: success_other_web

web	N	Mean	Std Dev	Std Err	Minimum	Maximum
0	889	0.6386	0.4646	0.0156	0	1.0000
1	712	0.6791	0.4025	0.0151	0	1.0000
Diff (1-2)		-0.0405	0.4380	0.0220		

web	Method	Mean	95% CL Mean		Std Dev	95% CL Std Dev	
0		0.6386	0.6080	0.6692	0.4646	0.4439	0.4872
1		0.6791	0.6495	0.7087	0.4025	0.3826	0.4245
Diff (1-2)	Pooled	-0.0405	-0.0837	0.0027	0.4380	0.4234	0.4538
Diff (1-2)	Satterthwaite	-0.0405	-0.0830	0.0020	8		

Method	Variances	DF	t Value	Pr > |t|
Pooled	Equal	1599	-1.84	0.0665
Satterthwaite	Unequal	1589.2	-1.87	0.0623

Equality of Variances				
Method	Num DF	Den DF	F Value	Pr > F
Folded F	888	711	1.33	<.0001

Variable: minority

web	N	Mean	Std Dev	Std Err	Minimum	Maximum
0	889	0.4601	0.7204	0.0242	0	2.0000
1	712	0.4228	0.7461	0.0280	0	2.0000
Diff (1-2)		0.0373	0.7319	0.0368		

web	Method	Mean	95% CL Mean		Std Dev	95% CL Std Dev	
0		0.4601	0.4126	0.5075	0.7204	0.6884	0.7555
1		0.4228	0.3679	0.4776	0.7461	0.7092	0.7870
Diff (1-2)	Pooled	0.0373	-0.0349	0.1095	0.7319	0.7074	0.7582
Diff (1-2)	Satterthwaite	0.0373	-0.0352	0.1098			

Method	Variances	DF	t Value	Pr > |t|
Pooled	Equal	1599	1.01	0.3109
Satterthwaite	Unequal	1499.7	1.01	0.3128

Equality of Variances				
Method	Num DF	Den DF	F Value	Pr > F
Folded F	711	888	1.07	0.3233

Variable: took_dev web students are significantly less likely to have taken a DEV course

web	N	Mean	Std Dev	Std Err	Minimum	Maximum
0	889	0.6400	0.4803	0.0161	0	1.0000
1	712	0.4424	0.4970	0.0186	0	1.0000
Diff (1-2)		0.1976	0.4878	0.0245		

web	Method	Mean	95% CL Mean		Std Dev	95% CL Std Dev	
0		0.6400	0.6084	0.6717	0.4803	0.4589	0.5037
1		0.4424	0.4058	0.4790	0.4970	0.4725	0.5243
Diff (1-2)	Pooled	0.1976	0.1495	0.2457	0.4878	0.4714	0.5053
Diff (1-2)	Satterthwaite	0.1976	0.1493	0.2459			

Method	Variances	DF	t Value	Pr > |t|
Pooled	Equal	1599	8.06	<.0001
Satterthwaite	Unequal	1500	28.03	<.0001

Equality of Variances				
Method	Num DF	Den DF	F Value	Pr > F
Folded F	711	888	1.07	0.3332

Variable: arith_score (Score_Ct) web students have a significantly higher arithmetic score

web	N	Mean	Std Dev	Std Err	Minimum	Maximum
0	819	58.2589	27.6179	0.9650	1.0000	120.0
1	579	66.2919	29.2692	1.2164	9.0000	120.0
Diff (1-2)		-8.0330	28.3133	1.5373		

web	Method	Mean	95% CL Mean		Std Dev	95% CL Std Dev	
0		58.2589	56.3646	60.1531	27.6179	26.3421	29.0245
1		66.2919	63.9028	68.6810	29.2692	27.6749	31.0598
Diff (1-2)	Pooled	-8.0330	-11.0487	-5.0173	28.3133	27.3010	29.4041
Diff (1-2)	Satterthwaite	-8.0330	-11.0794	-4.9867			

Method	Variances	DF	t Value	Pr > |t|
Pooled	Equal	1396	-5.23	<.0001
Satterthwaite	Unequal	1199	-5.17	<.0001

Equality of Variances				
Method	Num DF	Den DF	F Value	Pr > F
Folded F	578	818	1.12	0.1286

Variable: math_score (Score_Ct)

web	N	Mean	Std Dev	Std Err	Minimum	Maximum
0	502	50.2351	26.2355	1.1709	0	119.0
1	449	48.8352	26.7657	1.2632	0	119.0
Diff (1-2)		1.3999	26.4871	1.7205		

web	Method	Mean	95% CL Mean		Std Dev	95% CL Std Dev	
0		50.2351	47.9345	52.5356	26.2355	24.7068	27.9673
1		48.8352	46.3528	51.3176	26.7657	25.1221	28.6412
Diff (1-2)	Pooled	1.3999	-1.9765	4.7763	26.4871	25.3473	27.7350
Diff (1-2)	Satterthwaite	1.3999	-1.9804	4.7801			

Method	Variances	DF	t Value	Pr > |t|
Pooled	Equal	949	0.81	0.4160
Satterthwaite	Unequal	932.8	20.81	0.4166

Equality of Variances				
Method	Num DF	Den DF	F Value	Pr > F
Folded F	448	501	1.04	0.6623

Variable: read_score (Score_Ct) web students have a significantly higher reading score

web	N	Mean	Std Dev	Std Err	Minimum	Maximum
0	739	76.5345	19.5502	0.7192	0	120.0
1	476	80.6134	20.6938	0.9485	0	120.0
Diff (1-2)		-4.0789	20.0058	1.1758		

web	Method	Mean	95% CL Mean		Std Dev	95% CL Std Dev	
0		76.5345	75.1227	77.9464	19.5502	18.6018	20.6013
1		80.6134	78.7497	82.4772	20.6938	19.4575	22.0992
Diff (1-2)	Pooled	-4.0789	-6.3857	-1.7722	20.0058	19.2405	20.8350
Diff (1-2)	Satterthwaite	-4.0789	-6.4148	-1.7431			

Method	Variances	DF	t Value	Pr > |t|
Pooled	Equal	1213	-3.47	0.0005
Satterthwaite	Unequal	971.48	-3.43	0.0006

Equality of Variances				
Method	Num DF	Den DF	F Value	Pr > F
Folded F	475	738	1.12	0.1684

Variable: write_score (Score_Ct) web students have a significantly higher writing score

web	N	Mean	Std Dev	Std Err	Minimum	Maximum
0	740	72.5554	26.6954	0.9813	0	120.0
1	479	79.8184	24.7119	1.1291	0	120.0
Diff (1-2)		-7.2630	25.9344	1.5209		

web	Method	Mean	95% CL Mean		Std Dev	95% CL Std Dev	
0		72.5554	70.6289	74.4820	26.6954	25.4011	28.1296
1		79.8184	77.5997	82.0370	24.7119	23.2399	26.3846
Diff (1-2)	Pooled	-7.2630	-10.2468	-4.2791	25.9344	24.9439	27.0075
Diff (1-2)	Satterthwaite	-7.2630	-10.1983	-4.3276			

Method	Variances	DF	t Value	Pr > |t|
Pooled	Equal	1217	-4.78	<.0001
Satterthwaite	Unequal	1075.8	-4.86	<.0001

Equality of Variances				
Method	Num DF	Den DF	F Value	Pr > F
Folded F	739	478	1.17	0.0654

Variable: colmath_score (Score_Ct)

web	N	Mean	Std Dev	Std Err	Minimum	Maximum
0	36	30.2778	22.7754	3.7959	6.0000	80.0000
1	46	24.8478	18.7118	2.7589	3.0000	88.0000
Diff (1-2)		5.4300	20.5886	4.5815		

web	Method	Mean	95% CL Mean		Std Dev	95% CL Std Dev	
0		30.2778	22.5717	37.9839	22.7754	18.4727	29.7091
1		24.8478	19.2911	30.4045	18.7118	15.5203	23.5680
Diff (1-2)	Pooled	5.4300	-3.6874	14.5473	20.5886	17.8334	24.3585
Diff (1-2)	Satterthwaite	5.4300	-3.9361	14.7960			

Method	Variances	DF	t Value	Pr > |t|
Pooled	Equal	80	1.19	0.2394
Satterthwaite	Unequal	67.167	1.16	0.2513

Equality of Variances				
Method	Num DF	Den DF	F Value	Pr > F
Folded F	35	45	1.48	0.2132

Grades are non-constant across web, FTF:

Kruskal-Wallis Test	
Chi-Square	6.5722
DF	1
Pr > Chi-Square	0.0104

Kolmogorov-Smirnov Two-Sample Test (Asymptotic)			
KS	0.043400	D	0.088415
KSa	1.472405	Pr > KSa	0.0262

Full-Time Part-Time status is also non constant

Kruskal-Wallis Test	
Chi-Square	32.0580
DF	1
Pr > Chi-Square	<.0001

Kolmogorov-Smirnov Two-Sample Test (Asymptotic)			
KS	0.069888	D	0.141282
KSa	2.666772	Pr > KSa	<.0001

Age is detected in these tests as well:

Kruskal-Wallis Test	
Chi-Square	94.9567
DF	1
Pr > Chi-Square	<.0001

Kolmogorov-Smirnov Two-Sample Test (Asymptotic)			
KS	0.129135	D	0.261052
KSa	4.927469	Pr > KSa	<.0001

Cumulative GPA:

Kruskal-Wallis Test	
Chi-Square	12.9638
DF	1
Pr > Chi-Square	0.0003

Kolmogorov-Smirnov Two-Sample Test (Asymptotic)			
KS	0.057848	D	0.116943
KSa	2.207355	Pr > KSa	0.0001

Took DEV course

Kruskal-Wallis Test	
Chi-Square	48.4353
DF	1
Pr > Chi-Square	<.0001

Kolmogorov-Smirnov Two-Sample Test (Asymptotic)			
KS	0.089805	D	0.181545
KSa	3.426741	Pr > KSa	<.0001

Arithmetic test scores

Kruskal-Wallis Test	
Chi-Square	23.0878
DF	1
Pr > Chi-Square	<.0001

Kolmogorov-Smirnov Two-Sample Test (Asymptotic)			
KS	0.058769	D	0.119612
KSa	2.127909	Pr > KSa	0.0002

Reading Scores:

Kruskal-Wallis Test	
Chi-Square	16.9922
DF	1
Pr > Chi-Square	<.0001

Kolmogorov-Smirnov Two-Sample Test (Asymptotic)			
KS	0.065133	D	0.133746
KSa	2.202047	Pr > KSa	0.0001

Writing Scores:

Kruskal-Wallis Test	
Chi-Square	23.4187
DF	1
Pr > Chi-Square	<.0001

Kolmogorov-Smirnov Two-Sample Test (Asymptotic)			
KS	0.063939	D	0.131182
KSa	2.166401	Pr > KSa	0.0002

Stepwise regression

FTF										
Analysis of Variance										
Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**					
Model	6	2.84179	0.47363	16.45	<.0001		model for FTF classes is significant			
Error	18	0.51821	0.02879							
Corrected Total	24	3.36								
Variable	**Parameter Estimate**	**Standard Error**	**Type II SS**	**F Value**	**Pr > F**					
Intercept	0.97142	0.29221	0.31817	11.05	0.0038					
math_score	-0.006664	0.00145	0.60048	20.86	0.0002					
colmath_score	-0.003001	0.00161	0.10034	3.49	0.0783					
read_score	-0.009	0.00263	0.33775	11.73	0.003		These variables are significant:			
write_score	0.00652	0.00248	0.19941	6.93	0.0169		math, reading, and writing scores,			
Cumulative_GPA	0.17046	0.0378	0.58538	20.33	0.0003		cumulative GPA and Full Time status			
FT	0.33158	0.07506	0.56178	19.51	0.0003					

Web										
Analysis of Variance										
Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**					
Model	6	4.60868	0.76811	8.48	0.0002	←	model for web classes is significant			
Error	18	1.63132	0.09063							
Corrected Total	24	6.24								
Variable	**Parameter Estimate**	**Standard Error**	**Type II SS**	**F Value**	**Pr > F**					
Intercept	0.3723	0.53447	0.04397	0.49	0.495					
math_score	0.00445	0.0027	0.24568	2.71	0.117					
colmath_score	-0.00337	0.00438	0.05379	0.59	0.451					
read_score	-0.00747	0.00462	0.23758	2.62	0.1228					
write_score	-0.00075562	0.00437	0.00271	0.03	0.8647					
FT	0.334	0.13139	0.58569	6.46	0.0204	↖	These variables are significant:			
success_other_web	0.74466	0.15642	2.05394	22.66	0.0002		Full Time Status and success in			
							other web based classes			
							(proportion of other online classes			

							where student succeeded).			

MTSU Educational Data

Demogrpahics

gender	ftf	web	overall
male	22.44%	20.90%	21.75%
female	77.56%	79.10%	78.25%
ethnic status	ftf	web	overall
minority	19.31%	10.98%	15.57%
non-minority	66.77%	73.54%	69.82%
unknown	0.1392	0.1548	14.62%
Age	ftf	web	overall
min	15	15	15
max	62	60	62
average	26.8	30.0	28.2

DEV Grades FTF

For all FTF classes

DEV064_grade	Frequency	Percent	Cumulative Frequency	Cumulative Percent
P	13	25.49	13	25.49
S	38	74.51	51	100
success	51			
non-success	0			

DEV065_grade	Frequency	Percent	Cumulative Frequency	Cumulative Percent
A	80	30.42	80	30.42
B	109	41.44	189	71.86
C	43	16.35	232	88.21
F	2	0.76	234	88.97
N	2	0.76	236	89.73
P	20	7.6	256	97.34
W	7	2.66	263	100
success	252			
non-success	11			

DEV075_grade	Frequency	Percent	Cumulative Frequency	Cumulative Percent
N	1	0.7	1	0.7
P	66	46.15	67	46.85
S	74	51.75	141	98.6
W	2	1.4	143	100
success	140			
non-success	3			

DEV084_grade	Frequency	Percent	Cumulative Frequency	Cumulative Percent
N	6	6.74	6	6.74
P	17	19.1	23	25.84
S	64	71.91	87	97.75
W	2	2.25	89	100

success	81
non-success	8

DEV085_grade	Frequency	Percent	Cumulative Frequency	Cumulative Percent
A	106	29.61	106	29.61
B	121	33.8	227	63.41
C	85	23.74	312	87.15
F	10	2.79	322	89.94
N	6	1.68	328	91.62
P	25	6.98	353	98.6
W	5	1.4	358	100
success	337			
non-success	21			

DEV108_grade	Frequency	Percent	Cumulative Frequency	Cumulative Percent
A	112	22.76	112	22.76
B	155	31.5	267	54.27
C	131	26.63	398	80.89
F	18	3.66	416	84.55
N	19	3.86	435	88.41
P	22	4.47	457	92.89
W	31	6.3	488	99.19
Z	4	0.81	492	100
success	420			
non-success	72			

DEV110_grade	Frequency	Percent	Cumulative Frequency	Cumulative Percent
A	102	29.82	102	29.82
B	112	32.75	214	62.57
C	67	19.59	281	82.16
F	7	2.05	288	84.21
I	1	0.29	289	84.5
N	9	2.63	298	87.13
P	26	7.6	324	94.74
W	16	4.68	340	99.42

Z	2	0.58	342	100
success	307			
non-success	35			

DEV130_grade	Frequency	Percent	Cumulative Frequency	Cumulative Percent
C	1	50	1	50
W	1	50	2	100
success	1			
non-success	1			

* A B C P S = success
other = non-success

DEV Grades WEB

for all online classes

DEV064_grade	Frequency	Percent	Cumulative Frequency	Cumulative Percent
P	4	28.57	4	28.57
S	9	64.29	13	92.86
U	1	7.14	14	100
success	13			
non-success	1			

DEV065_grade	Frequency	Percent	Cumulative Frequency	Cumulative Percent
A	28	34.57	28	34.57
B	32	39.51	60	74.07
C	11	13.58	71	87.65
F	3	3.7	74	91.36
N	1	1.23	75	92.59
P	5	6.17	80	98.77
Z	1	1.23	81	100
success	76			
non-success	5			

DEV075_grade	Frequency	Percent	Cumulative Frequency	Cumulative Percent
F	2	5.26	2	5.26
N	2	5.26	4	10.53
P	12	31.58	16	42.11
S	22	57.89	38	100
success	34			
non-success	4			

DEV084_grade	Frequency	Percent	Cumulative Frequency	Cumulative Percent
P	5	19.23	5	19.23
S	19	73.08	24	92.31
U	1	3.85	25	96.15
W	1	3.85	26	100
success	24			
non-success	2			

DEV085_grade	Frequency	Percent	Cumulative Frequency	Cumulative Percent
A	48	29.63	48	29.63
B	70	43.21	118	72.84
C	28	17.28	146	90.12

F	3	1.85	149	91.98
N	2	1.23	151	93.21
P	6	3.7	157	96.91
W	3	1.85	160	98.77
Z	2	1.23	162	100
success	152			
non-success	10			

DEV108_grade	Frequency	Percent	Cumulative Frequency	Cumulative Percent
A	82	29.39	82	29.39
B	90	32.26	172	61.65
C	57	20.43	229	82.08
F	9	3.23	238	85.3
I	1	0.36	239	85.66
N	14	5.02	253	90.68
P	12	4.3	265	94.98
W	12	4.3	277	99.28
Z	2	0.72	279	100
success	241			
non-success	38			

DEV110_grade	Frequency	Percent	Cumulative Frequency	Cumulative Percent
A	53	43.44	53	43.44
B	47	38.52	100	81.97
C	10	8.2	110	90.16
F	2	1.64	112	91.8
N	2	1.64	114	93.44
P	5	4.1	119	97.54
W	3	2.46	122	100
success	115			
non-success	7			

Fisher's Exact Test	
Cell (1,1) Frequency (F)	223
Left-sided Pr <= F	1.10E-11

Right-sided Pr >= F	1
Table Probability (P)	5.57E-12
Two-sided Pr <= P	1.94E-11

Chem 120 Success Rates:

	fail 085	succeed 085
fail 120	219	52
succeed 120	15	653

the observed numbers are in in each cell

chi-square = 636.032

p<.001

the overall pass rate for CHE-120 students who passed DEV 085 (92.6%) is significantly higher than the pass rate for CHE-120 students that did not pass 085 (6.4%)

Table of success by DEV085_success

		DEV085_success		
		0	1	Total
success				
0	**Frequency**	219	52	271
	Percent	23.32	5.54	28.86
	Row Pct	80.81	19.19	
	Col Pct	93.59	7.38	
1	**Frequency**	15	653	668
	Percent	1.6	69.54	71.14
	Row Pct	2.25	97.75	
	Col Pct	6.41	92.62	
Total	**Frequency**	234	705	939

	Percent	24.92	75.08	100

Frequency Missing = 744

Statistic	DF	Value	Prob
Chi-Square	1	636.032	<.0001
Likelihood Ratio Chi-Square	1	645.8609	<.0001
Continuity Adj. Chi-Square	1	631.8398	<.0001
Mantel-Haenszel Chi-Square	1	635.3546	<.0001
Phi Coefficient		0.823	
Contingency Coefficient		0.6355	
Cramer's V		0.823	

Fisher's Exact Test	
Cell (1,1) Frequency (F)	219
Left-sided Pr <= F	1
Right-sided Pr >= F	1.21E-141
Table Probability (P)	2.02E-139
Two-sided Pr <= P	1.21E-141

Chem 120 Success Rates:

	fail 108	succeed 108
fail 120	298	54
succeed 120	45	679

the observed numbers are in in each cell

chi-square = 671.1362

p<.001

the overall pass rate for CHE-120 students who passed DEV 108 (89.9%) is significantly higher than the pass rate for CHE-120 students that did not pass 108 (7.4%)

Table of success by DEV108_success

		DEV108_success		
		0	1	Total
success				
0	Frequency	298	54	352
	Percent	27.7	5.02	32.71
	Row Pct	84.66	15.34	
	Col Pct	86.88	7.37	
1	Frequency	45	679	724
	Percent	4.18	63.1	67.29
	Row Pct	6.22	93.78	
	Col Pct	13.12	92.63	
Total	Frequency	343	733	1076
	Percent	31.88	68.12	100

Frequency Missing = 607

Statistic	DF	Value	Prob
Chi-Square	1	671.1362	<.0001
Likelihood Ratio Chi-Square	1	708.1325	<.0001
Continuity Adj. Chi-Square	1	667.5288	<.0001

Mantel-Haenszel Chi-Square	1	670.5125	<.0001
Phi Coefficient		0.7898	
Contingency Coefficient		0.6198	
Cramer's V		0.7898	

Fisher's Exact Test	
Cell (1,1) Frequency (F)	298
Left-sided Pr <= F	1
Right-sided Pr >= F	2.38E-155
Table Probability (P)	1.88E-153
Two-sided Pr <= P	2.38E-155

ANOVA

FTF Classes:								
	parameter	estimate	SE	T	p-value			
	intercept	0.108264	0.012851	8.42	<.0001			
	success_other_web	0.880334	0.016357	53.82	<.0001			
							significant result	
Web Classes:								
	parameter	estimate	SE	T	p-value			
	intercept	0.041903	0.025689	1.63	0.1033			
	success_other_web	0.7701	0.0332	23.1	<.0001			

		95	05	9				
	So there is a significant effect of other web course success on the success rate in CHE-120							

Correlations

read_ score	**write_ score**	**Cumulative_GPA**	**FT**	**success_other_web**	**DEV085_success**	**DEV108_success**	**grade85**	**grade108**
0.09149	0.06562	0.48766	0.17782	0.7436	0.81274	0.78156	0.26941	0.27092
0.0014	0.0219	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
1216	1219	1601	1601	1601	889	1018	436	611
read_ score	**write_ score**	**Cumulative_GPA**	**FT**	**success_other_web**	**DEV085_success**	**DEV108_success**	**grade85**	**grade108**
0.13526	0.10127	0.52676	0.23361	0.86333	0.81077	0.79144	0.31275	0.30386
0.0002	0.0058	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
740	740	889	889	889	538	609	300	393
read_ score	**write_ score**	**Cumulative_GPA**	**FT**	**success_other_web**	**DEV085_success**	**DEV108_success**	**grade85**	**grade108**
0.069	0.0673	0.47041	0.06	0.61393	0.82006	0.77662	0.22	0.279

11	1		931				832	37
0.1322	0.1413	<.0001	0.0645	<.0001	<.0001	<.0001	0.0075	<.0001
476	479	712	712	712	351	409	136	218

Stepwise Regression

FTF										
Analysis of Variance										
Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**					
Model	6	2.84179	0.47363	16.45	<.0001	← model for FTF classes is significant				
Error	18	0.51821	0.02879							
Corrected Total	24	3.36								
Variable	**Parameter Estimate**	**Standard Error**	**Type II SS**	**F Value**	**Pr > F**					
Intercept	0.97142	0.29221	0.31817	11.05	0.0038					
math_score	-0.006664	0.00145	0.60048	20.86	0.0002					
colmath_score	-0.0030	0.00161	0.10034	3.49	0.0783					

	1									
read_score	-0.009	0.00263	0.33775	11.73	0.003		These variables are significant:			
write_score	0.00652	0.00248	0.19941	6.93	0.0169		math, reading, and writing scores,			
Cumulative_GPA	0.17046	0.0378	0.58538	20.33	0.0003		cumulative GPA and Full Time status			
FT	0.33158	0.07506	0.56178	19.51	0.0003					
Web										
Analysis of Variance										
Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**					
Model	6	4.60868	0.76811	8.48	0.0002		model for web classes is significant			
Error	18	1.63132	0.09063							
Corrected Total	24	6.24								
Variable	**Parameter Estimate**	**Standard Error**	**Type II SS**	**F Value**	**Pr > F**					
Intercept	0.3723	0.53447	0.04397	0.49	0.495					
math_score	0.00445	0.0027	0.24568	2.71	0.117					
colmath_score	-0.003337	0.00438	0.05379	0.59	0.451					
read_score	-0.007477	0.00462	0.23758	2.62	0.1228					
write_scor	-	0.004	0.0027	0.03	0.864					

e	0.00075562	37	1		7					
FT	0.334	0.13139	0.58569	6.46	0.0204		These variables are significant:			
success_other_web	0.74466	0.15642	2.05394	22.66	0.0002		Full Time Status and success in			
							other web based classes			
							(proportion of other online classes			
							where student succeeded).			

Major Breakdown for Part II Study

At a Glance

	FTF	Web
Business and Public Services	81	101
Liberal Arts & Sciences	128	123
Life & Health	526	306
STEM	40	29
Personal Interest & Undeclared	113	153
Total	888	712

FTF Web

Business and Public Services

Accounting (ACC)	7	7
Business Information Systems (BIS)	35	30
Computer Information Systems (CIS)	8	16
Criminal Justice Science (CJS)	9	9
Emergency Medical Services (EMS)	6	12
Fire Science Technology (FST)	2	4
Hospitality Management & Tourism (HMT)	3	6
Management, Business (MAN)	5	7
Paralegal (PAR)	0	1
Real Estate (RES)	2	2
Unknown BPS	4	7
Total	81	101

Liberal Arts & Sciences

Africana Studies (AFR)	0	0
American Sign Language (ASL)	0	1
Art (ART)	3	4
Communication (COM)	6	1
Early Childhood Education (ECE)	10	12
English (ENG)	0	1
Geography (GEO)	0	0
History (HIS)	0	2
Interior Design (IND)	0	1
Humanities (HUM)	1	2
Liberal Arts (LSC)	94	88
Music (MUS)	0	0
Political Science (PLS)	2	2
Psychology (PSY)	6	4
Social Work (SWK)	0	2
Theatre (THE)	0	0
Visual Communications (VIS)	6	3
Total	128	123

Life & Health

Allied Health (ALH)	68	49
Dental Health Sciences (DEH)	53	22
Dietetics Tech (DIT)	8	6
Exercise, Nutrition and Sport Sciences (ENS)	4	2
Health Information Management (HIM)	4	6
Medical Asst Tech (MAS)	7	5

	Mental Health Tech (MHT)	9	6
	Nursing (NSG)	256	155
	Occupational Therapy Assistant (OTA)	6	5
	Physical Therapist Assistant (PTA)	43	8
	Radiologic Technology (RAT)	27	15
	Respiratory Care (RET)	30	14
	Surgical Technology (SUT)	7	9
	Unknown L&H	4	4
Total		526	306
STEM			
	Automotive Tech (AUT)	5	6
	Aviation Technology (AVT)	0	2
	Biology (BIO)	14	4
	Computer Aided Manufacturing (CAM)	0	0
	Civil Architectural Technology (CAT)	7	5
	Chemistry (CHE)	0	0
	Electronics Engineering Tech (EET)	2	4
	Automation and Control Technology (EGR)	0	0
	Engineering Technology Design (ETD)	3	2
	Environmental Tech (EVT)	3	3
	Heating Ventilation and Air Conditioning (HVA)	0	0
	Mathematics (MAT)	0	0
	Mechanical Engineering Tech (MET)	0	0
	Operations Technology (OPT)	2	2
	Science, Mathematics and Engineering Division (SME)	3	0
	Unknown STEM	1	1
Total		40	29
Personal Interest & Undeclared			
		113	153
Total		**888**	**712**

Business and Public Services				
General Name	**Program ID**	**Program Name**	**FT F**	**We b**
Accounting (ACC)			7	7
	ACC.92.AAS	ACCOUNTING-AAS		
	ACC.94.AAS	ACCOUNTING-AAS		
	ACC.97.AAS	ACCOUNTING-AAS		
	ACC.AAS	ACCOUNTING-AAS		
	ACC.AS	ACCOUNTING -- AS - OBSOLETE - DO NOT USE		
	ACC.S.AAS	ACCOUNTING-AAS		
	TAXP.S.STC	TAX PRACTITIONER - SHORT TERM CERTIFICATE		
	TAXP.STC	TAX PRACTITIONER - SHORT TERM CERTIFICATE		
	Subtotal		7	7
Business Information Systems (BIS)			1	1
	AS	BUSINESS ADMINISTRATION/UNIV PARALLEL-AS		
	BIAO.AAS	BUSINESS INFORMATION SYS/ACCOUNTING OFFICE OPTION-AAS	1	
	BICPA.AAS	BUSINESS INFORMATION SYSTEMS/PERSONAL COMPUTER APP AAS		
	BILO.AAS	BUSINESS INFORMATION SYS/LEGAL OFFICE OPTION-AAS		
	BIMO.AAS	BUSINESS INFORMATION SYS/MEDICAL OFFICE OPTION-AAS	1	3
	BIMO.S.AAS	BUSINESS INFORMATION SYS/MEDICAL OFFICE OPTION-AAS		
	BIPCA.AAS	BUSINESS INFO SYS/PERSONAL COMPUTER APPLICATIONS-AAS		

	BIPCA.S.AAS	BUSINESS INFO SYS/PERSONAL COMPUTER APPLICATIONS-AAS		
	BIS.AAS	BUSINESS INFORMATION SYSTEMS-AAS		
	BIS.S.AAS	BUSINESS INFORMATION SYSTEMS-AAS		
	BM.CRT	BUSINESS MANAGEMENT CERTIFICATE		
	BM.S.CRT	BUSINESS MANAGEMENT CERTIFICATE		
	BOSS.S.STC	BUSINESS OPERATIONS SYSTEM SUPPORT I -STC		
	BOSS.STC	BUSINESS OPERATIONS SYSTEM SUPPORT I -STC		
	BOSS2.STC	BUSINESS OPERATIONS SYSTEM SUPPORT II - STC		
	BPS.ND	BUSINESS & PUBLIC SERVICES - NO DEGREE AWARDED	1	1
	BU.ND	BUSINESS-NO DEGREE AWARDED	10	3
	BUIP.CRT	BUSINESS INFO SYS/INFORMATION PROCESSING CERTIFICATE		
	BUIP.S.CRT	BUSINESS INFO SYS/INFORMATION PROCESSING CERTIFICATE		
	BUMS.CRT	BUSINESS INFO SYS/MEDICAL OFFICE SPECIALIST CERTIFICATE		1
	BUMS.S.CRT	BUSINESS INFO SYS/MEDICAL OFFICE SPECIALIST CERTIFICATE		
	BUS.AAS	BUSINESS ADMINISTRATION - AAS - OBSOLETE - DO NOT USE	20	19
	BUS.ABA	BUSINESS ADMINISTRATION - ABA -OBSOLETE - DO NOT USE		
	BUS.AS	BUSINESS ADMINISTRATION - AS		
	BUS.BBA	BUSINESS ADMINISTRATION - BBA - OBSOLETE -DO NOT		

		USE		
	BUS.BUD.02.AS	BUSINESS ADMINISTRATION - UD - AS		
	BUS.BUD.AS	BUSINESS ADMINISTRATION/UNIVERSITY OF DAYTON-AS		
	BUS.BWCSE.02.AS	BUSINESS ADMINISTRATION - CSE - WSU - AS		
	BUS.BWCSE.AS	BUSINESS ADMINISTRATION/WRIGHT STATE UNIV/CSE-AS		
	BUS.BWSU.02.AS	BUSINESS ADMINISTRATION - WSU - AS		
	BUS.BWSU.03.AS	BUSINESS ADMINISTRATION - WSU -AS		
	BUS.BWSU.AS	BUSINESS ADMINISTRATION/WRIGHT STATE UNIVERSITY-AS		
	BUS.CSU.92.AS	BUSINESS ADMINISTRATION - CSU - AS		
	BUS.CSU.AAS	BUSINESS ADMINISTRATION - CSU - AS		
	BUS.CSU.AS	BUSINESS ADMINISTRATION/CENTRAL STATE UNIVERSITY-AS		
	BUS.MSU.AS	BUSINESS ADMINISTRATION/MOREHEAD STATE UNIV - AS		
	BUS.S.AS	BUSINESS ADMINISTRATION-AS		
	BUS.UC.AS	BUSINESS ADMINISTRATION/UNIVERSITY OF CINCINNATI-AS		
	BUS.UC.IS.AS	BUS ADM/UC/INFORMATION SYSTEMS/PRE-BUSINESS-AS		
	BUS.UD.02.MIS.AS	BUSINESS ADMINISTRATION - UD - AS		
	BUS.UD.AS	BUSINESS ADMINISTRATION/UNIVERSITY OF DAYTON-AS		
	BUS.UD.MIS.AS	BUSINESS ADMINISTRATION - MIS - UD - AS		
	BUS.UU.AS	BUSINESS ADMINISTRATION/URBANA		

		UNIVERSITY-AS		
	BUS.UU.CIS.AS	BUS ADM/URBANA UNIV/COMPUTER INFORMATION SYSTEMS-AS		
	BUS.WCSE.AS	BUSINESS ADMINISTRATION - CS - WSU - AS		
	BUS.WCSE.CRT	BUSINESS ADMINISTRATION - CSE - WSU - AS		
	BUS.WIL.AS	BUSINESS ADMINISTRATION/WILBERFORCE UNIVERSITY-AS		
	BUS.WSU.AS	BUSINESS ADMINISTRATION - WSU - AS		
	BUS.WSU.CSE.AS	BUSINESS ADMINISTRATION - CSE - WSU - AS		
	BUS.WSU.IBE	BUS ADMIN - INTEGRATED BUSINESS EDU - WSU - AS		
	BUS.WSU.IBE.AS	BUS ADM - INTEGRATED BUSINESS EDUCATION - WSU - AS		
	BUS.WSU.MIS.02.AS	BUSINESS ADMINISTRATIOIN - MIS - WSU - AS		
	BUS.WSU.MIS.AS	BUSINESS ADMINISTRATIOIN - MIS - WSU - AS		
	BUS.XAV.AS	BUSINESS ADMINISTRATION/XAVIER UNIVERSITY - AS		
	IP.CRT	INFORMATION PROCESSING - CRT		
	IPO.AAS	OIS/INFORMATION PROCESSING OPTION-AAS		
	PCB.92.CRT	PERSONAL COMPUTERS IN BUSINESS CERTIFICATE	1	2
	PCB.CRT	PERSONAL COMPUTERS IN BUSINESS CERTIFICATE		
	PCB.S.CRT	PERSONAL COMPUTERS IN BUSINESS CERTIFICATE		
	WP.CRT	WORD PROCESSING - CRT		
	WPO.AAS	OFFICE INFORMATIONS SYS - INFORMATION PROCESSING OP- AAS		
	SA.S.STC	SOFTWARE APPLICATION FOR PROFESSIONAL CERTIFICATION-STC		

	SA.STC	SOFTWARE APPLICATION FOR PROFESSIONAL CERTIFICATION-STC		
	SAC.ND	SOFTWARE APPLICATIONS FOR PROFESSIONALS -ND		
	SAP.CRT	SOFTWARE APPLICATIONS FOR PROFESSIONALS - CRT		
	Subtotal		35	30
Computer Information Systems (CIS)			3	10
	CIS.AAS	COMPUTER INFORMATION SYSTEMS-AAS		
	CSS.AAS	A.A.S. - COMPUTER INFORMATION SYSTEMS/COMPUTER SUPPORT SERV		
	CSSO.AAS	COMPUTER INFO SYS - COMPUTER SUPPORT SERV OP - AAS		
	CYIT.AAS	CYBER INVESTIGATION TECHNOLOGY - AAS		
	CYIT.S.AAS	CYBER INVESTIGATION TECHNOLOGY - AAS		
	CYSE.ATS	CYBER SECURITY & COMPUTER FORENSICS - ATS		
	CYSEC.CRT	CYBER INVESTIGATION CERTIFICATE		
	CYSEC.S.CRT	CYBER INVESTIGATION CERTIFICATE		
	DA.S.CRT	DATA ANALYTICS		
	DA.S.STC	DATA ANALYTICS		
	DA.STC	DATA ANALYTICS		
	ISSC.S.STC	INFORMATION SYSTEMS SECURITY CERTIFICATE - STC		
	ISSC.STC	INFORMATION SYSTEMS SECURITY CERTIFICATE - STC		
	LSNE.S.STC	LINUX SECURITY & NETWORK ESSENTIALS - STC		
	LSNE.STC	LINUX SECURITY & NETWORK ESSENTIALS - STC		
	MCCS.S.AAS	MICROSOFT SECURITY SPECIALIST - AAS		

	MSSC.AAS	MICROSOFT SECURITY SPECIALIST - AAS		
	MSSC.S.AAS	MICROSOFT SECURITY SPECIALIST - AAS		
	NEA.S.STC	NETWORK ENGINEERING ASSOCIATE-STC	2	
	NEA.STC	NETWORK ENGINEERING ASSOCIATE-STC		
	NEEN.AAS	COMPUTER INFORMATION SYSTEM/NETWORK ENGINEER-AAS		
	NEEN.S.AAS	COMPUTER INFORMATION SYSTEM/NETWORK ENGINEER-AAS		
	NEMA.AAS	COMPUTER INFORMATION SYSTEM/NETWORK MANAGER-AAS		2
	NEMA.S.AAS	COMPUTER INFORMATION SYSTEM/NETWORK MANAGER-AAS		
	OST	OFFICE SYSTEMS TECHNOLOGY - AAS		
	USSU.AAS	COMPUTER INFORMATION SYSTEMS/USER SUPPORT - AAS		1
	USSU.S.AAS	COMPUTER INFORMATION SYSTEMS/USER SUPPORT - AAS		
	WA.STC	WEB AUTHORING CERTIFICATE		
	WEDE.AAS	CIS/WEB DEVELOPMENT-AAS	1	
	WEDE.S.AAS	CIS/WEB DEVELOPMENT-AAS		
	SNP.STC	SECURITY FOR THE NETWORKING PROFESSIONAL - STC		
	SODE.AAS	COMPUTER INFORMATION SYSTEMS/SOFTWARE DEVELOPMENT-AAS	2	3
	SODE.S.AAS	COMPUTER INFORMATION SYSTEMS/SOFTWARE DEVELOPMENT-AAS		
	SOHO.STC	SMALL OFFICE HOME OFFICE COMP USE AND SECURITY-STC		

	WW.STC	WEB PROGRAMMING CERTIFICATE - STC		
	WW1.S.STC	WEB PROGRAMMING CERTIFICATE		
	WW1.STC	WEB PROGRAMMING CERTIFICATE		
	WW2.STC	WEB PROGRAMMING CERTIFICATE-JAVA TRACK		
	Subtotal		8	16
Criminal Justice Science (CJS)				
	CCBO.AAS	CORRECTIONS: COMMUNITY BASED OPTION	1	1
	CJCM.S.STC	CRIME MAPPING - STC		
	CJCM.STC	CRIME MAPPING - STC		
	CJCO.AAS	CRIMINAL JUSTICE SCIENCE: CORRECTIONS OPTION - AAS	2	
	CJCO.S.AAS	CRIMINAL JUSTICE SCIENCE: CORRECTIONS OPTION - AAS		
	CJHS.S.STC	CRIMINAL JUSTICE SCIENCE: HOMELAND SECURITY - STC		
	CJHS.STC	CRIMINAL JUSTICE SCIENCE: HOMELAND SECURITY - STC		
	CJLE.AAS	CRIMINAL JUSTICE SCIENCE: LAW ENFORCEMENT OPTION - AAS	1	3
	CJLE.S.AAS	CRIMINAL JUSTICE SCIENCE: LAW ENFORCEMENT OPTION - AAS		
	CJLES.S.STC	CRIMINAL JUSTICE SCIENCE: LAW ENFORCEMENT - STC		
	CJLES.STC	CRIMINAL JUSTICE SCIENCE: LAW ENFORCEMENT - STC		
	COR.AAS	CORRECTIONS - AAS		
	COR.S.STC	CORRECTIONS - SHORT TERM CERTIFICATE		
	COR.STC	CORRECTIONS - SHORT TERM CERTIFICATE		
	CORI.AAS	CORRECTIONS: INSTITUTIONAL OPTION		
	IRSO.AAS	LAW ENFORCEMENT: INDUSTRIAL/RETAIL		

		SECURITY OPTION		
	LEP.AAS	LAW ENFORCEMENT - AAS		3
	POLO.AAS	LAW ENFORCEMENT: POLICE SCIENCE OPTION	5	2
	POLO.ACADEMY. AAS	LAW ENFORCEMENT/POLICE SCIENCE OPTION - AAS		
	Subtotal		9	9
Emergency Medical Services (EMS)				
	EBST.S.STC	EMT-BASIC CERTIFICATION	2	1
	EBST.STC	EMT-BASIC CERTIFICATION		
	EMR.S.STC	EMERGENCY MEDICAL RESPONDER - STC		
	EMS	EMERGENCY MEDICAL SERVICES 1 + 1 - AAS		
	EMSFO.AAS	EMERGENCY MEDICAL SERVICES FIRE SCIENCE OPTION - AAS		
	EMSFO.S.AAS	EMERGENCY MEDICAL SERVICES FIRE SCIENCE OPTION - AAS		
	EMST.STC	EMERGENCY MEDICAL SERVICES/PARAMEDIC CERTIFICATION-STC		1
	EMSVS.AAS	EMERGENCY MEDICAL SERVICES		1
	EMSVS.S.AAS	EMERGENCY MEDICAL SERVICES		
	EPST.CRT	EMT-PARAMEDIC CERTIFICATION	1	5
	EPST.S.CRT	EMT-PARAMEDIC CERTIFICATION		
	EPST.STC	EMT-PARAMEDIC CERTIFICATION		
	P-EMS.ND	PRE-EMERGENCY MEDICAL SERVICES-NO DEGREE AWARDED	3	4
	RT.STC	RESCUE TECHNICIAN CERTIFICATION-STC		
	Subtotal		6	12

Fire Science Technology (FST)			1	1
	FAO.AAS	FST/FIRE ADMINISTRATION OPTION-AAS	1	2
	FAO.CRT	CERTIFICATE (CRT) - FIRE ADMINISTRATION OPTION CERTIFICATE		
	FAO.S.AAS	FST/FIRE ADMINISTRATION OPTION-AAS		
	FCO.S.STC	FIRE DEPARTMENT COMPANY OFFICER - STC		
	FCO.STC	FIRE DEPARTMENT COMPANY OFFICER - STC		
	FEO.S.STC	FIRE DEPARTMENT EXECUTIVE OFFICER - STC		
	FEO.STC	FIRE DEPARTMENT EXECUTIVE OFFICER - STC		
	FST.AAS	FIRE SCIENCE TECHNOLOGY-AAS		
	FST.CRT	FIRE SCIENCE TECHNOLOGY CERTIFICATE		
	FST.S.AAS	FIRE SCIENCE TECHNOLOGY-AAS		
	FT.STC	FIREFIGHTER TECHNICIAN CERTIFICATION-STC		
	PFC.S.STC	PROFESSIONAL FIREFIGHTER CERTIFICATION - STC		1
	PFC.STC	PROFESSIONAL FIREFIGHTER CERTIFICATION - STC		
	Subtotal		2	4
Hospitality Management & Tourism (HMT)			1	1
	BAN.CRT	BANKING CERTIFICATE - CRT		
	BPSE.S.STC	BAKING SPECIALIST- STC		
	BPSE.STC	BAKING SPECIALIST- STC		
	CAO.93.AAS	HOSPITALITY MANAGEMENT TECH/CULINARY ARTS OPTION-AAS		1
	CAO.AAS	HOSPITALITY MANAGEMENT-CULINARY ARTS OPT AAS		
	CAO.S.AAS	HOSPITALITY MANAGEMENT-		

		CULINARY ARTS OPT AAS		
	HMT.AAS	HOSPITALITY MANAGEMENT-AAS		
	HMT.CRT	HOSPITALITY MANAGEMENT - CRT		
	HMTT.AAS	HOSPITALITY MANGEMENT & TOURISM - AAS		
	HMTT.S.AAS	HOSPITALITY MANGEMENT & TOURISM - AAS		
	HMTTL.AAS	HOSP MGMT & TOURISM/HOTEL LODGING CONCENTRATION - AAS		
	HMTTL.S.AAS	HOSP MGMT & TOURISM/HOTEL LODGING CONCENTRATION - AAS		
	HMTTM.AAS	HOSP MGMT & TOURSIM/ MEET AND EVENT PLAN CONCENTRA- AAS		
	HMTTM.S.AAS	HOSP MGMT & TOURSIM/ MEET AND EVENT PLAN CONCENTRA- AAS		
	HMTTT.AAS	HOSP MGMT & TOURISM/TOURISM CONCENTRATION - AAS		
	HMTTT.S.AAS	HOSP MGMT & TOURISM/TOURISM CONCENTRATION - AAS		
	HOS.AAS	HOSPITALITY MANAGEMENT.AAS		
	TNT.AAS	TRAVEL & TOURISM-AAS	2	4
	Subtotal		3	6
Management, Business (MAN)				
	CSE.AS	BUSINESS ADMINISTRATION - COMPUTER SCIENCE EMPHASIS - AS		
	CSO.AAS	BUSINESS ADMINISTRATION/COMPUTER SCIENCE OPTION-AS		
	ENT.CRT	ENTREPRENEURSHIP - CRT		
	ENT.S.CRT	ENTREPRENEURSHIP - CRT		
	ENTR.AAS	BUSINESS MGMT-		

		ENTREPRENEURSHIP CONCENTRATION- AAS		
	ENTR.S.AAS	BUSINESS MGMT-ENTREPRENEURSHIP CONCENTRATION- AAS		
	GBM.AAS	BUSINESS MANAGEMENT-AAS	4	6
	GBM.AS	BUSINESS MANAGEMENT-AS		
	GBM.S.AAS	BUSINESS MANAGEMENT-AAS		
	HR.STC	HUMAN RESOURCE MANAGEMENT CERTIFICATE (DEPARTMENTAL)		
	HRMT.S.STC	HUMAN RESOURCE MANAGEMENT CERTIFICATE-STC		
	HRMT.STC	HUMAN RESOURCE MANAGEMENT CERTIFICATE-STC		
	HUMS.CRT	HUMAN SERVICES CERTIFICATE		
	MAN.AAS	MANAGEMENT-AAS		
	MRK.AAS	MARKETING MANAGEMENT-AAS		
	MIO.AAS	MANAGEMENT + INDUSTRICAL ORGANIZATION - ATS		
	MISE.AS	BUS ADM - MANAGEMENT INFORMATION SYSTEM EMP - AS		
	MMR.AAS	MID-MANAGEMENT RETAILING-AAS	1	1
	SCM.AAS	BUSINESS MANAGEMENT-SUPPLY CHAIN MANAGEMENT - AAS		
	SCM.S.AAS	BUSINESS MANAGEMENT-SUPPLY CHAIN MANAGEMENT - AAS		
	SCMC.CRT	SUPPLY CHAIN MANAGMENT CERTIFICATE - CRT		
	SCMC.S.CRT	SUPPLY CHAIN MANAGMENT CERTIFICATE - CRT		
	SCMS.STC	SUPPLY CHAIN MANAGEMENT - STC		

	Subtotal		5	7
Paralegal (PAR)				1
	PAR.AAS	PARALEGAL-AAS		
	PAR.S.AAS	PARALEGAL-AAS		
	Subtotal		0	1
Real Estate (RES)			2	2
	RES.00.AAS	REAL ESTATE/PROPERTY MANAGEMENT-AAS		
	RES.92.AAS	REAL ESTATE/PROPERTY MANAGEMENT-AAS		
	RES.94.AAS	REAL ESTATE/PROPERTY MANAGEMENT - AAS		
	RES.AAS	REAL ESTATE/PROPERTY MANAGEMENT-AAS		
	RES.S.AAS	REAL ESTATE/PROPERTY MANAGEMENT-AAS		
	RESB.STC	OHIO REAL ESTATE BROKER-STC		
	RESS.S.STC	OHIO REAL ESTATE SALES ASSOCIATE-STC		
	RESS.STC	OHIO REAL ESTATE SALES ASSOCIATE-STC		
	Subtotal		2	2
Not sure where these fall				
	CC.STC	CALL CENTER CERTIFICATION-STC		
	CO.ATS	Catering Ownership - Ats		
	CO.CRT	COMPUTER OPERATIONS - CRT		
	CR.STC	COURT REPORTING - ATS		
	CT.CRT	CLERK TYPIST -CRT		
	DP.STC	DESKTOP PUBLISHING CERTIFICATION-STC		
	EXS.AAS	EXECUTIVE SECRETARIAL-AAS		
	EXS.AS	EXECUTIVE SECRETARIAL-AS		

	FMT.AAS	FINANCIAL MANAGEMENT-AAS		2
	FMT.STC	FINANCIAL MANAGEMENT-STC		
	FSM.AAS	FOOD SERVICE MANAGEMENT-AAS		
	FSM.CRT	FOOD SERVICE MANAGEMENT CERTIFICATE		
	FSM.S.CRT	FOOD SERVICE MANAGEMENT CERTIFICATE		
	FTE.STC	FAST TRACK ENTREPRENEUR - STC		
	FTPA.CRT	FAST TRACK PROGRAM ANALYST CERTIFICATION-STC-DO NOT USE		
	FTPA.STC	FAST TRACK PROGRAM ANALYST -STC		
	FTPA1.S.STC	FAST TRACK/PROGRAMMER ANALYST - ENTERPRISE OPTION		
	FTPA1.STC	FAST TRACK/PROGRAMMER ANALYST - ENTERPRISE OPTION		
	FTPA2.STC	FAST TRACK/PROGRAMMER ANALYST - WEB DEVELOPMENT-STC		
	HD.STC	HELP DESK ANALYST CERTIFICATE		
	HHSO.AA	PUBLIC SERVICES: HUMAN SERVICES OPTION		
	JEDI.STC	JAVA ENTERPRISE DEVLPMNT IMPLEMENTN CERTIFICATION STC		
	JEDIC	JAVA ENTERPRISE DEVLPMNT IMPLEMENTN CERTIFICATION-STC		
	LAP.AAS	LEGAL ASSISTING-AAS	1	2
	LSO.AAS	OIS/LEGAL OFFICE SPECIALIST OPTION-AAS		
	PAO.AA	PUBLIC SERVICES: PUBLIC ADMINISTRATION OPTION		
	PSA.AA	PUBLIC SERVICES ASSOCIATE - AA		
	P-LAP.ND	PRE-LEGAL ASSISTING - NO	3	2

		DEGREE AWARDED		
	P-PAR.ND	PRE-PARALEGAL-NO DEGREE AWARDED		1
	SAO.AAS	OIS/SECRETARIAL ACCOUNTING OPTION=AAS		
	SAV.CRT	SAVINGS AND LOAN ADMINSTRATION - CRT		
	SEC.AAS	EXECUTIVE SECRETARIAL-AAS		
	SECC	SECRETARIAL SCIENCE - CRT		
	subtotal		4	7
Total			81	101

Appendix D: Institutional Approval for Part II Data

SINCLAIR
COMMUNITY COLLEGE
Research, Analytics & Reporting

December 14, 2012

Patrick Greco
Chemistry
Sinclair Community College
444 West Third Street
Dayton, OH 45402-1460

RE: Confirmation of authorization to use institutional data

Dear Patrick:

This letter serves as confirmation that you have permission to use the data you were provided via your work with Sinclair's Research, Analytics and Reporting Office for program evaluation and your research/dissertation. As the information is non-identifying and is routinely used in program evaluation, your work with it was determined to be exempt from IRB review.

If you have any questions or concerns, please feel free to contact me. Good luck with your venture.

Sincerely,

Laura A. Mercer
Director, Research, Analytics and Reporting
Chair, Sinclair Institutional Review Board
Phone: 937-512-4571
laura.mercer@sinclair.edu